The Journal of the International Society for Prosthetics and Orthotics

Prosthetics and Orthotics International

April 1982, Vol. 6, No. 1


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Prosthetics and Orthotics International

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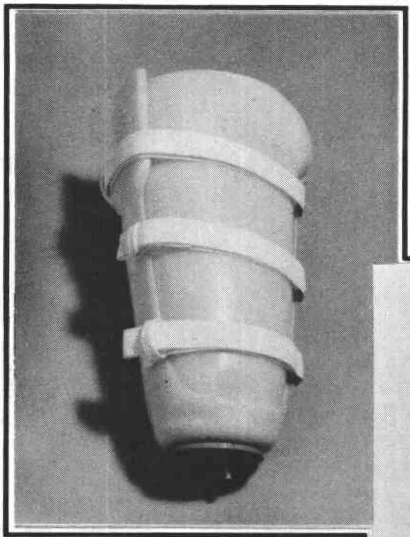

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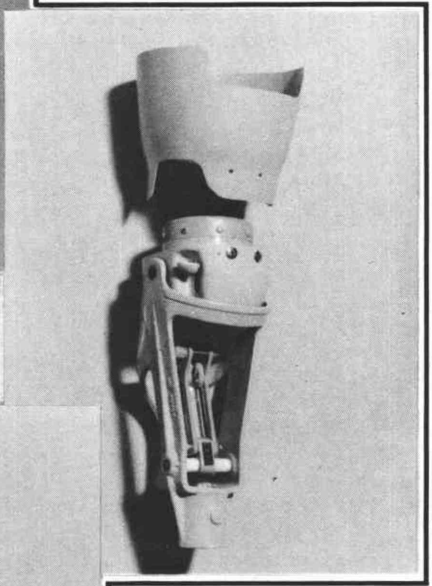

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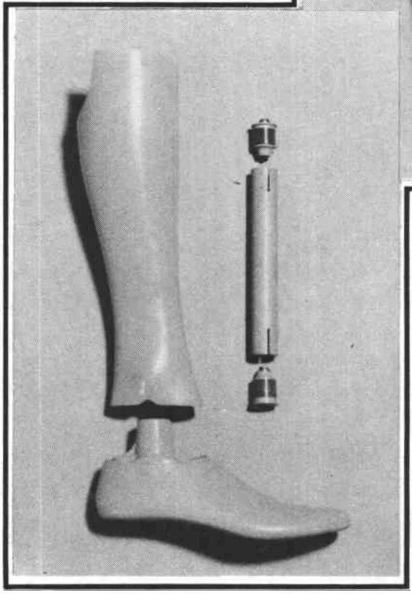

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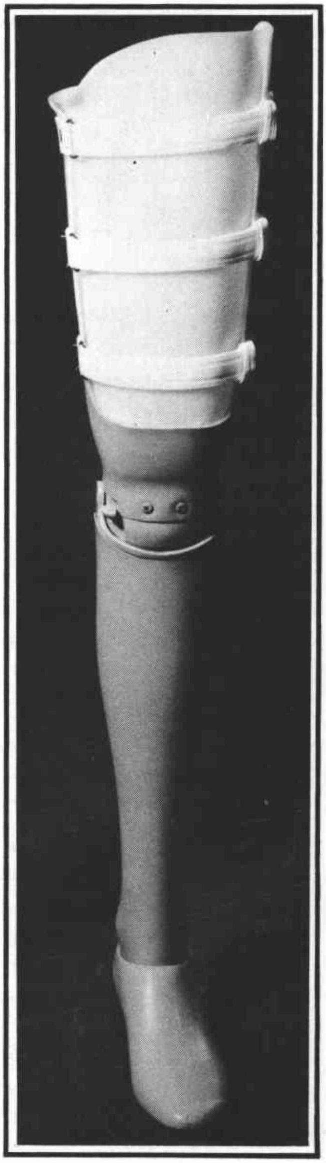

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The Journal of the International Society for Prosthetics and Orthotics

April 1982, Vol. 6, No. 1

Contents

Executive board of ISPO

Prosthetics and Orthotics International, 1982, 6, 5

Editorial

In this issue of the journal the financial reports for the fiscal years 1980 and 1981 are presented to the members of ISPO. We apologise for the delay in presenting 1980's accounts.

In spite of the financial crises and consequent increasing inflation, which exist in most countries, ISPO has managed to keep the increase in the membership fee down to less than 10 per cent, i.e. less than the average inflation.

As will be seen from the financial report, contributions from the Society and Home for Disabled in Denmark as well as sponsorship fees add a substantial amount of money to the income from membership fees. Furthermore ISPO receive office space free of charge from the Society and Home for Disabled—a substantial contribution which does not appear in the account.

The deficit in producing and distributing this journal is now D.kr. 27.142 (app. US$ 3.600) against a deficit in 1979 of D.kr. 42.998 (app. US$ 5.700). Congratulations to the editorial staff for their tremendous and successful work and gratitude to the University of Strathclyde group and the Scottish Home and Health Department for their support in this activity.

Travel expenses have been increasing as a consequence of rising air fares as well as increasing activities. Furthermore the global economic crises cause increasing difficulties for members of the board to recover expenses from national sources,

Although the Bologna congress in 1980 was a successful event as far as the scientific programme and the exhibition were concerned, the economic results were not satisfying. As will be seen from the financial report a contribution to the Bologna congress of D.kr. 76.718 (app. US$ 10.200) has not been recovered. The precise loss is yet to be determined, however it is expected to be less than the above mentioned sum.

The activities of ISPO must be continuously expanding. The board has several projects which could be initiated within a short time if funding were available. We therefore urge the national societies as well as the individual member to seek funds for ISPO to help the board in its effort to accomplish the aims of our society.

Erik Lyquist
Honorary Treasurer and Vice-President.

Prosthetics and Orthotics International, 1982, 6, 6–9

I.S.P.O. Statement of Accounts, 1980

Balance as at December 31, 1980				
Income:				
Membership fees			240.203	
Sponsorship fees			—	
Contributions:				
Society and Home for Disabled			36.000	
The War Amputations of Canada C.$ 5.000			24.935	
United States Manufacturing Co. US$ 5.000			28.084	329.222
Interest:				
Bonds			900	
Bank accounts			27.982	28.882
Expenditure:				
Fees: Aase Larsson		69.758		
Reimbursement to Gentofte Hospital 1.1—30.6.1980		16.458	86.216	
A.T.P. and Pension			6.188	
Printing expenses:				
Journal: Prosthetics and Orthotics International:				
Printing cost incl. air mail posting		148.995		
Production service		8.120		
Labels		1.840		
		158.955		
Less income:				
Advertising	41.060			
+Debtors, December 31, 1980	16.870	57.930		
Subscriptions		46.701	54.324	
Printing expenses:				
Journal: Deformed Foot		14.257		
Less income		1.702	12.555	
Stationery and printed matters			2.388	
Postage and freight			7.809	
Meeting and travelling expenses:				
Miscellaneous		7.449		
Honorary Secretary		18.250		
Executive Boards, incl. Meetings, Copenhagen, Toronto, Bologna		44.048	69.747	
I.S.R.D. Fees 1978–79–80			6.236	
Telephone			5.356	
Repairs and maintenance (Office Equipment)			11.511	
Miscellaneous expenses: Data system		10.720		
Sundry		403	11.123	
Auditing			2.518	
			275.971	358.104
Surplus as at December 31, 1980			82.133	
			Kr. 358.104	Kr. 358.104

Balance as at December 31, 1980

Assets			
Cash on hand		1.167	
Bank accounts:			
Handelsbanken, Chech no. 524.052	57.526		
Handelsbanken Book no. 398.871	1.397		
Handelsbanken, Book no. 705.154	247.944	306.867	
Debtors: Advertising US$ 2.803		16.870	
Bonds:			
Nom. kr. 18.000 10% Østifternes Kreditforening 18/2003 (course 9.3.81 58¾ value)		12.690	
Contributions to: World Congress 1980	84.959		
Less repayment	8.241	76.718	
Liabilities			
Fees: Pension 1.7—31.12.1980			5.972
Auditing			732
Printing Cost: Volume 4, No. 3			55.170
Balance as at December 31, 1980: (capital account):			
January 1.1980	270.305		
+ Surplus for the period 1.1—31.12.1980	82.133		352.438
		Kr. 414.312	Kr. 414.312

The above mentioned Accounts, which have been examined, are in Accordance with the book-keeping for the year 1980. Journal Prosthetics and Orthotics International, Volume 4 No. 3., payments for advertising are not included in the above mentioned figures. Debtors: Advertising US$ 2.803.

Bogsvoerd, March 15, 1981.

GUNNER PETERSEN,
Registered Accountant,
Denmark.

I.S.P.O. Statement of Accounts, 1981

Balance as at December 31, 1981				
Income:				
Membership fees			366.229	
Sponsorship fees			5.393	
Contributions: Society and Home for Disabled			57.000	
Film directory			261	428.883
Interest:				
Bank accounts			37.090	
Bonds			1.800	38.890
Expenditure:				
Salary: Aase Larsson			135.230	
A.T.P. and pension			15.125	
Printing expenses:				
Journal: Prosthetics and Orthotics International:				
Printing cost incl. air mail posting		173.550		
Production service		17.532		
Labels		4.100		
		195.182		
Less income:				
Advertising	70.605			
+Debtors, December 31, 1981	20.733	91.338		
Subscriptions		76.702	27.142	
Printing expenses:				
Journal: Deformed Foot		—		
Less income		5.138		5.138
Stationery and printed matters			11.236	
Postage and freight			13.608	
Meeting and travelling expenses:				
Miscellaneous		4.701		
Honorary Secretary		26.070		
Executive boards, incl. meetings, Copenhagen, Bologna, London		55.866	86.637	
R. I. Fee 1981			2.292	
Telephone			7.131	
Repairs and maintenance			1.380	
Miscellaneous expenses:				
Data system		12.398		
Sundry		111	12.509	
Auditing			4.146	
			316.436	472.911
Surplus as at December 31, 1981			156.475	
			Kr. 472.911	Kr. 472.911

Balance as at December 31, 1981

Assets			
Cash on hand		102	
Bank accounts:			
Handelsbanken Chech no. 524.052	20.430		
Handelsbanken Book no. 398.871	122		
Handelsbanken Book no. 705.154	313.015		
Handelsbanken Book no. 503.314	10.000	343.567	
Debtors: Advertising US$ 2.859		20.733	
Bonds:			
Nom. kr. 18.000 10% Østifternes Kreditforening 18/2003 (course 31.12.1981 59¼ value D. Kr. 10.665)		12.690	
Contributions to: World Congress 1980	84.959		
Less repayment	8.241	76.718	
World Congress, London 1983		56.753	
Liabilities			
Creditor, Auditing			1.650
Balance as at January 1, 1981 (Capital account)	352.438		
+Surplus for the period 1.1—31.12.1981	156.475		508.913
		Kr. 510.563	Kr. 510.563

The above mentioned Accounts, which have been examined, are in Accordance with the book-keeping for the year 1981.

Bagsvoerd, January 29, 1982.

GUNNER PETERSEN,
Registered Accountant,
Denmark.

Prosthetics and Orthotics International, 1982, 6, 10–16

Retrospective study of 14,400 civilian disabled (new) treated over 25 years at an Artificial Limb Centre

I. C. NARANG and V. S. JAPE

Artificial Limb Centre, Pune, India

Abstract

This paper reports on 14,400 civilian disabled treated over 25 years at the Artificial Limb Centre, Pune, India. It examines in some detail sex and age distribution, cause of disability, levels of amputation, sources of payment and other factors relating to the rehabilitation of the patient.

Introduction

Rehabilitation of the disabled is a vital problem not only for the Armed Forces but also for the nation at large; apart from war injuries, accident and disease also produce large numbers of disabled.

An awareness of the importance of the ultimate rehabilitation of the patient is a marked feature of modern surgical practice and bio-medical engineering. It is now an accepted principle that the surgeon's responsibility extends beyond the operating table and that of the engineer beyond the workshop to the point where the return of the patient to more or less normal activity becomes a reality.

The Artificial Limb Centre Pune

The Artificial Limb Centre was established in 1944 with the help of experts from Roehampton, London, primarily to look after disabled veterans of the Second World War. From 1954 onwards, facilities were gradually extended to civilians.

It is a unique and pioneer institution in India, in that it is not just a factory manufacturing artificial limbs, but an establishment where total care for the patient is provided from the time long before an artificial limb is required to his rehabilitation programme.

The Artificial Limb Centre incorporates a hospital of 200 indoor beds. The staff consists of surgeons, medical officers, paramedical personnel, engineers and technicians; total staff strength is 350 to 400.

Amputations, review amputations, tendon and joint surgery to correct deformities, plastic and reconstructive surgery etc. are carried out by the surgeons of this centre.

Along with the fabrication of artificial limbs, practice in their use is commenced in a very well equipped physiotherapy and rehabilitation department.

The centre is self-sufficient. The materials used for manufacture of limbs and appliances are indigenous and the various components are manufactured locally in the centre.

The study

During the last 25 years (from 1954 to 1978) a total of 14,400 civilian amputees and other orthopaedically handicapped persons were treated at this centre. This is more than twice the number of disabled soldiers and ex-Servicemen treated during the same time span.

Records are maintained for every case and recently a study was undertaken to analyse the civilian cases and compare them with other studies available in the literature.

Male patients comprise 88·37% of the total, and females 11·63% (Fig. 1 and Table 12). The reasons for male predominance or unequal distribution may be:

(1) Men have a more outdoor life and are thus more exposed to trauma.

(2) Indian society being male dominated, the bread winners are mostly males, therefore disabled males get preference for treatment over disabled females in the family.

All correspondence to be addressed to Brig. I. C. Narang, Commandant, Artificial Limb Centre, Post Box. 86, Pune-411001, India.

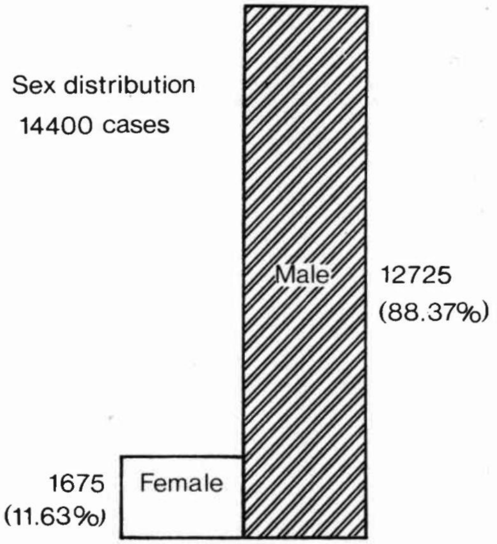

Fig. 1. Sex distribution in 14,400 cases.

However it will be noted that female children up to 10 years of age form almost one-third of the number of male children; probably parents are keen to have their daughters treated, otherwise deformity will be a great handicap in grown-up girls.

Most of the patients are in the age groups 10–20, 20–30 and 30–40 (Fig. 2). Young children are very active at this age and find new activity outside the home. Similarly, young adults are either seeking jobs after completing education or are holding jobs, and are more prone to accident.

Table 1. Cause of disability, 14,400 cases

Trauma	9,649	(67%)
Disease	3,930	(27·3%)
Congenital	821	(5·7%)

The major cause of disability is trauma, 67%, followed by disease 27·30%, and congenital 5·70% (Table 1). It is interesting that females form 25% and 30% respectively of the disease and congenital groups, but only 4·6% of the traumatic group.

Railway, vehicle and factory accidents form the largest group, 87% (Fig. 3). Recently, due to modernization, cases of electric shock and accidents with farm implements such as threshers etc. have considerably increased.

A large proportion of accident victims are in their most promising and productive phase of life and their disablement causes a great blow to their families and the community. Indian

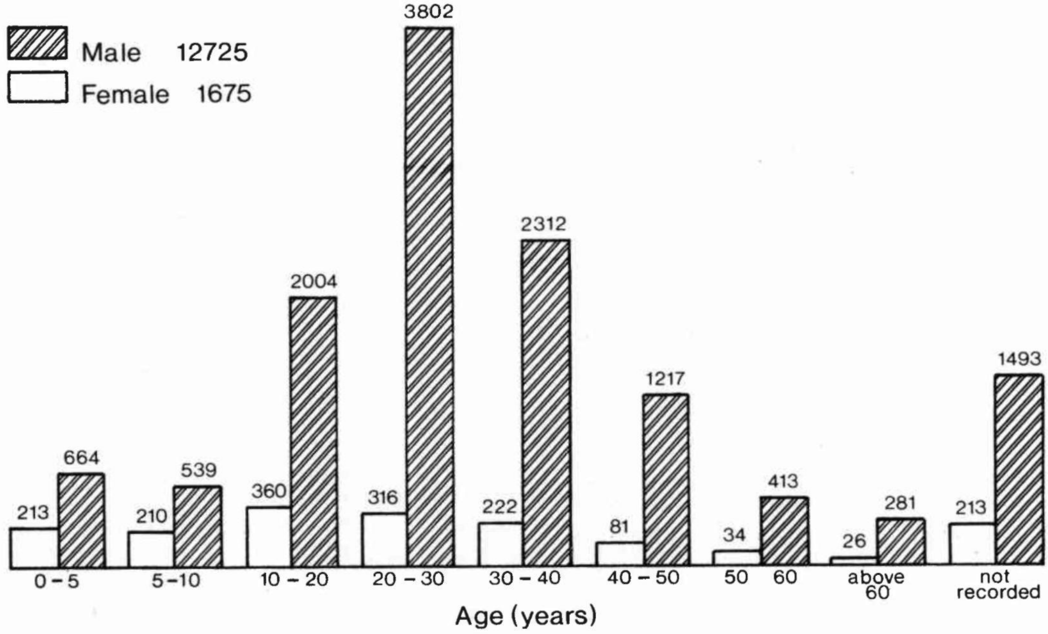

Fig. 2. Age distribution in 14,400 cases.

families are very closely knit so that, in spite of the economic problems caused by a disability, the victim does not suffer a great loss of status or socio-economic isolation in the family or community.

Table 2. Types of disease in 3,930 cases

Poliomyelitis	1,346	(34·25%)
Thromboangiitis obliterans	993	(25·27%)
Malignancy	339	(8·62%)
Diabetes	251	(6·40%)
Other*	1,001	(25·46%)

*Caries spine, leprosy, osteomyelitis, sacroiliac strain, prolapsed disc, scoliosis, lumbago, motorneuro disease, paralysis, hemiplegia, paraplegia, hernia, spastic paresis, tumour, chondroma, cervical spondylosis, spondylosthesis, etc.

Vascular disease was the main reason for amputation in the older age group; the main cause of deformity, mostly in children under 10 years of age, was poliomyelitis (Table 2). These children, especially from villages, were usually brought to the Centre late when deformities were gross and making orthoses was difficult without major and repeated surgical procedures. Cancer strikes at all ages, but the cases in the study were mostly below 30 years of age and their amputations were either through hip or above-knee.

Table 3. Congenital deformities

		Male	Female	Total
Lower limb	R	103	50	153
	L	116	32	148
	Bil	90	33	123
Upper limb	R	14	15	29
	L	15	17	32
	Bil	4	8	12
Foot deformities	R	20	9	29
	L	33	9	42
	Bil	93	64	157
Other		41	—	41
Total		529	237	766

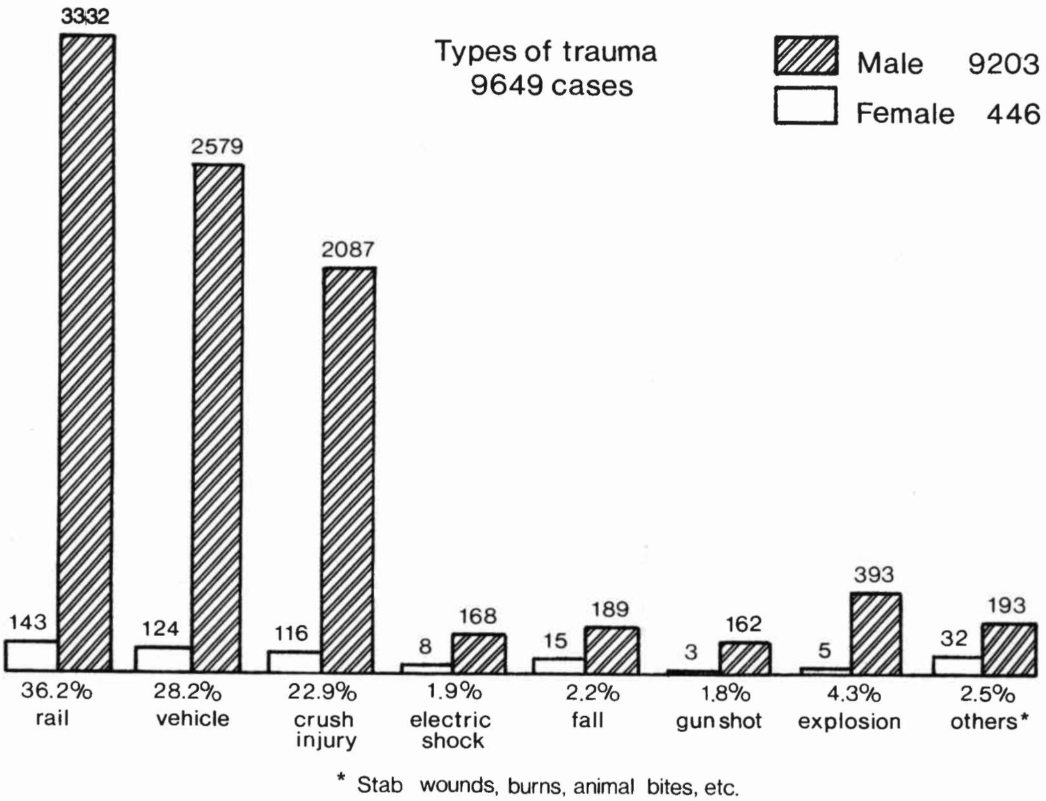

Fig. 3. Types of trauma in 9,649 cases.

Table 4. Congenital deficiencies

	Male	Female	Total
Lower limb	15	14	29
Upper limb	27	15	42
Multiple	2	1	3
Total	44	30	74

While phocomelic deformities were more common in the upper limb than the lower limb, the great majority of congenital deformities affected the lower limb and foot (Table 3). Males suffered almost double the number of upper limb deficiencies but an equal number of lower limb involvements (Table 4). Only three cases of multiple deficiencies were noted in this series.

Rehabilitation of the congenitally disabled is comparatively easy, because being born with a limb deficiency or deformity forces the child to make automatic adjustments to his surroundings and to his psychological environment. These children have usually developed ingenious methods of compensating for their disabilities.

Table 5. Disability

	Male	Female	Total	
Amputation	10,648	844	11,492	(80%)
Deformity	2,077	831	2,908	(20%)
Total	12,725	1,675	14,400	

Eighty per cent of the cases were of amputation and the remaining 20% of deformity (Table 5). Females comprised only 7·3% of the amputees but 28·5% of those with disability due to deformity.

The proportion of people with deformities, congenital or otherwise, coming for treatment has more than doubled in recent years. This shows a growing tendency to seek treatment for the less obvious disabilities which previously were tolerated without treatment. A child with a foot or leg deformity would drag itself around and the parents accept the disability as a stroke of ill-luck. If the child was not totally bed-ridden, nothing further would be done. The general attitude towards health was that health meant an apparent absence of disease or illness. It was a negative concept of health which suggested that if one was not actually in bed, one was healthy.

With a growing awareness about health matters, this attitude is giving way to a more positive approach, ie that health is not merely an apparent absence of illness but functioning of the body and the mind at their full efficiency, using their potential to the fullest. This changing attitude encourages the seeking of help for the avoidance and correction of minor or less obvious illnesses and disabilities so that the body can attain its optimum in efficiency and is reflected in the increased proportion of deformities coming for treatment.

Table 6. Amputations

	Male	Female	Total	
Lower limb	6,580	552	7,132	(62%)
Upper limb	3,974	276	4,250	(37%)
Miscellaneous	94	16	110	(1%)
Total	10,648	844	11,492	

Lower limb amputations were the most numerous, 62%, while upper limbs were 37% and those involving both limbs 1% (Table 6). Recently, an upward trend of upper limb amputees was noted.

Lower limb amputations were mostly caused by railway and vehicle accidents while upper limb amputations were the result of machine, electric and explosives accidents.

Table 7. Lower limb amputations

	Right	Left	Total
Above-knee (including through-hip and through-knee)	1,508	1,509	3,017
Below-knee (including Syme and Chopart)	1,752	1,812	3,564
Bilateral			511
Total	3,260	3,321	7,092

Below-knee amputations accounted for 46·3% of all the lower limb amputations and above-knee for 37·6%. There was no marked difference between right and left (Table 7).

In bilateral cases 50% were below-knee followed by above-knee 20% and the remainder in various combinations.

Table 8. Upper limb amputations

	Right	Left	Total
Above-elbow	848	602	1,450
Below-elbow	922	667	1,589
Through-elbow, through-shoulder	151	131	282
Through-wrist, PMH	461	262	723
Bilateral			206
Total	2,382	1,662	4,250

Seventy per cent of upper limb amputations were performed at the preferred level of above and below-elbow (Table 8). The interesting observation is that the total number of right side amputees is almost 1½ times more than left side (2,382 to 1,662), the reason being that the right arm is used more than the left in any type of work.

Amputations at wrist level and partially mutilated hand form 17% of this group. Bilateral cases account for 4·8%.

Rehabilitation is difficult for artisans and craftsmen and psychological problems are more pronounced. It has not been possible so far to provide a functional hand with moving fingers.

Below-elbow amputations form the biggest group in bilateral cases.

In the first six months after disability only 12·6% of patients reported for treatment but this increased to 31·8% within one year. However, 32·5% did not report for treatment until more than four years after disability (Fig. 4).

The reason for the small number reporting within six months may be that in the case of amputation, the stump needs time to stabilize before limb fitting and in polio much time is spent on initial physiotherapy.

The time lag is now reducing because of an increasing awareness and motivation and also improved availability of rehabilitation service, but amputees are still reporting earlier than patients with deformities. The obvious reason is that polio etc, occurring in early childhood or at birth, forces adjustment and mobility when the patient is at a more flexible age and less conscious of social stigmas. Also, the physical presence of limbs is sometimes more reassuring to the patients and parents therefore there is less inducement to go for treatment.

In cases of trauma, the sudden and dramatic physical loss of limbs is unsettling in the extreme. It shatters the body image of the victim and reduces his self esteem to an alarmingly low level. Therefore the psychological effects of amputation are more dramatic and incapacitating to the victim's ego and to his social relationships. Thus the patient and his immediate family have a powerful motive for seeking early treatment.

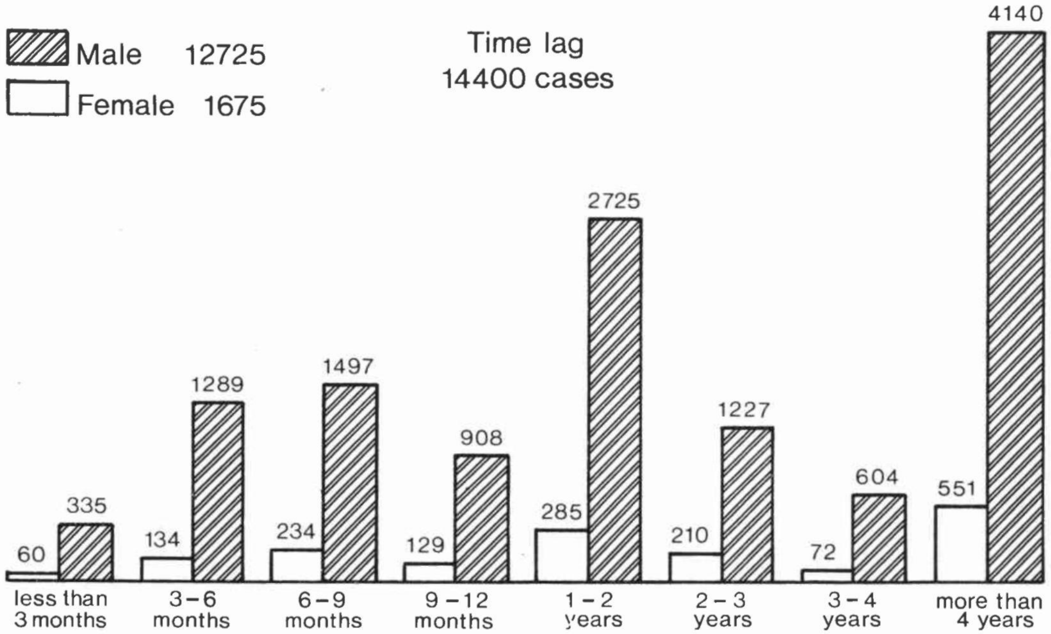

Fig. 4. Time lag in reporting for treatment, 14,400 cases.

Table 9. Sources of payment

Individual	10,258	(71%)
Government agencies	1,867	(13%)
Employer	1,719	(12%)
Voluntary agencies	556	(4%)
Total	14,400	

Seventy-one per cent of patients pay for their own treatment while 25% are paid for by their employers and Government agencies (Table 9). Voluntary agencies such as the Red Cross, Lions Club, Rotary Club and similar other organizations help in only about 4% of cases.

Table 10. Inpatients and outpatients

	Male	Female	Total
Inpatients	5,939	469	6,408 (44·5%)
Outpatients	6,786	1,206	7,992 (55·5%)
Total	12,725	1,675	14,400

Eleven per cent more outpatients than inpatients are seen at the Centre (Table 10). Patients from the local State make up about 20% of the total while 80% come from other States.

Seventy-five per cent of patients stay between 3 and 12 weeks, bilateral amputees staying longer than unilateral amputees. Only about 13% who undergo corrective surgery stay longer than 12 weeks.

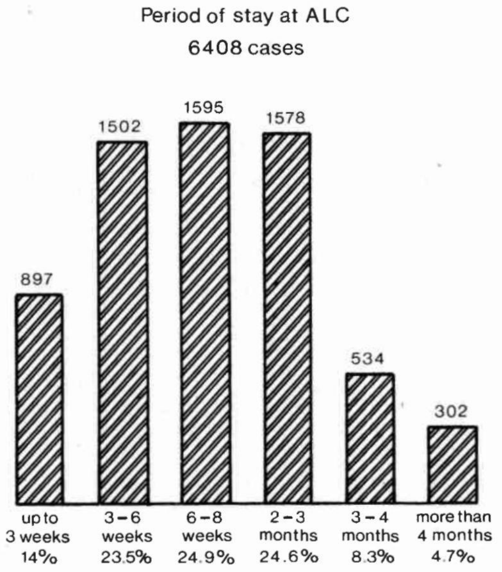

Fig. 5. Period of stay at the Artificial Limb Centre, 6,408 cases.

Only 14% of patients stay for less than 3 weeks, these are patients who are given priority for compassionate reasons.

Table 11. Number of issues to date (25 years)

No. of issues	Upper limb	Lower limb	Orthoses
1	3,526	5,334	2,877
2	249	1,119	188
3	51	493	83
4	38	296	27
More than four	1	114	4
Total	3,865	7,356	3,179

It was found that more lower limb amputees return for limb renewal than upper limb amputees (Table 11). The obvious reason is that lower limb prostheses are functionally and psychologically more satisfying than upper limb prostheses and receive more use.

Comparison with other studies

In this series, the traumatic group is the largest so far reported (Table 13), while the disease, congenital and tumour groups are small—either patients do not come forward for treatment as they are reconciled to fate, or the number affected is low.

Table 12. Sex ratio

	Present study	Munson and Dolan (1968)	Pellicore et al (1974)
Male	12,725	2,287	327
Female	1,675	1,708	132
Ratio	8 : 1	1·5 : 1	2·5 : 1

Table 13. Reason for amputation

	Disease	Trauma	Tumour	Congenital
Present study 1954-1978	20·3%	76%	3%	0·7%
Kegel et al (1976) 1964-1976 Lower extremity	49%	35%	8%	7%
Glattly (1964) 1961-1963 Upper and lower extremity	58%	33%	5%	4%
Kay & Newman (1974) 1973–1974 Upper and lower extremity	70%	22%	5%	3%
Kerstein et al (1974) 1961-1971 Lower extremity	85%	7%	3%	5%
Davies et al (1970) 1965-1967 Upper and lower extremity	37%	50%	4%	8%

Table 14. Cause of accidents

	Present study	Dept. of Veterans Affairs (1978)	Pellicore et al (1974)
Vehicle	28% (3·8% female)	24% (36% female)	15%
Industrial	22%	11%	16%
Train & farm	36%	10%	20·5%

The high incidence in this study (Table 14) may be due to fast industrialization, modernization of farms and fewer preventive and safety measures.

Table 15. Side affected

	Present study		Munson and Dolan (1968)	
	R	L	R	L
Upper limb	2,482	1,147	721	1,008
Lower limb	3,260	3,321	778	705

There is definite evidence of the right arm being injured more often than the left in this series (Table 15) as compared to other reported series.

Conclusions

1. The ratio of males to females seeking treatment at ALC is very high, i.e. 8:1.
2. The major cause of amputation in India is trauma due to vehicle, train, machinery and farm accidents.
3. Right arm amputees are almost double in number to left.
4. The majority of patients pay for their own prostheses.
5. The majority report late for treatment.
6. Lower limb prostheses are renewed more often than upper limb prostheses.
7. The average life of a prosthesis is about 5 years.
8. The average hospitalization or absence from work is about 8 weeks for manufacturing, fitting and prosthetic training.
9. Both poliomyelitis and accidents, which produce the maximum number of disabled in India are preventable.

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Upper limb prosthetics for high level arm amputation

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Abstract

The paper covers the analysis of residual stump and upper body motions and their involvement in the patients' manipulatory functions. Attention is given to prosthetic techniques that do not restrict the residual motions. A single cable controlled hybrid arm prosthesis is presented with different individual cases. The kinetic structure and the control of prosthesis vary in each case to meet the individual manipulatory characteristic of the patient. The universal unconventional technique is presented which has modular possibilities seen from the kinematic point of view.

Introduction

In the last two decades development in arm prosthetics has focused on the application of external energy sources. There was great hope invested in the outcome of this work and resources were directed to support it. The rehabilitation practitioners however are very sceptical as they think of it as "research for research sake" and remember multi-functional arms which were noisy, machinelike, heavy and difficult to control. On the other hand attempts to restore manipulatory functions in cases of bilateral high level arm amputations, with a conventional body power approach, lead to completely unsuccessful solutions. Those patients are simply knitted together with different harnesses and straps. The worst conclusion from this controversy was the statement, that everything possible in the application of body power had been achieved and that progress in arm prosthetics would only come from the application of external power.

The consequence of this was that in the last decades work on body powered prosthetics did not attract attention and support. The above controversy has a more general background related to the question of what should be the appropriate strategy in rehabilitation engineering. To use as an example the loss of manipulatory functions caused by limb amputation, the question arises what is the correct role for technology in such a case? Should technology be used for substituting for lost functions or instead of this, should it be used only for supporting the residual manipulatory functions. These alternatives are not only different verbally, but mean quite different approaches. When supporting the residual functions, these functions cannot be treated as an unimportant remnant and must in no way be restricted by the applied technology.

Provision of manipulatory functions

Two of the three basic components of upper limb function, depicted in Figure 1, gripping and positioning, can be, with some degree of adequacy, substituted for by technology but the manipulatory component, which is in fact the fine coordinated, multi-axial, movement cannot as yet be restored by some prosthetic system. The only possibility is to provide a new function involving the residual part of the biokinetic chain

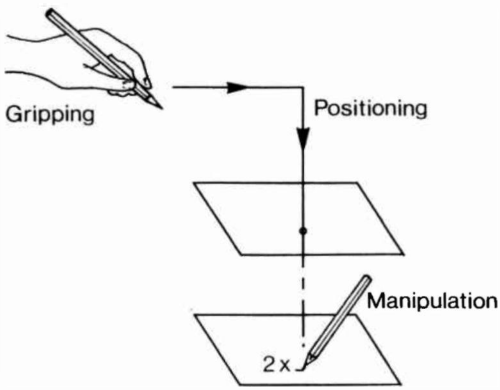

Fig. 1. Components of typical manual activity.

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of the upper limb and even the whole body (Fig. 2). These manipulatory functions can be performed by the arm-stump, shoulder girdle, thoracolumbar spine, and in case of bilateral shoulder disarticulation, by the cervical spine, as well as by the lower limbs. The most important condition for using this compensatory potential for manipulatory purposes is careful application of the technology needed for the restoration of gripping and positioning functions. The restrictions on stump and upper body movement must be minimized. There are two elements in such restrictions—the socket with the suspension and the control harness. The socket-suspension, in some cases of arm amputation, can be avoided by application of the revolutionary technique of angulation osteotomy (Marquardt and Neff, 1974; Marquardt, 1975). There is an essential difference between the above two types of restriction. The restrictions caused by the socket-suspension are passive in character, they act like simple range-of-motion limiters. On the other hand, the control harness restricts the stump and shoulder girdle motions in an active way, due to the interference or overlapping of manipulatory motions with prosthesis control movements. In most practical situations forward-flexion of the arm overlaps with flexion of the prosthetic elbow or operation of the terminal device. The only way to avoid this difficulty is by a radical simplification of the control harness and possibly by reducing it to a single strap, running over the shoulder girdle. It is possible to meet this demand by better use of the physiological control capabilities of upper body motions.

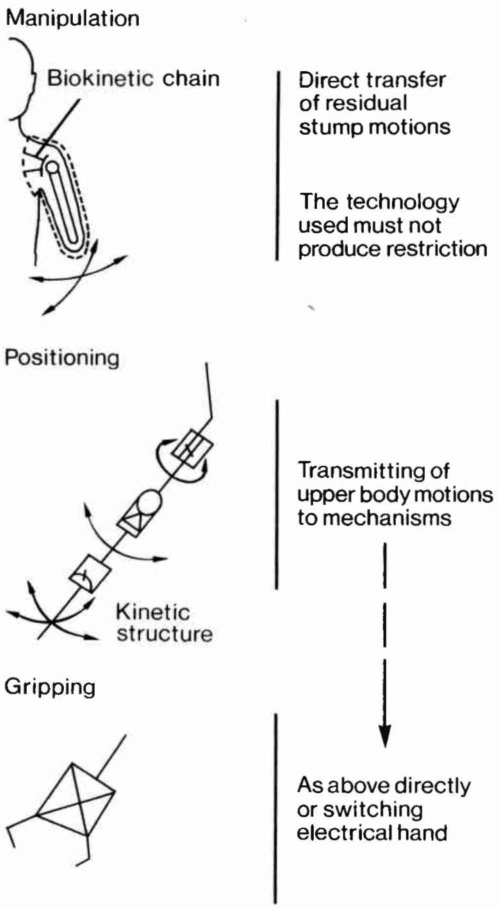

Fig. 2. Functional components of arm prosthesis.

Single cable control of hybrid arm prosthesis

In the past, body motions have been seen only as the mechanical energy source for driving the prosthetic mechanisms or alternatively as a control signal source for activating pneumatic or electric switches and mechanical locks etc. The new concept in the proposed hybrid—single cable controlled arm prosthesis—is the simultaneous powering and controlling of the prosthesis by means of only one body motion. This is possible due to the existence of many physiological control loops, external as well as internal. They offer the patient full control over the force, displacement, velocity and acceleration of the shoulder abduction movement, which is the most powerful motion within the amputee's upper body. This excellent control of body power and the application of this concept is the main reason for suggesting that body power may be seen in a new light when thinking about the future development of upper extremity prosthetics. Failure to recognize and apply the physiological capabilities of body power is the main reason for unsuccessful development in this field, in spite of the revolutionary development of technology. Basic biomechanical research will be needed before the potential capabilities of this system (some of which are summarized in Fig. 3) can be widely applied. Considering the advantages of electrical power in arm prosthetics, one application is obvious. The low power requirement for gripping and the ease of control of electrical power, indicated the application of an electrical hand in the hybrid arm prosthesis. The diagram of the prosthesis (Fig. 4) presents the concept of single cable control. The one upper body motion flexes the forearm, locks the elbow joint, switches the electrical hand in closing-opening and the same cable can control another function, for example the locking of a pronation/supination joint etc. These possibilities have not yet been fully applied to our present prosthesis.

The presentation in Figure 4 is not very clear and convenient for visualizing the multi-function prosthesis. As we are using only three types of conventional arm prostheses, there is no necessity for presentation of the prosthesis structure.

The introduction of multifunction hybrid arm prostheses having many variations of kinetic structure, as well as different types of control, necessitates a diagrammatic presentation which identifies the functional characteristics.

The proposed new presentation of prosthetic structure and control is achieved by overlapping two diagrams. The first is the kinematic chain, built up of prosthetic segments, represented by straight lines connected with three types of kinetic linkages as shown in Figure 5. The second

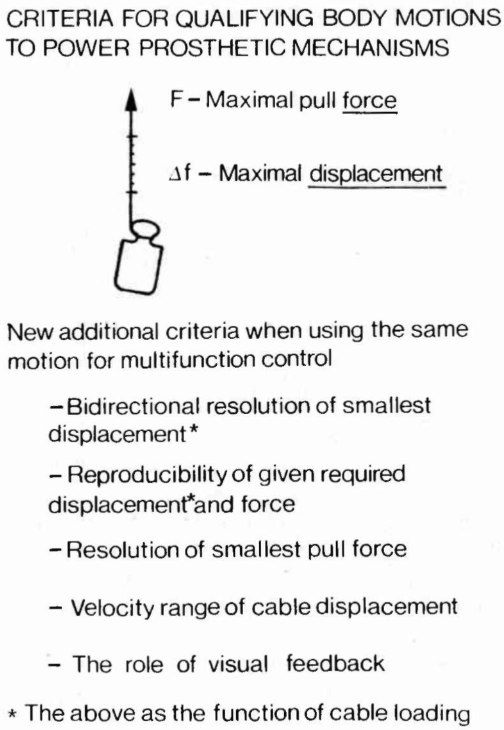

Fig. 3. Body power evaluation parameters.

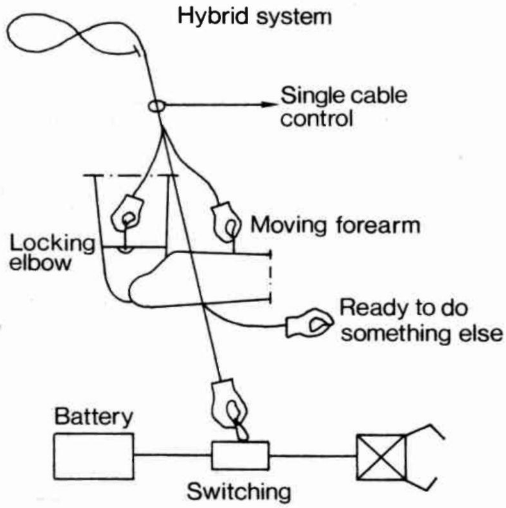

Fig. 4. Single cable multifunction control.

diagram (Fig. 6) displays the functions of the control cable when applied to the previously presented kinematic chain. Figure 7 shows the hybrid arm prosthesis using the newly introduced symbols. The principle of the single cable control of a hybrid arm prosthesis was developed in Poland (Ober and Piatek, 1977). The hybrid system is now available through Viennnatone, Austria.

A further example of innovation in arm prosthetics, making the use of the prosthesis more efficient and easy, is the device for adjustment of control cable length. Normally when standing, the patient makes use of the full range of forearm flexion, about 140°. The

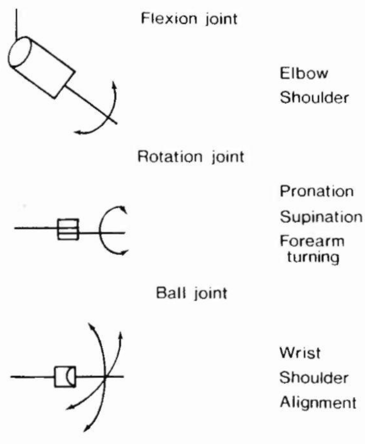

Fig. 5. Kinetic components of arm prosthesis.

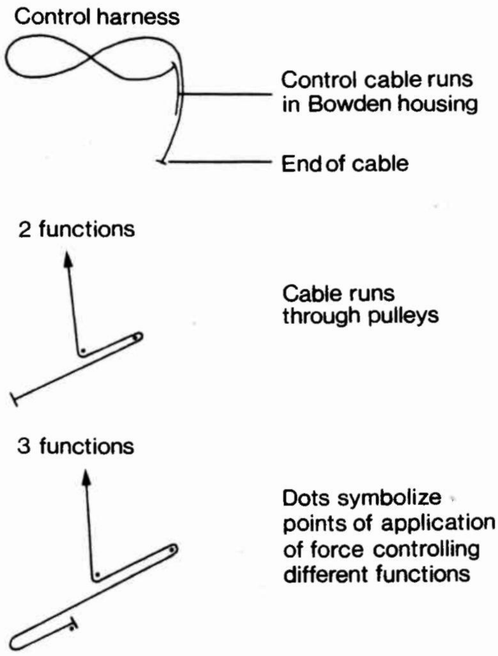

Fig. 6. Diagrammatic presentation of control harness.

situation changes when the patient is sitting working on a table surface. In this case forearm extension is limited by the table surface to about 50° and consequently nearly 70% of cable displacement is not used, however every time the patient operates the elbow, as well as controlling the grip, he must "take up" the unused, loose

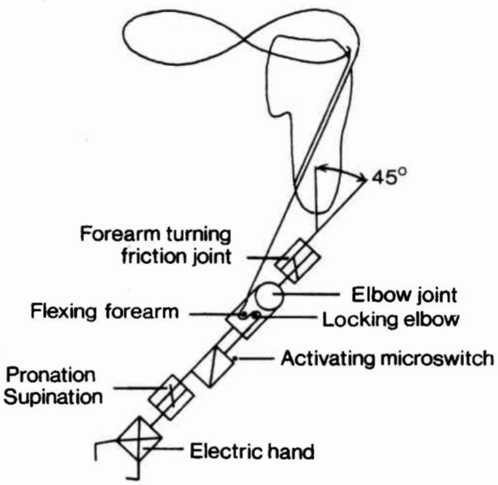

Fig. 7. Diagram of single cable control hybrid arm prosthesis.

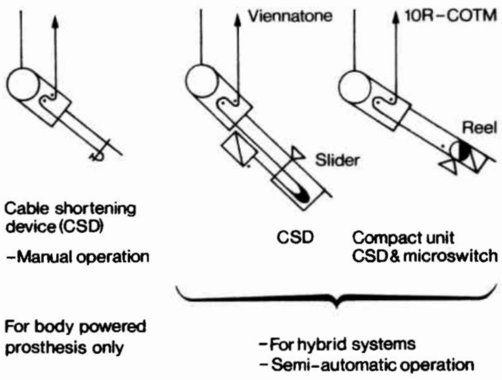

Fig. 8. Manual and semi-automatic operation of cable shortening device.

portion of the cable. The patient thus operates the prosthesis close to the end point of control movement. This is very inconvenient especially when sitting. A cable shortening device has been developed which takes up the loose portion of the cable. This is operated by hand or semiautomatically as shown in Figure 8.

Summary

The paper deals with the application of stump and upper body movement to manipulatory functions for the arm amputee. A system is proposed which ensures that the residual motions will not be restricted by the applied technique. A single cable controlled hybrid arm prosthesis is presented adaptable to different individual cases. The kinetic structure and the control of the prosthesis are different in each case, to meet the individual manipulatory characteristic of the patient. This universal unconventional technique which has modular capabilities from the kinematic point of view is presented, along with the design considerations which have a secondary role.

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New plastic joints for plastic orthoses

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Abstract

Plastic joints for orthoses have more advantages than metal joints. They are lightweight, noiseless comfortable to use, rust proof, corrosion free, and radiolucent.

Two types of plastic joints were developed by the authors, one for the ankle joint and the other for the knee joint, elbow joint or hip joint. Polypropylene was chosen as the joint material because of its appropriate flexibility and toughness.

Introduction

The use of plastic orthoses for lower limbs is increasing due to recent advances in thermoplastic materials and vacuum forming technique (Watanabe et al, 1976, a, b). The posterior leaf spring type (C.P.R.D., 1971) and spiral type (Lehneis, 1974) of ankle foot orthoses are widely used all over the world.

However, when regarding dorsiflexion or plantarflexion of the foot in these orthoses, the position of the mechanical ankle joint of the orthosis differs basically from the axis of the anatomical ankle joint i.e. the talocrural joint axis. Moreover, the corrective force of the posterior leaf spring type of ankle foot orthosis on varus or valgus deformity of ankle is weak. Therefore in many cases, one has no choice but to use a conventional ankle foot orthosis with lateral metal uprights and metal ankle joints.

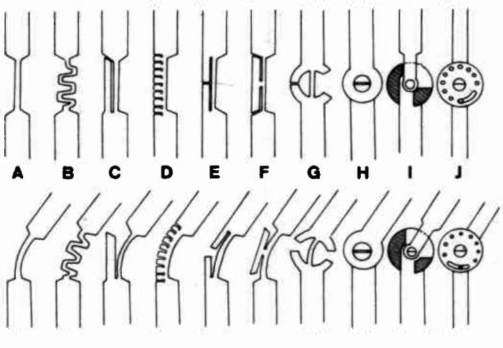

Fig. 1. Ten types of plastic joints produced for experimental use.

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Development of plastic ankle joint

Since plastic is lightweight, noiseless, good for cosmesis and radiolucent, we have been trying for several years to develop a plastic ankle joint that possesses a similar function to a metal joint (Watanabe et al, 1978).

Ten types of plastic joints (Fig. 1) were made for trial and for experimental use. All of these joints have some advantages and disadvantages, however, a rectangular shape with small flexible plastic bar and stopper(s) in the middle, has been chosen as the plastic ankle joint to develop (Fig. 1c, and Fig. 2).

The plastic material for an ankle joint must have appropriate flexibility, be good for cosmesis, have fairly good durability, be easily processed and inexpensive. In order to choose an appropriate material for the plastic ankle joint, experimental tests on seven types of thermoplastics were carried out. These were polyvinyl chloride, polycarbonate, polypropylene, low density polyethylene, acrylonitrile-butadiene-styrene resin, Ortholen, and Subortholen.

For flexibility the force necessary to bend the plastic piece was investigated. For distortion the restoration of form after a certain force had been applied to the plastic object was examined. A durability test was conducted by bending the plastic object more than 200,000 times cyclically. The result of these tests showed that polypropylene was the best material with respect to the above features.

Fig. 2. Top, ankle joints showing plantarflexion stop, dorsiflexion stop and stop motion. Bottom, plastic ankle-foot orthosis with plantarflexion stop.

By cutting a part of the stopper, the plastic ankle joint can be set with a dorsiflexion stop, plantarflexion stop, limited motion or free motion (Fig. 2).

More than forty ankle foot orthoses with these plastic ankle joints were prescribed for patients with hemiplegia, peripheral nerve palsy of the lower limbs and Achilles tendon rupture and good results were obtained.

Development of plastic knee joint and elbow joint

In order to develop the new plastic knee joint, the ten plastic knee joints already mentioned (Fig. 1) were evaluated. Unlike the ankle joint, smooth flexibility up to about 130 degrees is necessary for the knee joint. Therefore, the C, D, E, and F types are not suitable.

After screening the others carefully, the circular type (G) with a small flexible plastic bar in the centre was chosen for clinical test (Fig. 3), the material again being polypropylene. The flexion angle of the knee is set for each patient according to his knee pathology.

A smaller plastic knee joint can be used as an elbow joint in an elbow orthosis (Fig. 4) and a larger one as a hip joint in a hip orthosis.

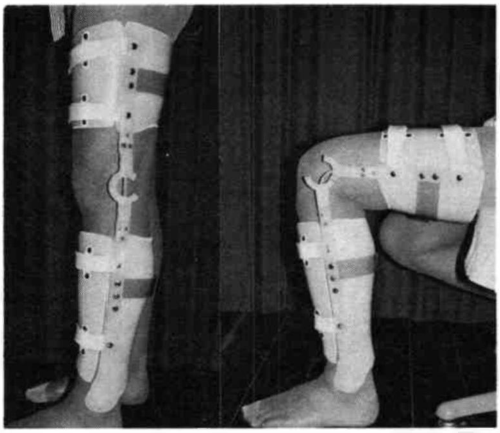

Fig. 3. Knee orthosis fitted with plastic knee joint.

Discussion

A plastic lower limb orthosis set with lateral uprights and plastic joints has an obvious advantage compared with a conventional orthosis set with metal joints or a plastic posterior leaf spring type orthosis. The newly developed plastic ankle joint has stoppers on both sides and is made to stop almost all ankle motion. It can be brought into wider application by cutting the stopper(s) in accordance with the patient's symptoms and type of disability allowing functional use of the ankle joint. Complete removal of the anterior stopper of the

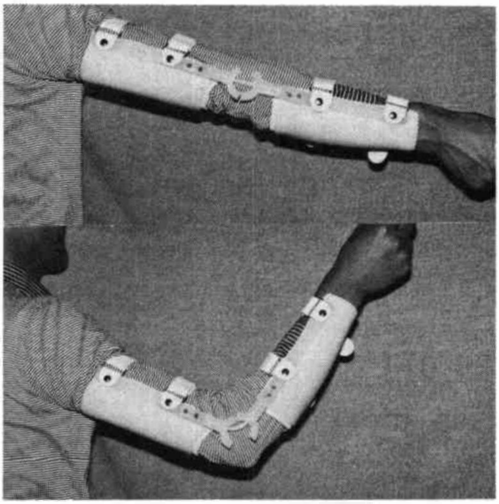

Fig. 4. Elbow orthosis with plastic elbow joint.

joint, for example, will be effective for the drop-foot condition as a plantarflexion stop ankle joint. By removing the posterior stopper, it becomes a dorsiflexion stop joint for pes calcaneus.

The plastic ankle joint is also effective for correcting varus or valgus deformity of the ankle because of its laterally positioned uprights.

The same principle can be applied to the plastic knee joint, elbow joint and hip joint. The desired flexion angle can be obtained by shaving the stopper of these joints appropriately.

Generally speaking, a lock mechanism is also necessary for the plastic knee joint and hip joint. Several locking methods (Fig. 5) have been tested but a completely satisfactory one has not been found. However this will be a theme for future research.

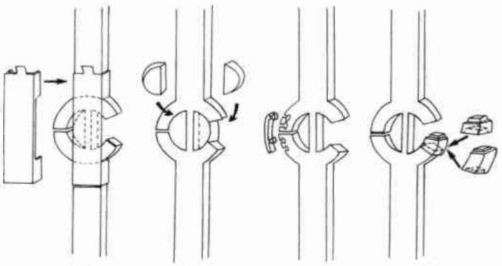

Fig. 5. Experimental locks for the plastic knee joint.

The plastic joints have been fitted to fracture patients as part of a functional orthosis (Fig. 6). They have also been fitted as quickly made orthoses or temporary orthoses with good results. Their one disadvantage is that they are less durable than metal joints.

Summary

The main features of the newly developed plastic joints for plastic orthoses are that they are lightweight, noiseless, comfortable in use because of the coincidence of the joint axes, corrosion free, and radiolucent.

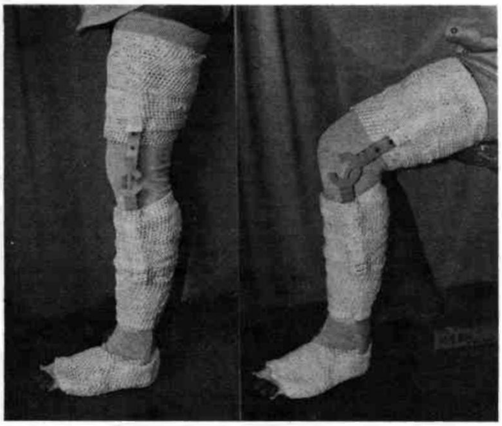

Fig. 6. Functional orthosis with plastic knee and ankle joints.

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Orthoses for functional treatment of ankle fractures. A preliminary report

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Abstract

This report examines the orthotic management of patients with ankle fractures. Two functional orthoses that allow movement in the talocrural joint are described. The results of using these orthoses on ten patients are discussed.

Introduction

Immobilization of an extremity, for example after a fracture, has certain unwanted effects. Osteoporosis arises (Enneking and Horowitz, 1972; Mattsson, 1972) and cartilage changes similar to those described at an early stage of osteoarthritis take place in the joint (Enneking and Horowitz, 1972; Langenskiöld et al, 1979). Changes also occur in ligaments and joint capsule (Finsterbush and Friedman, 1973; Videman et al, 1976; Langenskiöld et al, 1979), in synovial membrane (Finsterbush and Friedman, 1973), in muscles (Mattsson, 1972; Finsterbush and Friedman, 1973) and in blood flow (Semb 1969).

So-called functional fracture treatment has been used in different types of fractures. It favours fracture healing but is also said to have beneficial effects on muscle function, joint mobility and time of rehabilitation (Sarmiento, 1967 and 1970; Sarmiento, Cooper, Sinclair, 1975; Sarmiento, Pratt, Berry, Sinclair, 1975; Mooney et al, 1970).

However, Andersson and Nilsson (1979) did not find any difference in bone mineral loss in patients with tibial shaft fracture treated with or without weight-bearing and function.

As far as we know, functional treatment has not been applied to ankle fractures which is why we started an investigation. This report only describes the orthoses used and the preliminary clinical impressions.

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Material and technique

Our purpose, in a number of operated ankle fractures with supination—outward rotation injuries stage II–IV (Lauge-Hansen, 1942), was to compare cases treated postoperatively with conventional lower leg plaster and cases treated with an orthosis allowing movements in the talocrural joint.

Classification of the fractures was made with the aid of Roentgen pictures and operative findings. Routine operative method was fixation of the fibular fracture with encircling wire/s. The fibula was secured against the tibia with Wiberg's staple/s and on the medial side pin/s or a screw have been used, or alternatively ligament suture (Cedell, 1967). Treatment of a possible posterior tibial fracture was individualized depending on size of fragment and degree of dislocation.

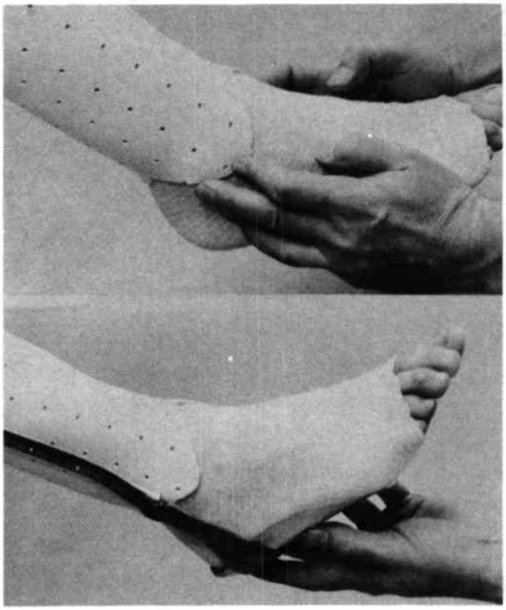

Fig. 1. Top, the Isoprene R plastic shell is carefully modelled around the malleoli. Bottom, metal hinges and footplate are attached.

Postoperatively the patient has been supplied with a split lower leg plaster. After a fortnight the plaster was removed and replaced with an irremovable orthosis permitting full dorsal and plantar flexion in the talocrural joint and full mobility in the knee and the toes including metatarsophalangeal joints.

Pronation and supination of the foot was almost impossible.

Two orthoses with the same functional principle have been tried out. For stability purposes the orthosis was originally made of plastic (Isoprene R. Johnson and Johnson) with metal hinges and foot plate, the foot plate being a semi-manufactured arch support. First of all a lower leg plastic shell was made and carefully modelled around the malleoli (Fig. 1, top). After the foot plate had been fixed to the metal hinges (Fig. 1, bottom) it was then fastened to the plastic shell and the foot with plastic slabs (Fig. 2).

The other type of orthosis was made from plaster using a prefabricated plastic hinge with a foot plate (Fig. 3). The manufacturing process is essentially the same as the first orthosis described. The mobility of the ankle can be seen in Figure 4.

The second orthosis is easier to make and is also much cheaper. The cost of the plastic orthosis is about 1600 Swedish crowns while the alternative costs only 300.

Fig. 2. Footplate and hinges are fixed around the foot with plastic slabs.

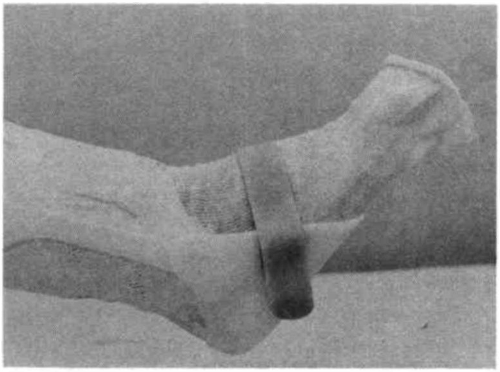

Fig. 3. Plaster shell orthosis with prefabricated plastic ankle with hinges for the talocrural joint.

The patients have been instructed and encouraged to move the ankle as much as possible. Clinical and Roentgenological checks have been made comparatively often and if required the orthosis has been adjusted or exchanged. After 6 (stage II–III) or 8 (stage IV) weeks, depending on the type of fracture, the orthosis was removed and the patient allowed

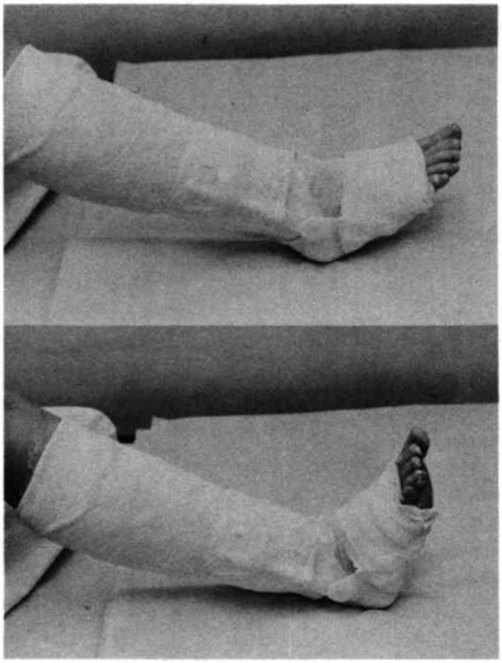

Fig. 4. The completed plaster shell orthosis showing the mobility of the talocrural joint.

full weight-bearing. The clinical and Roentgenological checks continued until at least 10 or 12 weeks, respectively, after the operation.

Results

So far 10 patients, 5 men and 5 women, have been treated. All patients have expressed their satisfaction. They have been easily taught to practise mobility and supervision by a physiotherapist has not been necessary. The mobility training has caused no or slight pain.

Owing to discomfort, mostly from dorsum pedis, the orthosis was in some cases exchanged or adjusted. In no case pressure sores appeared.

The wound healing has been uncomplicated and dislocation of the fractures has not occurred. Clinical results and Roentgen examinations have not given any reason to suspect pseudarthrosis. Based on long experience of the results of fixation using conventional lower leg plaster we have the firm clinical impression that patients using an orthosis have a faster course of rehabilitation.

Discussion

It appears comparatively safe to conclude that with the above mentioned operative method and orthoses certain ankle fractures can be allowed early mobility training of the talocrural joint without disadvantages in position and healing of the fracture/s. Presumably this treatment is advantageous.

It is quite likely that the same or similar treatment can be applied to other types of ankle fractures. However, it should probably not be used in elderly people where osteoporosis may diminish stability of the osteosynthesis. In these cases another operative technique can of course be used.

The orthoses described are relatively expensive and probably unnecessary stable. The reasons for the present constructions are firstly a wish to avoid a setback in the beginning of an investigation and secondly that the next planned step in the investigation is to be weight-bearing in the orthosis.

When further experience has been gained, treatment can probably be more individualized, for example by having a simpler orthosis, applying the orthosis immediately after operation or abandoning external fixation completely. The role which open reduction and osteosynthesis should play in the treatment of ankle fractures is not yet settled.

The investigation will continue and comparisons between the possible effects of different methods of treatment will be made with clinical, Roentgenological and clinical-physiological methods.

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Evaluation pertinent to the gait of children with myelomeningocele

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Abstract

Many children with spina bifida who require long term and costly clinical management and rehabilitation are seen at the Ontario Crippled Children's Centre (OCCC). The aims of orthopaedic management can best be achieved through an "effective" assessment of each child, which guides the provision of conservative and operative treatment throughout infancy and childhood.

Surgery and orthotic aids are the major ways available to correct or prevent the formation of orthopaedic deformities. At present the only way of assessing an orthosis is to wait and see if it improves function or prevents a deformity.

This paper addresses pilot work undertaken to elucidate the factors which contribute to deformity progression in the lower limbs. The intent was to measure these factors in as cost effective and non-invasive a manner as possible and utilize the information gained in orthotic assessment and development for these children.

The initial goal of the study was to quantify the effect of a prescribed orthosis upon the gait of each child. Some 15 children with a lumbar or sacral level myelomeningocele have been examined in a total of 59 trials. The data collection process involved a three stage protocol implemented by the orthopaedist, physical therapist and engineer. A comprehensive clinical examination, a visual gait assessment from video-tape and an instrumented gait assessment were performed in the OCCC gait laboratory. Assessment criteria were proposed and extracted from the data collected. These criteria were posed after examining the frequency distribution of certain features of gait in the study group. A case study illustrating the application of the assessment is provided.

In examining the performance and influence of an orthosis upon a child's gait situations were identified in which no clear statement of "best" or "better" could be made. The value of the assessment was to point out the trade-offs and *relative* merits of selected orthotic options. By combining the objectivity of data acquired with gait analysis instrumentation with the subjective, but tangible, skills of the experienced observer, significant improvement in performance of the assessment is likely.

Introduction

The Ontario Crippled Children's Centre (OCCC) is a provincial rehabilitation centre for children up to the age of eighteen years. A multidisciplinary team exists at OCCC and the Hospital for Sick Children (HSC) to provide for the clinical management and rehabilitation of the spina bifida affected child. The most severe and frequent form of this disorder is represented by the child with a myelomeningocele which causes extensive problems. The most disabling problem is the effect upon the spinal cord which almost always results in some degree of paralysis to the lower limbs, the bladder and the bowel. The higher the spinal cord is affected the greater will be the total management problem, due to the high probability of associated malformations and secondary complications developing. A comprehensive description of approaches to orthopaedic management has been published (Menelaus, 1980).

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Ambulatory status

A study at OCCC and HSC reported and conducted by DeSouza and Carroll (1976) examined available data to indicate the important factors in predicting the eventual ambulatory status of a child with a myelomeningocele. They found that, for their series, the ambulatory status seemed to depend upon (in order of priority):

(1) The neurological level of lesion.
(2) The motor power present at the neurosegmental level.
(3) The extent and degree of orthopaedic deformities present in the spine and lower limbs.
(4) Age, height and sex of the patient.
(5) Motivation.
(6) Spasticity.
(7) Design and effectiveness of orthoses.
(8) Surgical procedures.

From these determinants it is clear that once a spina bifida child survives the first few months, it is possible to have realistic goals for the child's ambulation abilities; these being largely governed by the 'uncontrollables' of lesion level and motor power. For any child, it is clear that ambulation goals may be strongly governed by the extent and degree of the orthopaedic deformities present.

Orthopaedic management

The aims of orthopaedic management are:

a) To correct deformity, to maintain its correction, to prevent recurrence and to avoid production of other deformities.
b) To obtain the best possible locomotor function.
c) To prevent or minimize the effects of sensory and motor deficiency.

The achievement of these interdependent aims depends upon a correct and adequate assessment at "suitable" intervals, together with conservative and operative treatment as indicated. Surgical and orthotic treatments are complementary in correcting deformities and aiming to prevent others from developing.

Factors in the causation of deformity

The factors responsible for deformity in spina bifida are:

(1) Co-existent congenital malformation.
(2) Unbalanced muscle activity.
(3) Gravitation (external force) effects.
(4) Abnormal bone growth or fractures.

The commonest cause of deformity appears to be unbalanced muscle activity. Deformity is progressive and proceeds more rapidly in infancy and early childhood.

The sequence of affected structures is likely to be;

i. Muscles and tendons
ii. Ligaments and soft tissues
iii. Bone.

Bony deformity develops only months after the initiation of the "deforming force", therefore, the effectiveness of a treatment plan (whether orthotic or surgical) only becomes apparent after an unfortunate delay. Surgical treatment will not be successful in maintaining the correction of a lower limb deformity (if the deforming force still exists) without complementary orthotic fitting.

Orthotics

Having corrected any pre-existing problems by surgery, orthoses are used to prevent deformities from recurring. With an orthosis we can state some realistic goals for its use. (Henderson and Lamoreux, 1969). All an orthosis may achieve is to:

(a) Relieve limb areas which are load sensitive.
(b) Control motion at a joint with respect to range and direction.
(c) Maintain the shape of body tissues in spite of the activity of deformity producing forces.

In addition to these functional goals an orthosis has some acceptance constraints which concern overbracing, cosmesis, cost and effect upon the child's endurance.

With the AFO (ankle-foot orthoses) systems applied to the children in this study several stages are used in their manufacture.

(a) A plaster cast of the limb is made with some correction of foot and ankle position if both possible and necessary.
(b) Rectification and finishing of cast.
(c) Vacuum forming of a thermosetting plastic to the shape of the cast.
(d) Trimming and fitting the AFO to the child and ensuring compatability with shoe type and shoe sole contour.

Aims of the study

The aim was to investigate the nature of an assessment protocol which could enhance the identification of an undesirable orthotic fitting for the ambulatory child. The initial efforts are described here.

The initial goal was to quantify the effect of an orthosis on each child in the study group. This orthosis had been prescribed and fitted by the regular clinic team. After describing the effect of the orthosis provided for each child, criteria were developed to judge the relative value of the observed differences and provide a basis for orthotic improvement.

Subjects

Fifteen children have been examined so far in a total of 59 trials. All the children seen were selected from within the caseload of the Spina Bifida Orthotic Clinic of OCCC and had a low lumbar or sacral level myelomeningocele (9 female, 6 male). All these children were independently mobile with bilateral polypropylene AFO's. The youngest child was 2 years and the eldest 11 years of age (mean 6 years).

Data collection process

The data collection process involved three stages implemented by the team of orthopaedist, physical therapist and engineer:

(1) A comprehensive clinical examination.
(2) A subjective gait assessment from video tape.
(3) An instrumented gait assessment in the laboratory.

The clinical examination

The clinical examination was designed to detect what could be considered as the individual child's locomotor function deficits; including those apparent from an observation of;

(a) Clinical history pertinent to surgery and orthotic aids.
(b) Muscle tone and power in the lower limbs.
(c) Passive ranges of joint motion in the lower limbs.
(d) Spinal alignment and rigidity in frontal and lateral views (sitting and standing).
(e) Standing posture.

In performing this examination the approach was taken that only those features illustrative of a deficit would be noted. This allowed some reduction in the volume of data recorded whilst (hopefully) retaining information of value to the study. As in any "hands on" examination, subjective judgement errors are possible. In this study, group discussion of problems which arose was designed to minimize bias.

Subjective gait assessment

The intent in this section was to utilize the pattern recognition powers of the trained observer. The process allowed the gait of a child (anterior posterior (AP) and lateral (L) video views) to be observed and dissected in a guided fashion. A subjective analysis form, evolved from one used at the Children's Hospital Gait Laboratory in Boston, USA, was utilized (Simon, 1980). The form was scored independently by the orthopaedist or therapist and the engineer. Scoring consisted of indicating on the form the presence of a gait abnormality and the phase of gait in which it occurred.

It should be emphasized here that the aim was not to try and make the gait of these children necessarily normal (which was very likely unrealistic). However, by comparing the assessment forms completed for different orthotic situations, it was hoped to detect the changes in a child's gait which are symptomatic of these introduced orthotic changes. The gait changes observed could then be used to guide the extraction of objective data from the more formal instrumented gait assessment.

Instrumented gait assessment

The gait laboratory at the OCCC has the space and equipment to collect all pertinent data during gait assessment. A PDP 11/34 computer and peripheral equipment provided for the interactive acquisition, manipulation and display of multiple signals.

A 9261A Kistler force platform provides ground reaction force data and was used in conjunction with two orthogonally positioned video cameras. The two camera views were blended on a single monitor and recorded on a time-lapse video tape recorder. This recording could be replayed at varying speed, or field by field. Grey scale copies were made of each field using a Tektronix 4632 hard copy unit. The set of hard copy papers were then digitized using a Tektronix interactive plotter (4662) interfaced to a Tektronix 4051 computer. When digitization is complete the kinematic data may be transmitted to the PDP-11 computer via an RS232 interface for combination with the force platform data. A light beam system was used to calculate average walking velocity along the laboratory. A document describing the gait laboratory instrumentation and configuration is available from the authors.

Methodology

With each subject the clinical examination would be conducted by the therapist and orthopaedist immediately prior to the gait evaluation. As many trials as possible were conducted with the ground reaction forces, 3D video recording and average walking velocity recorded for each trial.

Skin surface reflective-markers were used to define points of anatomical interest. Stick markers were placed at the sacrum and lateral knee joint line. Spot markers were located at the anterior superior illiac spines (ASIS), the greater trochanters, tibial tubercle, proximal to the lateral malleoli and heel and toe. Joint centre positions at the hip, knee and ankle were predicted by relating these known marker positions to physical measurements and prior standing X-rays if these were available. "Normal" data for the prediction of joint centres from surface measurements cannot be realistically used; particularly at the hip. These joint centre predictions were used for the "stick" man representations of Figure 5. The video system was calibrated and ready prior to the child's arrival. The video records were taken and retained both for visual analysis and for correlation with the force platform data.

Total test time was of the order of 20–30 minutes. Force platform data were generated within seconds of a trial in order to verify success or failure. The video records were monitored and reviewed very briefly for each test.

With each child at least two situations, (with or without the prescribed orthosis) were considered and multiple trials conducted for each situation to ensure that comparative data were available.

Discussion of methodology

Speed of testing soon proved to be very important for the successful completion of the study. Many of the children had very short attention spans. It took considerable ingenuity to keep a child amused whilst data were collected and therefore long delays between walking sessions were unacceptable, except if the child appeared to be becoming too tired to continue. Evidence of tiring was detected by monitoring walking velocity and noting verbal complaint. On the basis of experience the use of a fast method of data collection and display would seem essential. For example, it was endeavoured to conduct repeat walking trials within 30 seconds of the previous one.

The child was not told of the existence of the force platform and was instructed to walk toward a toy placed across the walkway and located on a path which would cross the force platform. Initial experiences showed the importance of not indicating the presence of the force platform because this would often lead to a deliberate walking "performance" by these children. Demonstrations of frustration by the research staff, because the child missed contact with the force platform, were undesirable.

Results

Introduction

Having compiled fairly complete data concerning the gait of these children several steps were envisaged;

(a) Compare the gaits of each of these children in the braced and unbraced situations.
(b) Using the observed differences pose some tentative assessment criteria which could best discriminate between braced and unbraced situations.
(c) Apply these assessment criteria to each child to quantify the differences between the braced and unbraced situations and comment on the benefits to the child of these differences.
(d) Make specific orthotic modifications guided by these assessments when possible and repeat the evaluation.

Braced and unbraced gait

The subjective assessment forms were used to illustrate some generalized features of the study group with respect to the effect of the AFO's upon gait. All of the children were capable of unbraced gait for the short period of testing.

The frequency of observation of the chosen gait deviations are shown with respect to their occurrence in a particular phase of gait. Unbraced and braced situations are tabulated in Figures 1 and 2. The numbers in the table represent the percentage of children in the study group who were subjectively judged to demonstrate a particular gait deviation. Figure 3 illustrates the difference between the braced and unbraced situations. The largest negative values indicate the largest reductions in the percentage of children demonstrating a gait deviation. Positive values indicate an increase in the percentage of children demonstrating a particular deviation.

The most significant improvements correlated with the addition of an orthosis are in the control of foot and ankle position and the extent of flexion at the knee and the hip during the whole gait cycle. Very slight generalized improvement is noted with lordosis and anterior/posterior trunk position with the addition of the AFO, although there is a significant increase in the extent of lateral trunk motion.

Additional features in the unbraced situation which are not represented in the figures were considered to be:

FREQUENCY OF OBSERVATION OF GAIT FEATURES
IN THE BRACED SITUATION
(AS PERCENT OF POSSIBLE NUMBER OF AFFECTED LIMBS)

MOTION		INITIAL CONTACT	WEIGHT ACCEPT.	MID STANCE	WEIGHT RELEASE	EARLY SWING	LATE SWING
TRUNK	Anter/Poster lean	41	41	41	41	41	41
	Right/Left lean	36	45	45	45	45	36
	Rotation	5	5	5	0	0	5
PELVIS	Lordosis	64	64	64	64	64	64
	Trendelenburg	0	0	0	0	0	0
HIP	Flexion	14	14	14	14	14	18
	Abduction	0	0	0	0	9	5
	Adduction	14	23	23	0	0	5
	Inter. Rot.	14	18	23	0	0	9
	Exter. Rot.	9	9	9	23	41	14
KNEE	Flexion	45	45	45	45	45	50
	Hyperextension	0	0	9	0	0	0
	Tibial Progression	0	5	9	0	0	0
	Valgus	0	23	18	0	0	0
	Varus	0	0	0	0	0	0
ANKLE	Dorsi Flexion	0	0	0	0	0	0
	Plantar Flexion	5	0	0	0	0	0
	Eversion	0	0	0	0	0	0
	Inversion	0	0	0	0	9	0
	Inter. Rot.	31	27	27	27	36	31
	Exter. Rot.	18	18	18	41	45	18

Fig. 2. Generalized motion assessment—braced.

FREQUENCY OF OBSERVATION OF GAIT FEATURES
IN THE UNBRACED SITUATION
(AS PERCENT OF POSSIBLE NUMBER OF AFFECTED LIMBS)

MOTION		INITIAL CONTACT	WEIGHT ACCEPT.	MID STANCE	WEIGHT RELEASE	EARLY SWING	LATE SWING
TRUNK	Anter/Poster lean	45	45	45	45	45	45
	Right/Left lean	27	27	32	27	32	27
	Rotation	0	0	0	0	0	0
PELVIS	Lordosis	68	68	63	68	68	68
	Trendelenburg	0	0	0	0	0	0
HIP	Flexion	45	45	40	23	54	54
	Abduction	0	0	0	9	31	9
	Adduction	32	27	14	0	0	40
	Inter. Rot.	27	27	14	0	0	18
	Exter. Rot.	9	9	9	40	31	14
KNEE	Flexion	64	77	77	77	86	86
	Hyperextension	0	0	0	0	0	0
	Tibial Progression	0	0	32	0	0	0
	Valgus	0	36	32	0	0	0
	Varus	0	0	0	0	0	0
ANKLE	Dorsi Flexion	18	14	14	9	5	5
	Plantar Flexion	41	18	0	9	45	27
	Eversion	36	36	36	36	41	41
	Inversion	0	0	0	0	14	5
	Inter. Rot.	27	27	18	23	18	18
	Exter. Rot.	32	32	32	45	36	36

Fig. 1. Generalized motion assessment—unbraced.

PERCENT DIFFERENCES IN THE FREQUENCY OF
OBSERVATION .... BRACED vs UNBRACED

MOTION		INITIAL CONTACT	WEIGHT ACCEPT.	MID STANCE	WEIGHT RELEASE	EARLY SWING	LATE SWING
TRUNK	Anter/Poster lean	-4	-4	-4	-4	-4	-4
	Right/Left lean	9	18	13	18	13	9
	Rotation	5	5	5	0	0	5
PELVIS	Lordosis	-4	-4	1	-4	-4	-4
	Trendelenburg	0	0	0	0	0	0
HIP	Flexion	-31	-31	-26	-9	-40	-36
	Abduction	0	0	0	-9	-22	-4
	Adduction	-18	-4	-9	0	0	-35
	Inter. Rot.	-13	-9	-9	0	0	-9
	Exter. Rot.	0	0	0	-17	10	0
KNEE	Flexion	-19	-32	-32	-32	-41	-36
	Hyperextension	0	0	9	0	0	0
	Tibial Progression	0	5	-23	0	0	0
	Valgus	0	-13	-14	0	0	0
	Varus	0	0	0	0	0	0
ANKLE	Dorsi Flexion	-18	-14	-14	-9	-5	-5
	Plantar Flexion	-36	-18	0	-9	-45	-27
	Eversion	-36	-36	-36	-36	-41	-41
	Inversion	0	0	0	0	-5	-5
	Inter. Rot.	4	0	9	4	18	13
	Exter. Rot.	-14	-14	-14	-4	9	-18

-ve values indicate improvement
+ve values indicate deterioration

Fig. 3. Generalized influence of AFO's.

(1) A limited ability to change walking velocity.
(2) The use of a wide base of support during double support phase of gait.
(3) A limited endurance.

Generalized data can only have limited value in guiding treatment for an individual child. This is because many things can contribute to gait abnormalities in the individual child. Menelaus (1980) quotes obesity, defective eyesight, sensory, cerebral and cerebellar factors as being responsible for gait abnormalities, in addition to the more obvious physical difficulties. However, these generalized data allowed the posing of tentative criteria to assess the change in gait of an individual child in response to an orthotic change. In addition, these data allowed a realistic view of the limits of likely success with any orthosis prescribed.

Assessment criteria

The intent was to define an assessment, sensitive to the relative merits of orthotic options for the *individual* child, but with sufficient scope for general application. Because of this, judgment of merit must be made sufficiently broad to suit the wide range of problems of these children.

The generalized features above, led to the following foci for assessments:

(1) Dynamic ranges of motion employed at the hips, knees and ankles (as appropriate) during gait.
(2) External forces and moments (magnitudes and directions) at the hips and knees.
(3) Stance/swing phase temporal ratios.
(4) Subject walking velocity and variability for the trials recorded.
(5) Subject dynamic stability. Judged by a composite factor of width of base of support, ability to change walking velocity and the tendency to unstable modes at the lower limb joints.
(6) Amount of lateral trunk sway.
(7) Endurance.

The emphasis placed on any one of these foci and their criteria will depend upon the individual treatment goals of each individual child. The use of the assessment is best described with a case study.

Case study

C.W. is a male, 6 years of age with a L4 neurosegmental level. He has a developmental and educational level appropriate for his age. He is a community ambulator fitted with bilateral polypropylene AFO's which have a high resistance to flexion and torsion.

In grading passive joint ranges he had no particular problems with good limb alignment. His motor power (graded 0–5) demonstrated hip flexors, adductors, quadriceps at 5; medial hamstrings at 4; hip extensors, abductors, lateral hamstrings, dorsiflexors, plantarflexors, invertors and evertors at grade 0.

Spinal alignment was good with a slight lumbar lordosis in observing him in standing. His AFO's were set at neutral ankle with slight forefoot supination and were paired with rocker bottom shoe modifications. Gait data were collected and the assessment conducted by the team.

The observations of braced and unbraced gait are depicted in Figure 4. The application of AFO's introduced some predictable and observed gait changes.

Considerable improvement during the weight acceptance phase was apparent, with better control of ankle and foot position with reduced hip adduction and internal rotation. The lack of hip abductor power meant that the trunk motion, apparent hip adduction and internal rotation during single support phase, could not be eliminated by the addition of the AFO.

There was an apparent valgus motion at the knee in the weight acceptance and midstance phases of both legs with or without the AFO's.

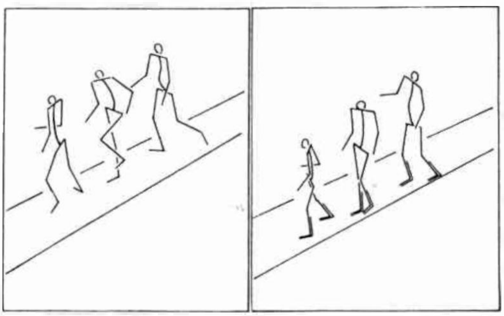

Fig. 4. Case study, influence of prescribed AFO's. Left unbraced, Right braced, showing improved foot and ankle position; reduced hip internal rotation and improved arc of motion at hip and knee.

Objective differences were defined using our assessment criteria. The most striking changes were as follows;

(a) With the addition of AFO's the hip range of useful motion increased by an average of 12 degrees (5 trials).

(b) The knee range of motion remained the same although the arc of that motion changed and there was some 10 degrees less knee flexion at foot contact.

(c) Stability was judged subjectively to increase from '2' to '4' (on a scale 0–5).

(d) The stance/swing ratio for left-right became more even (1·43 to 0·97).

(e) The average walking velocity of choice was significantly increased with the addition of the AFO's.

The stick diagrams shown in Figure 5 illustrate examples of the instantaneous positions of the lower limb segments together with the magnitude and direction of the ground reaction forces. In the interpretation of these diagrams particular attention was given to the peak magnitudes of created moments and to the phases of gait when these moments were transitional from one mode to another; for example, the point of transition from a moment tending to flex the knee to a moment tending to extend it.

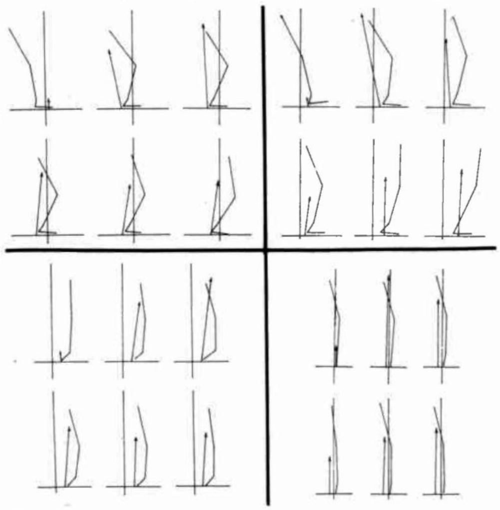

Fig. 5. Case study, top left, a, lateral view unbraced. Bottom left, b, frontal view unbraced. Top right, c, lateral view braced. Bottom right, d, frontal view braced. Seven fields per second.

The first step was to chart the directional tendency at a joint due to the external moments. These were then compared with the likely ability of the child being able to balance these moments with their muscles. Undesirable tendencies could then be identified. For example with C.W., forces attempting to flex the hips would not be greatly resisted by the hip extensors because they were found to be weak upon physical examination.

In the *unbraced situation* (Fig. 5, top and bottom left) the hip moments created by external forces were primarily trying to extend the hip which could be controlled by the hip flexor muscles. Close to midstance the external hip forces produced a low extension moment. Compensatory body movements would always ensure that a flexion moment is never reached as extensor muscle activity cannot be produced to control it. Both limbs were examined but only the right limb is shown in the figures.

In the frontal view the heel, ankle and foot are in poor alignment and are unprotected. The centre of pressure of the ground reaction forces was on the lateral border of the foot and the external forces at the knee were attempting to create a valgus stress at the knee.

In the *braced situation* (Fig. 5, top and botom right) the ground reaction forces are attempting to extend the hip and flex the knee (situations which can be handled by active muscles). In the frontal view the heel, ankle and foot are in good alignment and are protected but the ground reaction forces still act to create a valgus stress at the knee.

In summary, the hip external forces and moments were significantly *higher* but at the knee no significant change was apparent with the addition of the AFO.

Discussion and conclusions

Interpretation of criteria and recognition of undesirable states

The increased magnitudes of the hip external forces and moments may be considered a result of the child's ability to walk faster and with longer strides when fitted with AFO's. The fact that the valgus stress at the knee was not relieved by the AFO was recognized as an undesirable event. Stability was greatly improved with the AFO's. Lateral trunk motion was not significantly changed by the addition of the

AFO's. The value of the assessment in this case was to demonstrate the value and limitations of the prescribed AFO's.

In examining the values of the assessment criteria and comparing braced and unbraced situations it became clear that orthotic fittings often involve compromise. In this case study the addition of the AFO significantly improved the child's mobility and stability on the date of examination. However, the force actions at the knee and hip are still acting in a manner in which progressive deformities are likely. The recognition of these facts leads to the proposal of some orthotic modifications. It is wished to reduce the undesirable forces without sacrificing stability, mobility and endurance to any great degree. In practical situations it is also necessary to consider the additional constraints of cost and patient or parent acceptability. The strategy applied by the orthotist in this case was to change the shoe sole contour to bring the ground reaction forces medially during stance phase and thereby reduce the valgus stress at the knee. The stability and more obvious gait improvements need not be sacrificed in an attempt to reduce the likelihood of deformity development.

In further developing this assessment to consider higher levels of spinal lesion it is clear that the emphasis placed on assessment of endurance and stability will increase. The work of Stallard and Rose et al. (1978) is interesting in this regard and is being studied with a view to incorporating their methodologies, when appropriate, into the assessment.

Conclusion

In conclusion it should be emphasized that in many cases operational constraints make the implementation of an orthotic specification difficult or impossible using routine fabrication methods. For this reason the assessment system described cannot be instantly transplanted into the routine clinical process. It is expected however, that it can provide clear guidelines for orthotic research and development as well as making us better aware of how to present gait information to the clinical decision-maker. The best course of action for an individual child can then be chosen with cognizance of what can be realistic in terms of his or her ambulation.

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Incidence of major amputations following gangrene of the lower limb

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Abstract

The incidence of major amputations following gangrene of the lower limb during the period 1971 to 1979 in the county of Copenhagen was calculated. The overall incidence was found to be about 0·3 per thousand inhabitants over 40 years of age, the ratio of men to women was 2:1. The incidence was found to increase exponentially with age. The amputation-rate of the lower limb did not change during the 8 year period.

Introduction

Only a limited number of studies have been carried out to determine the incidence of major amputations of the lower limb due to vascular gangrene, even though the incidence was found to increase steadily from the Forties to the Sixties in Sweden (Hansson 1964, Hierton and James 1973) and despite the fact that the group of elderly amputees represents an increasingly important medical and socio-economic problem.

This study deals with the incidence of amputations due to gangrene of the lower limb in a suburban area in the Seventies.

Patients and Methods

During the period April 1st 1971 to March 31st 1979 amputation of the lower limb was performed in 307 patients over 40 years of age. The age and sex distribution is shown in Figure 1. The mean age was 70 years (the range being 40–94). Males with a mean age of 68 years (42–90) constituted 58 per cent (179/307) of the series, while females were on average 5 years older, their mean age being 73 years (40–94).

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The cause of amputation was gangrene due to chronic arteriosclerotic vascular disease or acute thrombosis in 75 per cent of cases (230/307), the remainder had concomitant diabetes mellitus. The primary level of amputation was above-knee (AK) in 33 per cent of cases (101/307), through-knee (TK) in 21 per cent (66/307) and below-knee (BK) in 46 per cent of cases (140/307).

In the suburban area studied there was a total of 1,027,867 inhabitants over 40 years of age resident during the 8 year period. This is equivalent to a background population of approximately 130,000 inhabitants. The number of elderly people increased slowly during the observation period. The patients were subdivided into age groups with 5 year increments and also according to sex. The population of the area was similarly subdivided into age and sex groups according to information obtained from the Danish Central Bureau of Statistics. From these data the incidence of major amputations of the lower limb was calculated and analysed by a multiplicative Poisson model (Andersen 1977).

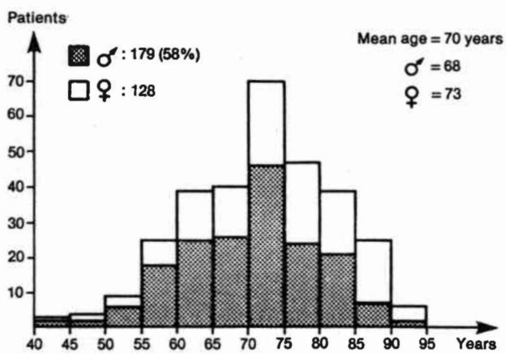

Fig. 1. Age and sex distributions for 307 patients over the age of 40 with amputations of the lower limb.

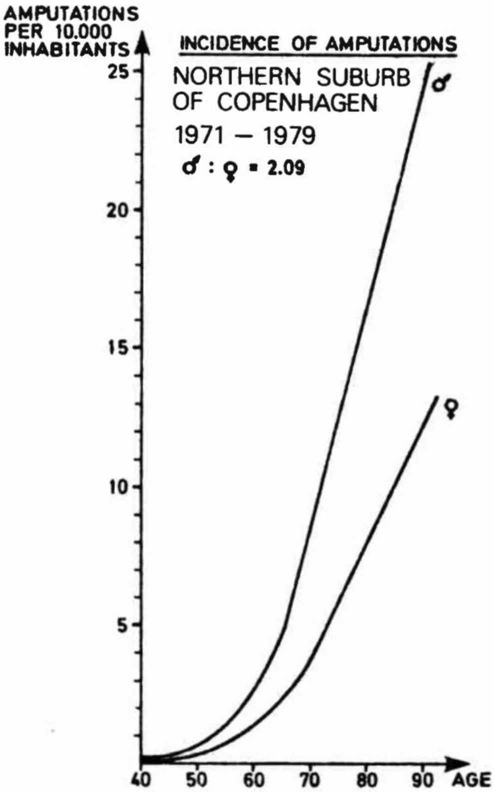

Fig. 2. Incidence of major amputations of the lower limb.

Results

The difference in mean age of 5 years between male and female amputees was significant ($P<0{\cdot}04$). The ratio of men to women was 2·09. The incidence of amputations of the lower limb did not change significantly during the 8 year period of observation. The overall incidence was 0·3 per thousand inhabitants over 40 years of age. As shown in Figure 2 the incidence of major amputations of the lower limb increased exponentially with age from the beginning of the 5th decade. The incidence increased tenfold from 0·1 per thousand at 55 years of age to 1 per thousand at 76 years of age. At 92 years of age the incidence had increased to 2 per thousand.

The distribution between the cause of amputation in relation to age and sex was analysed as shown in Figure 3. In males amputation was due to gangrene by arteriosclerotic vascular disease without concomitant diabetes mellitus in 75 per cent and this was independant of age. In females a decrease in the percentage of chronic arteriosclerotic vascular disease as cause of amputation was observed around the 7th decade.

Discussion

Hansson (1964) found the incidence of amputations on the lower limb over the age of 60 to increase from 34 to 93 per hundred thousand inhabitants during a 25 year period from 1947 to 1962. In a similar study by Hierton and James (1973) the increase was found to be 43 to 85 per hundred thousand in the period 1947 to 1969. Vitali and Harris (1964) reports the total number of patients provided with a prosthesis in England and Wales increased from 3262 new cases in 1959 to 4251 new cases in 1962. Using information from the British Central Statistical Office the incidence of patients over the age of 40 provided with a prosthesis can be calculated to be 16 per hundred thousand in 1959 and 20 per hundred thousand in 1962.

In the present study the amputation rate was constant from 1971 to 1979 which accords with the result of Christensen (1976) who studied the period of 1961 to 1971.

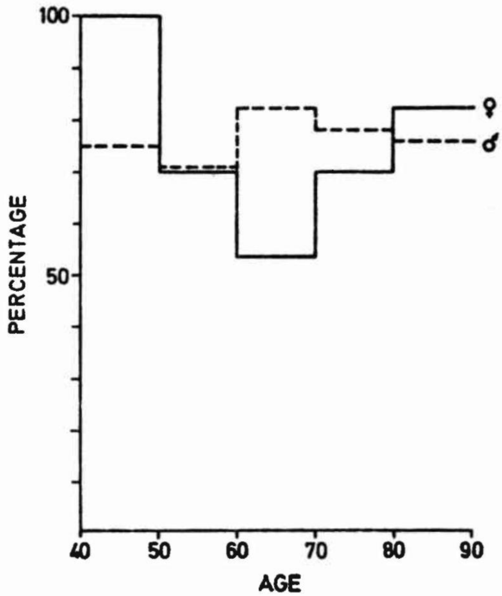

Fig. 3. Vascular causes of amputation in relation to age and sex.

Persson and Sundén (1971) found an incidence of 20 per hundred thousand in the county of Lund in Sweden in a comparable group of amputees with a mean age of 77 years and a lower age limit of 40 years. The population in the county of Lund is of mixed urban/rural composition, as it is in the county of Aalborg, Denmark, where the urban-rural ratio is 1·1:1. In the latter population Christensen (1976) found an amputation rate of 13·1 per hundred thousand inhabitants over the age of 50. In the present series an overall incidence of 30 per hundred thousand inhabitants over 40 years of age was found. The incidence was found to increase exponentially with increasing age. The difference in geographic background and populational composition might be an explanation for the different amputation rates found in the methodologically comparable studies. In the suburban county of Copenagen presented in this paper there is almost no rural population, and there is a prevalence of the eldest age groups with a higher economic status than in most parts of Denmark.

The difference in mean age between male and female amputees, the male amputees being 5 years younger than female and the ratio of men to women of 2:1 most likely refllects a higher prevalence and an earlier debut of arteriosclerotic vascular complications in males. The decrease in the percentage of chronic arteriosclerotic vascular discase as cause of amputation in females around the 7th decade is not readily explainable.

Since the elderly amputee requires a long hospitalization time after amputation and since frequent control is necessary during prosthetic fitting, incidence studies provide an important and realistic basis for the planning of the hospital care of patients with gangrene of the lower limb.

Acknowledgements

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Prosthetics and Orthotics International, 1982, 6, 38–40

The management of healing problems in the dysvascular amputee

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Abstract

This paper outlines the management of the dysvascular amputee. The surgical techniques and postoperative care that would prevent wound healing problems are described. The treatment of patients with established wound healing problems is discussed.

Introduction

With the introduction of new techniques and the use of more distal bypass procedures, advances in vascular surgery in the last few years have resulted in the preservation of limbs which would otherwise have been amputated because of rest pain or gangrene. However, this progress has meant that the patient with peripheral vascular disease faces amputation later in the evolution of his vascular disease than he would have done prior to these developments. Amputation at the below-knee level is still the most frequent level of primary amputation (Finch et al, 1980; Boontje, 1980) but at this level wound healing is frequently a problem (Boontje, 1980). At our Unit, we admit 150 new lower extremity amputees per year. Approximately 50% of the below-knee amputees have failure of primary wound healing, which we define as healing of the surgical incision by the fourteenth post-operative day. Wounds which break down after that are defined as having secondary wound breakdown. This paper describes our technique of management in patients with wound healing problems.

Prevention is better than cure

A number of steps can be taken to facilitate primary healing of the surgical incision. Skin flaps must be carefully marked so that when wound closure is performed dog-ears are avoided and there is no undue tension on the suture line. In the case of the below-knee amputation the anterior transverse skin incision should be performed 1·5 cm proximal to the level of tibial transection to prevent the suture line lying over the exposed bone which may cause wound breakdown (Fig. 1). Subcutaneous sutures should be avoided for these only serve to devitalize the subcutaneous tissue and compromise the already tenuous circulation in the dermis. (Carpenter et al, 1977). Penrose

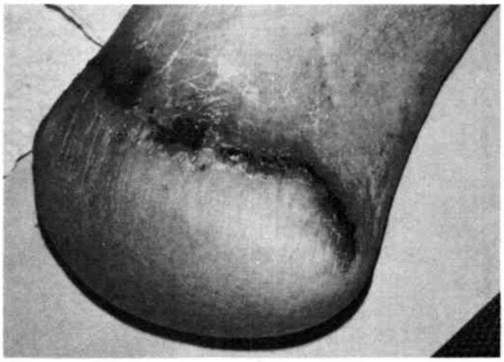

Fig. 1. Skin necrosis over the distal tibia.

Fig. 2. Sinus resulting from use of Penrose drain.

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drains should be avoided as following their removal there remains an open area in the wound which often takes several weeks to epithelialise (Fig. 2). We therefore advocate the use of a suction type drain. For skin suture, we prefer the use of the Donati (OA Manual) suture, as this minimizes trauma to the margin of the anterior flap and also permits accurate skin margin aposition.

Great care must be taken in the application of the rigid dressing. Adequate padding must be used to protect the skin flaps and at risk areas (Fig. 3 top); two amputation pads followed by an elasticized bandage are used as this can be applied with more even tension than an elasticized plaster bandage. After the application of a non-elasticized plaster bandage the posterior flap is moulded anteriorly around the distal end of the stump to minimize the tension along the wound margin.

Fig. 3. Top, pressure necrosis over fibular head. Bottom, oedema of stump end secondary to incorrect bandaging.

Positioning of the stump in the post-operative period is important as there is evidence to suggest that elevation of the stump, while reducing oedema, also reduces skin blood flow and thus potentiates healing problems. Measurement of transcutaneous oxygen levels along the margins of the anterior flap of a standard below-knee amputation, has shown that elevation of the stump above the horizontal reduces the transcutaneous oxygen level to zero in dysvascular patients (Ewald, 1981; Carpenter, 1977). Ambulation of the patient is delayed until the first cast change at ten days has confirmed that the wound is beginning to heal satisfactorily. If the wound is found to be healthy at ten days, gentle ambulation may be commenced using a temporary prosthesis of the prosthetist's choice. However, great care is necessary in fitting a temporary prosthesis because the wound is by no means stable at this time and the slightest malalignment will cause undue pressure on the stump and subsequent breakdown. Every effort should be made to control ambulation as patients who progress too rapidly have a higher incidence of secondary wound problems.

The established problem

Despite the amputee team's best efforts many dysvascular patients still have wound healing problems. General measures that should be employed in their management include complete bed rest, adequate diabetic control and good nutrition, all of which will enhance the healing process. The wound itself may need to be debrided. This can be achieved either mechanically when there is a large area of dead tissue involved, or chemically if the area is smaller and not so deep. The aim of debridement is to remove the eschar and any underlying necrotic debris. It is important to prevent further injury to the stump and thus further embarrass skin circulation. Stump oedema must be controlled by the proper application of a stump bandage. Improper application of the stump bandage may cause distal oedema and thus compromise wound healing (Fig. 3, bottom). A posterior splint should be applied to prevent further mechanical trauma and migration of the suture line distally over the cut surface of the tibia. If this distal migration occurs then adhesions develop between the suture line and the distal tibia and when the patient is mobilized in a prosthesis further wound breakdown is likely at the site of the adhesion. The posterior splint also prevents the development of a knee flexion deformity which is likely to compromise successive prosthetic fitting.

Routine wound cultures almost always indicate the presence of bacteria. However, this only means that the wound is contaminated and there may not be frank infection (Robson and

Heggars, 1969). If the patient exhibits any sign of infection, fever, cellulitis or the drainage of pus, then, and only then, are antibiotics indicated.

Progress in wound healing can be ascertained if the wound shows a clear, pink, granulating base and has contracting margins. However, if the wound appears to be enlarging; has a persistent necrotic base or continuing drainage, then, consideration should be given to revising the stump. We generally persevere with conservative management of the wound for at least six weeks before considering revision. If revision is indicated, we have used fluorescene angiography to determine whether a local revision will be successful or whether it will be necessary to amputate at a higher level (Horne and Tanzer, in press). If the area of necrosis has a fluorescent margin indicating marginal hyperemia, then local revision is likely to be successful. However if there is no marginal hyperemia it is necessary to go to a higher level.

Conclusions

The incidence of wound healing problems in dysvascular amputees is likely to increase as vascular surgery becomes more sophisticated. The management of patients with delayed healing is time-consuming and painstaking. However, with careful attention to detail, it is possible to obtain delayed primary healing in many of these patients.

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Technical note—test instructions for the technical testing of mono-functional myoelectrically-controlled prosthetic hands. A proposal.

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Abstract

To get an acceptable standard of prostheses and orthoses in Sweden, the Swedish Institute for the Handicapped is testing this group of aids. One important part of the work is to draw up test instructions.

In response to a request from the Swedish Institute for the Handicapped, the Laboratory of Rehabilitation Engineering at the University Hospital of Linköping in Sweden, has suggested instructions for the technical testing of mono-functional myoelectrically controlled prosthetic hands. These test instructions contain different inspection and control factors which are important for the function of the prosthetic hand.

Introduction

Increasing numbers of technical aids for handicapped people are being put on the market. At the same time these technical aids have the tendency to become more and more complicated and therefore there is a great need to test them in order to ensure that they are functional and durable.

In Sweden there are regular tests of different types of aids. In the field of orthotics and prosthetics several projects are now being carried out drawing up test instructions. At the laboratory of Rehabilitation Engineering at the University Hospital of Linköping, a proposal has been drawn up for technical testing of mono-functional myoelectrically controlled prosthetic hands.

The outline of these test instructions is presented here under the main topics considered.

Description

Information about the manufacturer and the supplier is to be stated as well as the type-designation, the manufacturing number, the size of the hand, the type of grip, wrist functions, and the way in which the hand is controlled, proportionally or on/off.

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Marking

The hand should be clearly and durably marked with the manufacturer's name or trade-mark, the type-designation and the manufacturing number.

Instructions

It is ascertained that a complete technical description is available and that instructions suitable for the use of patients are included. These must be written in Swedish.

Dimensions and weight

The dimensions identified on Figure 1 are measured.

The distance between the distal end of the wrist unit and the tip of the middle finger (A).

The length of the hand from the distal end of the wrist unit (B).

The length of the middle finger (C).

The maximum circumference when the hand is closed.

The prosthetic hand, including the cosmetic glove, is weighed.

Electronics and mechanics

The hand is inspected to ensure that it performs well. A visual inspection is made of cables, connections, assembly, looseness, etc.

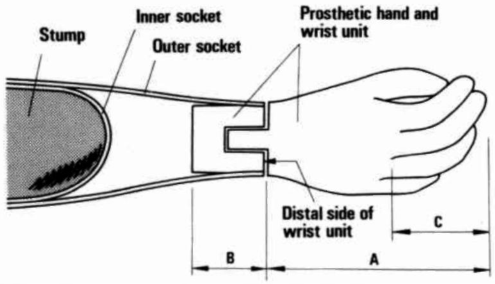

Fig. 1. The figure shows the distances which are noted.

The inner hand and the cosmetic glove

The inner hand and the cosmetic glove are inspected to confirm that they are clearly and durably marked with the manufacturer's name or trade-mark and type-designation. The fitting and the performance are inspected and the cosmetic appearance is examined.

Safety aspects

It is very important to measure the force required to open the hand during an active grip (Fig. 2). One must also inspect that the hand can be voluntarily opened in the normal way when the grip is loaded.

The on/off-switch, if present, must be easy to operate. The danger of fire in the prosthetic hand has to be examined.

Service organization

The address of the supplier's service organization is determined, as well as the time needed for routine servicing and supply of spare parts.

Gripping width

The maximum gripping width of the hand is measured by letting it grasp prisms and cylinders. The hand, which is horizontally placed, should be capable of grasping and then holding these objects without any assistance.

Opening and closing times

The times for the hand to open and to close are measured, i.e. the time from giving a signal to the motor until the hand has reached its maximum extension, after being completely closed, and until it is completely closed after being extended to maximum.

Gripping force

The maximum gripping force and the remaining gripping force after active gripping are measured. These measurements are made when the degrees of opening are 20 per cent, 50 per cent and 80 per cent of the maximum gripping width.

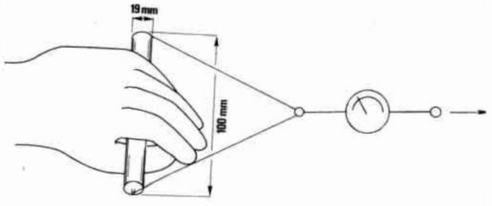

Fig. 2. Method of measuring force required to open the hand.

Current consumption

The current required by the prosthetic hand is measured when the hand is on but not moving, during opening and closing, when the hand is completely closed and extended to maximum with applied motor signal and during maximum gripping at the opening degree of 50 per cent.

Noise and vibration measurements

The sound level and the vibration emitted by the hand are measured when the hand is moving and gripping. These measurements are carried out well screened from external noise and vibrations.

Mechanical testing

The prosthetic hand should undergo environmental testing according to IEC Publication 68-2-27, Test Ea: Shock, Second Edition 1972 and according to IEC Publication 68-2-32, Test Ed: Free fall, Second Edition 1975.

Environmental testing

The hand should undergo environmental testing according to IEC Publication 68-2-1, Test A: Cold, Fourth Edition 1974.
IEC Publication 68-2-2, Test B: Dry heat, Fourth Edition 1974.
IEC Publication 68-2-3, Test Ca: Damp heat, steady state, Third Edition 1969.

Long-term testing

The prosthetic hand is placed in a fixture and driven by external control signals. The complete cycle of operation is: opening for 3 seconds, 1 second pause, closing for 3 seconds and 1 second pause.

After 25,000 cycles and then after every 50,000 cycles the current consumption, the time for opening and closing, the gripping width, the gripping force and the noise level are measured.

Discussion

It is emphasised that this is a proposal for test instructions. The next step is to draw up requirement specifications for myo-electrically controlled prosthetic hands in conjunction with these test instructions. The aim is to compare different prosthetic hands in the hope that this will result in better products.

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An investigation of kinematic and kinetic variables for the description of prosthetic gait using the ENOCH system

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Abstract

Gait patterns, joint angles, floor reaction forces and joint moments during walking were investigated for normal subjects and above-knee and below-knee amputees.

The investigation showed that the hip-knee angle diagram as well as different symmetry diagrams (e.g. left knee angle versus right knee angle) provide an easily interpreted means of evaluating abnormalities in the gait pattern. It was further concluded that a combined gait pattern-force vector diagram is valuable for the evaluation of the joint moments.

Floor reaction forces and muscular moments at the joints were also included in the analysis. The joint moments at the knee were quite different for both above-knee and below-knee amputees as compared to the normal subjects. Some interesting trends were also found concerning the knee stability of the amputees.

A system called ENOCH was used for the measurement and analysis. This system consists of a minicomputer connected on-line to equipment for measurement of displacement (Selspot) and floor reaction forces (Kistler). A graphic computer terminal (Tektronix) was used for the result presentation.

Introduction

It is generally agreed that there is a need for quantitative analysis of human gait for the evaluation of abnormalities in the locomotor apparatus. Many different types of equipment have been developed over the years. Among these are:

Goniometer systems which give joint angles that can be used to characterize the gait pattern. Here the data are given in direct electrical form.

Cinematography which gives a kinematic description of the gait. In this case quantitative evaluation is very time consuming and expensive.

Force plates which give the floor reaction forces.

TV-based systems which give the position of selected landmarks on the body. With the cameras connected on-line to a computer it is possible to make quantitative analyses in direct connection to a measurement. However, current systems have limited resolution and sampling rates.

Systems based on position sensitive photodetectors. This kind of equipment makes it possible to obtain cartesian coordinates for selected landmarks with a precision and sampling rate that is superior to the TV-based systems. A drawback is that light sources must be carried by the subject.

Reports on practical usage of all types of equipment mentioned above are extensively found in the literature, except for the last type which can hardly be found at all. It is this kind of equipment that was used for the present investigation.

In conjunction with such measurements, analyses of the data based on mathematical models of the human body (McGhee, 1981; Oberg, 1974) are used in research laboratories but can hardly be found in clinical use.

Method and material

A minicomputer based system—called ENOCH—was used for the measurements and analyses (Gustafsson and Lanshammar, 1977). In this system (Fig. 1), an optoelectronic device, Selspot, with position sensitive photodetectors is used for kinematic data collection. Ground reaction data are obtained from a Kistler force plate. Output of result diagrams are made on a graphical computer terminal with a hardcopy unit or in tabular form on a line printer.

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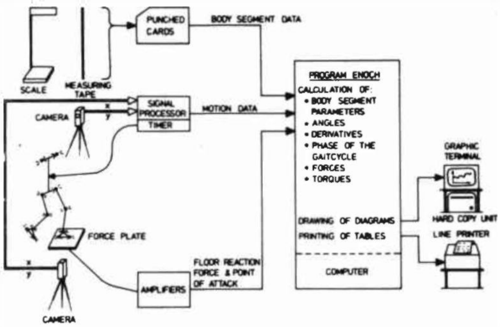

Fig. 1. Schematic diagram of the ENOCH gait measurement and analysis system.

Two Selspot cameras were used to obtain kinematic data for both legs. Landmarks (light emitting diodes) were placed on the shoulder, hip joint, knee joint, ankle joint, heel and toe base for both sides (Fig. 2). The measurement area was approximately 3 m × 3 m allowing for the registration of 3 steps in each measurement. Data was collected at the rate of 158 Hz. The standard deviation of the measurement noise was 2 mm and the systematic coordinate error was estimated to be less than 2 cm.

The displacements of the centre of mass for the different body segments in the model, HAT (that is head, arm, trunk), thighs and shanks, were calculated from the measured coordinate data. The required body segment parameters were obtained according to a method based on data from Drillis and Contini (1966) and Chandler et el (1975). Absolute angles for the body segments and relative angles at the joints were obtained from the linear displacement by straightforward application of trigonometric relations.

The velocities and accelerations of the different body segments were calculated by numerical differentiation of the displacement data. The differentiation procedure is described in Gustafsson and Lanshammar (1977). It is a design based on minimization of the total error in estimated derivatives where a systematic error component is obtained from the rest term in a Taylor series expansion of the signal, and a stochastic error component results from uncorrelated measurement noise added to the signal. The structure of the algorithm is a linear finite impulse response (FIR) filter where the filter coefficients are determined by the minimization mentioned above.

Gait phase changes were automatically determined by application of algorithmic tests on the velocities of the feet landmarks.

Finally, forces and moments at the joints were calculated by application of the Newtonian equations of motion.

It should be noted that only planar motion was included in the analysis. Further the shank and foot was treated as one rigid body.

Measurements were made on 5 male persons with below-knee (BK) and 3 male persons with above-knee (AK) amputations. For reference, measurements were also made on 4 normal subjects.

Results

Many different types of diagrams were studied with respect to their ability to characterize the gait.

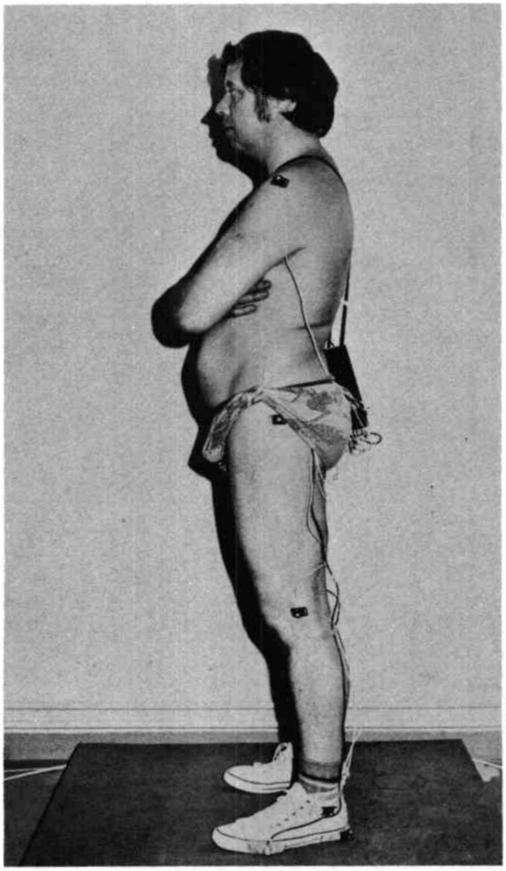
Fig. 2. Light emitting diodes (landmarks) mounted on an AK patient.

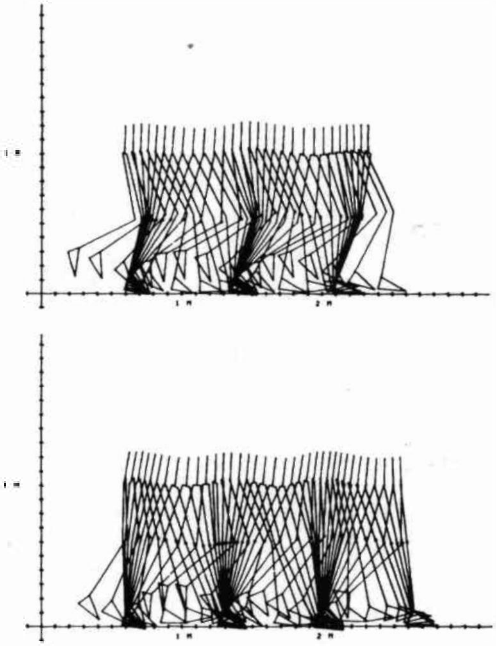

Fig. 3. Stick diagrams showing the geometrical gait pattern. Top, normal subject, bottom, right leg above knee amputee.

Figure 3, top, gives a description of the geometrical gait pattern. The force plate was located between 1·2 m and 1·8 m on the horizontal axis. The right leg is marked with a small square on the right knee. In this case the subject was a normal.

Figure 3, bottom, shows the same diagram for a right leg AK amputee, wearing a prosthesis with Blatchford stabilized knee and a Greissinger foot. The asymetry in the gait is obvious.

The well known hip-knee angle diagram (Lamoreux, 1978) is an already rather well established joint angle description. For an AK amputee Figure 4, bottom, shows a typical example. As can be seen the knee angle is zero during the stance phase, and the diagram looks very much like a triangle. This is in sharp contrast to the corresponding diagram for normal gait (Fig. 4, top), where the knee is flexing also during stance.

Figure 5, the knee-knee angle diagram, provides a means to evaluate the gait symmetry between the left and right side. If the gait is symmetric, which is the case in Figure 5, top, the curve is symmetric about a line with slope 1. For AK prosthetic gait the curve is not at all symmetric, which can be seen in Figure 5, bottom.

Another type of diagram that was studied were plots of joint moment versus time. In Figure 6, top, the knee moment for a normal subject is plotted. In the diagram a positive moment means a flexing muscle moment. During stance phase the moment is alternating between a flexion and an extension moment. For the prosthetic side of the AK patients, the corresponding diagram looked like that in Figure 6, bottom. In this case there is a flexion moment during the entire stance phase. This moment is due to the extension stop in the knee mechanism.

This observation can be understood by looking at Figure 7, where the floor reaction force is plotted on a stick diagram of the gait pattern for 5 points of time during stance phase. This diagram output was specially designed for this investigation.

Inertial forces have very little influence on the joint moments during stance. Therefore the joint

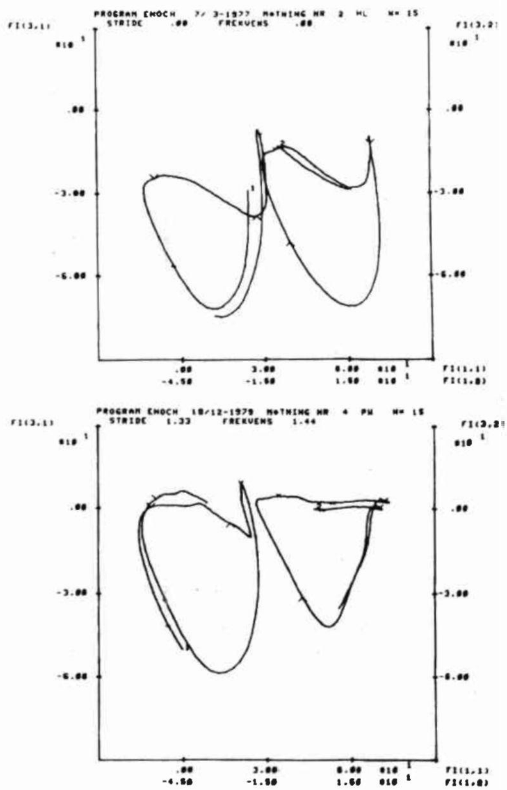

Fig. 4. Hip-knee angle diagram for left and right leg. Top, normal subject, bottom, right leg above knee amputee.

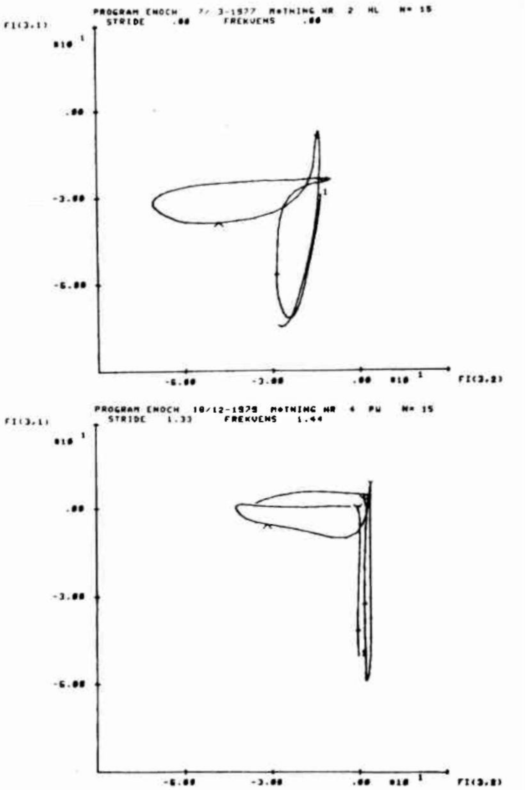

Fig. 5. Knee-knee angle diagram. Top, normal subject, bottom, right leg above knee amputee.

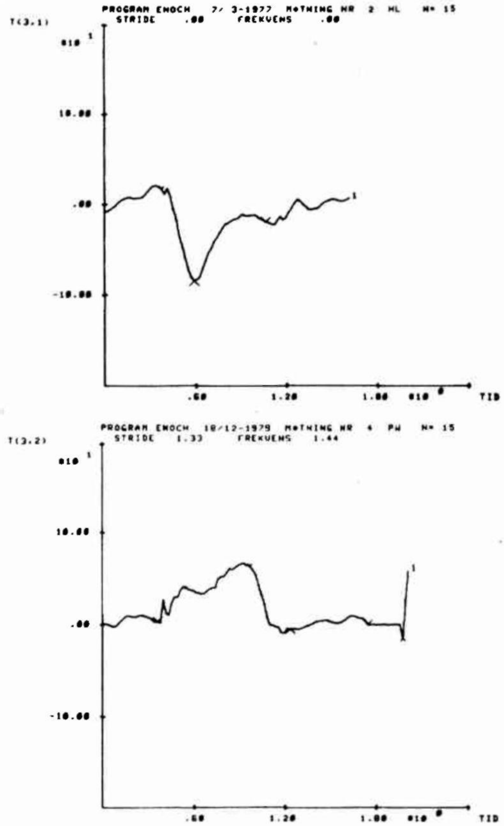

Fig. 6. Knee moment versus time. Top, normal subject, bottom, right leg above knee amputee.

moment resulting from the floor reaction force must be balanced by counteracting muscular moments.

In Figure 7, top, the direction of the floor reaction force is such that it results in a flexion moment in the middle of stance phase. Therefore the muscular moment at the knee joint is changing sign and exhibits an extension moment during most of the stance phase. This is in accordance with the muscular moments shown in Figure 6, top.

In Figure 7, bottom, it can be seen that the floor reaction force gives an extension moment during the entire stance phase (except at toe off). This explains the flexion moment observed in Figure 6, bottom.

The knee joint of this investigated AK amputee was fitted with a weight bearing controlled knee joint (Blatchford). However, since the person was stabilizing the knee joint by contracting the hip an extension moment at the prosthetic knee joint was produced. Therefore the knee lock was not used at all by this subject during the experiments.

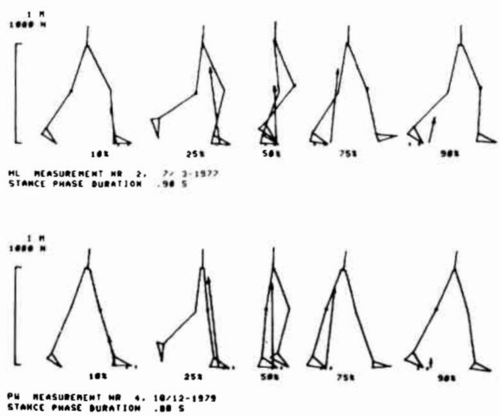

Fig. 7. Gait pattern-force vector diagram. Top, normal subject, bottom, right leg above knee amputee.

Conclusions

This investigation has demonstrated that simultaneous measurements of the displacements of body markers and floor reaction forces combined with on-line computer analysis is a powerful tool for the assessment of gait dynamics. By the utilization of positive sensitive photodetector based equipment, the displacements of the body markers can be determined with high precision and at relatively high sampling rates. Further by using computer graphics, the presentation of results can be made easy to interpret as, for instance, in the combined gait pattern-force vector diagram.

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Prosthetics and Orthotics International, 1982, 6, 48–52

Compression testing of foamed plastics and rubbers for use as orthotic shoe insoles

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Abstract

Thirty-one materials have been tested in compression in order to generate the stress (force per unit of cross-sectional area) versus strain (deformation) behaviour, for the purpose of assessing the suitability of various foamed plastics and rubbers as shoe insole materials. It was found that the materials could be classified into three distinct categories (very stiff, moderately deformable and very deformable) according to the shape of the characteristic stress versus strain curve. The moderately deformable group has been selected as the most promising for clinical application.

Introduction

The conservative management of many common foot disorders involves the prescription of appropriate footwear, often requiring modification to the interior of the shoes. Rheumatoid arthritis may be considered a model with the well known problems of hallux valgus, hammer toes, flattening of the longitudinal arch, pronation of the hind foot, metatarsalgia, thinned skin and thinned subcutaneous tissues (Broadley, 1974). Possible orthotic solutions include metatarsal mounds, metatarsal bars, scaphoid pads, soft insoles and custom moulded foot orthoses incorporating pressure-distributing features (Hollingsworth, 1978; Adams, 1972; Hollander, 1974).

Leather, rubber and cork have been the traditional materials used in the fabrication of these various foot orthotic devices. In many centres newer materials, specifically foamed plastics and rubbers, are beginning to replace the traditional materials, but there is very little clinical or scientific information readily available about them. Choice of material tends to be based on personal experience, cost and/or availability. Plastazote is the most common thermoplastic material described in the medical literature. Other materials that are commonly used in North America, although not described as extensively, are: Aliplast, high density neoprene, and Spenco. Less commonly used materials are: Lynco, Celltite, Evazote and Poron, for which there is no data available in the literature. "Dr. Scholl's Cushion Insoles" and "Odor-Eater Insoles" are widely available to the public through drug stores and department stores, and again no data is available.

Our clinical experience suggests that one should consider the characteristics listed below when attempting to choose an insole material:

1. biocompatibility
2. ease of use
3. ease of fabrication
4. availability
5. durability
6. simulation of the mechanical properties of soft tissue
7. subjective comfort
8. cost
9. pressure distributing properties

We felt it would be possible to correlate measurable physical properties with the desirable clinical characteristics. To date, 31 materials have been identified by our group for this application, on the basis of information derived from the literature, shoe and foot clinics, technical material from companies producing the materials, and miscellaneous other sources.

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A series of tests (compression, shear, accelerated ageing, compression set and cyclic compressive loading) have been selected, which will provide relevant information about the physical properties.

This study was initiated for the purpose of determining the compressive properties for the 31 materials mentioned previously.

Methods and materials

The applicable test procedures for foamed rubbers and plastics, published by the American Society for Testing and Materials (ASTM) were reviewed. The subsequent procedure is a modified version of the Compression Deflection Test outlined in ASTM D1667–70.

Standard disc-shaped specimens (2·85 cm in diameter) were cut from each of the 31 materials, and the thickness of each specimen was measured with a dial micrometer. The specimen, in the form of either a single ply or multiple plies, was placed on the lower platen of a model 1125 Instron Universal Testing Centre and pre-conditioned by an initial compression to 23 kg. The upper platen of the Instron was positioned until it was in contact with the upper surface of the specimen. Figure 1 illustrates specimen placement in the Instron Testing Centre.

The specimen was compressed at a constant rate of 10 mm/min, 100 mm/min, or 500 mm/min to a maximum load of 23 kg. The maximum load of 23 kg is equivalent to a stress of 3·6 kg/cm² which is slightly greater than the maximum stress sustained by the foot during normal walking. (Godfrey *et al,* 1967). Since the results for the different plies at the various compression rates were comparable, only the results for the 10 mm/min compression rate on a single ply will be reported in this paper.

As a result of the unique structure of the product called "Pacer" it was necessary to slightly modify the test procedure solely for this material. The test specimen was a slab of the material, 2 cm larger than the size of the upper platen illustrated in Figure 1. The loading scheme outlined above was duplicated and the increased area of material tested was accounted for in the computation of the "Stress".

The load versus deformation recordings obtained as a result of the above procedure were plotted as "Stress versus Strain" curves. The magnitude of the "Stress" is computed by dividing the load at any location along the load versus deformation recording, by the cross-sectional area (6·36 cm²) of the specimen and it is expressed as kg/cm². The magnitude of the "Strain" is computed as the ratio of the deformation of the specimen (measured from the initial thickness of the specimen) divided by the initial thickness of the specimen. Strain is expressed as cm/cm or percent. The stress versus strain relationship is a common method employed in the field of materials science to illustrate the relevant characteristic of a material.

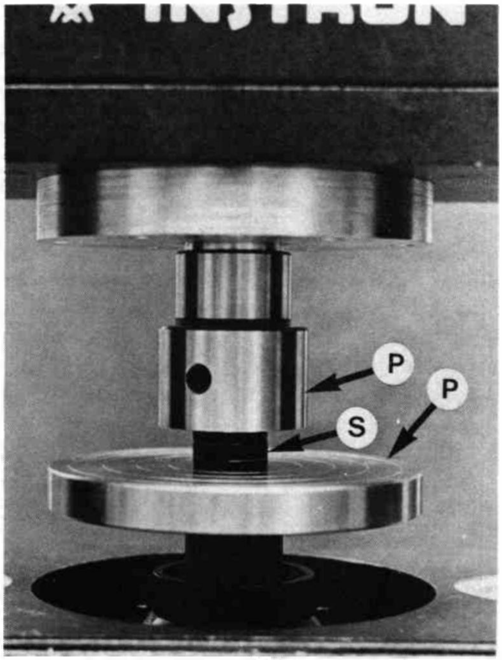

Fig. 1. The specimen of the material (S) is shown positioned between the platens (P) of the Instron Testing Centre.

Results

A typical stress versus strain curve is illustrated in Figure 2 using Lynco which is an open-cell, nylon-covered neoprene. The initial portion of the curve demonstrates a moderate increase in stress with a moderate increase in strain (moderate slope). The final portion of the curve illustrates a rapid increase in the stress with very little increase in the strain or deformation (steep slope). The intermediate portion of the curve is usually regarded as the transition region.

A similar review of the stress versus strain curves for the remaining materials revealed that

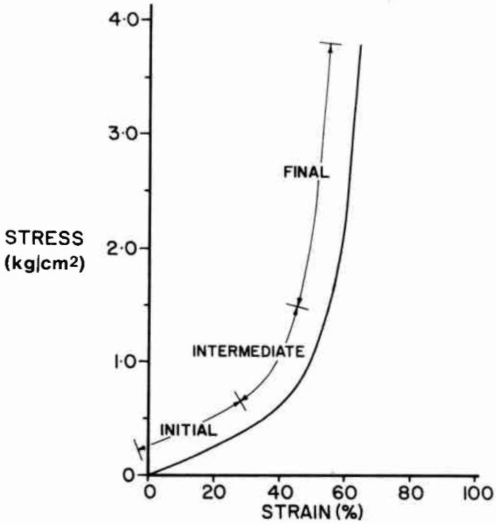

Fig. 2. A representative compression stress versus strain curve for the material "Lynco", illustrates the three portions of the curve.

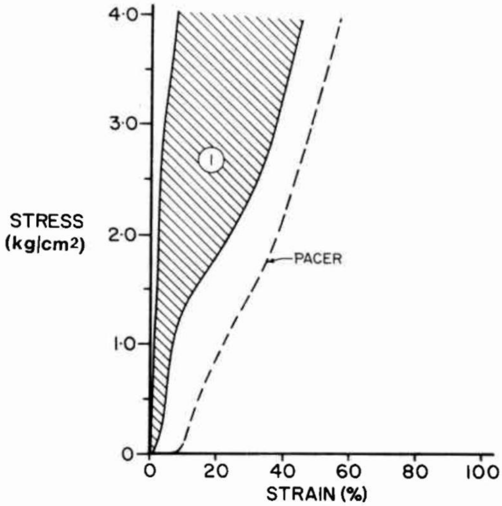

Fig. 3. The stress versus strain curve envelope for category 1 (very stiff), and the product "Pacer" (moderately deformable).

the materials could be classified into three distinct categories—very stiff, moderately deformable, and highly deformable, as illustrated in Figures 3, 4 and 5. The results for each category have been depicted as an envelope since the presentation of all the individual stress versus strain curves was considered confusing. Categorization of the materials is presented in Table 1.

The first classification (1) designated "very stiff" is illustrated in Figure 3 and is characterized by a continuous steep slope relative to the other materials. Examples of materials in this classification are Kemblo, Aliplast 10, and Pelite (1·6 mm). The product called Pacer illustrated in Figure 3 has been allocated to this category since it demonstrated an initial offset followed by a steep slope.

The second category (2) illustrated in Figure 4 and designated "moderately deformable" has two sub-classifications. The first subclassification (2A) demonstrates a high-moderate initial slope followed by a plateau region that gradually transforms into a steep slope in the final portion of the curve. The distinction between sub-classification 2A and 2B was determined by the arbitrary selection of a slope 2·9 kg/cm² for the initial portion of the curve. The materials

Table 1. Categorization of materials

Categories	Materials			
1 Very Stiff	High Density Neoprene Pacer	Aliplast—10 Kemblo	Pelite (1·6 mm thick)	
2A Moderately Deformable	Poron-20125 Aliplast-6A Poron-'Sport'	Plastazote-Low Density (3·2 mm, 6·35 mm thick) Neoprene-R 425N (6·35 mm thick) Neoprene-431 (3·2 mm, 6·35 mm thick)		
2B Moderately Deformable	Ensolite (3·2 mm, 6·35 mm thick) Evazote (1·6 mm, 12·7 mm thick) Neoprene-R 425N (3·2 mm thick) Poron-17125 Carpet—Wool (pile weight of 1·15 kg/m²) Carpet—Polypropylene (pile weight of ·74 kg/m²)		Aliplast-4E Ethafoam Celltite Pelite (12·7 mm thick)	Spenco Bonfoam Lynco
3 Highly Deformable	"Dr. Scholl's Cushion Insole"	"Odor-Eater Insole	Polyurethane Foam	

illustrating this type of compressive behaviour (2A) are: Poron "Sport" and Aliplast 6A. The second sub-classification (2B) illustrated in Figure 4 has a low-moderate initial slope which gradually transforms into a steep slope in the final portion of the curve. Examples of this type of material are: Plastazote, Evazote, Pelite, Spenco, and Lynco.

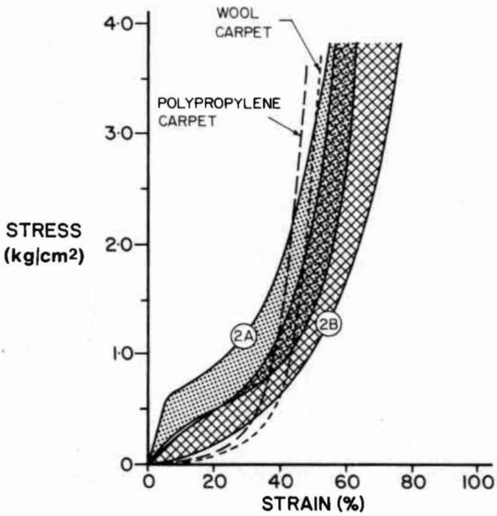

Fig. 4. The stress versus strain curve envelopes for category 2 (moderately deformable), divided into 2A an 2B. Also illustrated are the individual stress versus strain curves for polypropylene and wool carpets of different pile weights.

Two further materials assigned to category 2 are the wool and polypropylene carpets, since their characteristic stress versus strain curves overlap a substantial portion of this category. Nevertheless, the initial slope of the curve is very low, similar to category 3, but the amount of strain is considerably less.

The third category (3) illustrated in Figure 5 and designated "highly deformable", is characterized by a low initial slope which quickly transforms into a steep slope with a narrow transition region. Examples of the materials in this category are: Dr. Scholl's Cushion Insole and Odor-Eater Insole.

Materials which vary only in thickness usually fall within the same category (*e.g.*, Ensolite, Evazote, Neoprene 431). The slight difference in the initial portion of the curve between the 1·6 mm and the 3·2 mm thickness of Neoprene—R 425N accounts for the allocation to sub-groups 2B and 2A respectively. However, the

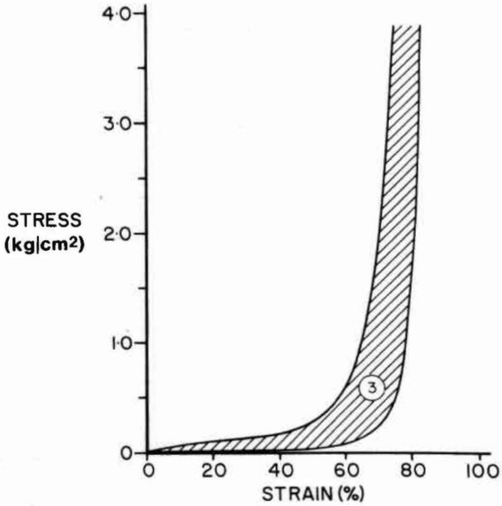

Fig. 5. The stress versus strain envelope for category 3 (highly deformable).

substantial difference for the characteristic stress versus strain curves for 1·6 mm and 12·7 mm thick Pelite indicate that the products vary in another factor such as density, polymer or structure.

Discussion

The visual assessment of the compression stress versus strain curves, provides a comparison of the compression characteristics for any group of materials. Compression of any foamed material by the bony prominences of the foot will result in an increase in the stress within the material which corresponds to the pressure or stress within the soft tissue covering the bony prominence. This situation could create excessive pressure and possible tissue breakdown about the bony prominences, unless the increased load is transferred to an adjacent area.

The ideal insole material would progressively deform throughout the full range of load to accommodate the shape of the bony prominence and to transfer a portion of the load to other less prominent regions of the foot.

The "highly deformable" group of materials (category 3) will deform rapidly under increased load until the material becomes almost completely compressed. Continued loading will result in very little further deformation of the material. The materials in this category reach this limit of deformation at a very low stress (about 0·5 kg/cm²). This rapid deformation of a material to its limit is commonly referred to as "bottoming-out". Since these materials will not transfer a significant portion of the stress to adjacent regions of the foot, they have been judged to possess poor characteristics for use as an orthotic shoe insole material.

The second category of materials which was described as "moderately deformable" demonstrates a reasonable degree of deformation with increased load, almost to the maximum anticipated stress. During loading, these materials will transfer the high pressure or stress associated with bony prominences to the adjacent tissue, thereby reducing the pressure on the bony prominences. Although the materials still exhibit a steep slope in the final portion of the compression stress versus strain curve, they have been judged to exhibit the most promising characteristics as an orthotic shoe insole material. At present, there is not a distinct preference between the materials with a gradual transition from the initial to the final portions of the curve, and the materials that exhibit a plateau in the transition region.

The "very stiff" materials in Category 1 deform very little, which prevents the redistribution of the stress on the bony prominences to the adjacent tissue. Consequently, materials in this category used by themselves are probably less useful as an orthotic shoe insole material.

An assessment of the suitability of a particular material for use as an orthotic shoe insert based exclusively on the compression stress versus strain curve associated with a material is not justified, since there are many other factors which must be considered. Further tests are in progress to investigate other properties of foamed rubbers and plastics to assess the applicability of these materials for clinical use.

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Prosthetics and Orthotics International, 1982, 6, 53–55

Letters to the Editor

Dear Sirs,
With reference to the article by Mr. Katsuaki Koike et al, "The TC double socket above-knee prosthesis" (Pros. Orth. Int., 5(3), 129–134).

The authors report development of a double walled socket for above the knee amputees as a means of solving problems of oedema, perspiration and malalignment of soft tissues in the sockets of prostheses of such amputees. I wish to comment particularly on what is identified as the TC-2 prosthesis. The features of particular interest include (a) the use of the double walled system; (b) the use of thermoplastic materials for the inner socket and the outer socket; (c) the use of a rubber sheet valve.

(a) Double walled socket. The double walled socket was introduced for use with modular components by the researchers at the Prosthetics/Orthotics Research and Development Unit, Winnipeg during the mid 1960's. The outer socket was called a receptacle in that prosthetic system. The findings of the group were that the receptacle system, which was fashioned out of plastic laminate which included stockinette and fibreglass reinforcements, could be made quickly and accurately by building an extension onto the end of the socket and then laminating the mating outer socket directly against the inner socket and the extension. This format of the socket made is possible to bypass finishing around the valve. Only a port through the outer shell (receptacle) need be made to give valve access. The system was very strong and permitted moderate adjustments to be made in socket alignment when the upper border was cut straight across just below the ischial shelf level. Then internal-external rotation of the socket with respect to the remainder of the components could be made. Further, it was often possible to substitute a different socket when the original one was not ideal provided the difference in shape was not too great. Also, it was possible to prefabricate the receptacles in a variety of sizes so that a socket could be pressed into position when the receptacle was heat-softened so that it would conform to the shape of the socket. With this format the socket was bonded in place as the final step. Such receptacles were designed for both above-knee and below-knee use. It is not clear why this approach did not enter into general use. At Winnipeg, the clinical people verged away from the sort of receptacles that were level with the lower edge of the ischial-gluteal shelf to receptacles which enclosed the entire socket like those in the article. I endorse the use of such a format for linking sockets to modular components.

(b) Use of thermoplastic materials. In view of the number of cases fitted with the TC-2 (and TC-1), it is assumed that the use of thermoplastic material (polypropylene) for the receptacle or outer socket has proven suitable. Use of this material means that the outer shell can be very quickly and accurately made over the inner socket with the extension built on it. Thus, the complete technique is a promising way to fabricate the socket-support elements of the prosthesis. Use of these materials would take less time than to fabricate such a system out of plastic laminates. The method of attachment between receptacle and modular components probably requires a metal plate on either side of the base to distribute loads through the bolts. This method of attachment was first seen in a BK prosthesis designed at Northwestern University. There, a ring inside the container served as an anchor plate for attachment of the leave-in N.U. BK pylon prosthesis. A similar method of anchorage is used in the hip disarticulation prosthesis system devised at N.U.

(c) The rubber sheet valve. I believe this is novel idea, but I have a vague recollection of such a procedure having been used. As with the double walled socket approach however, such an approach re-examined is a worthwhile step. Valves have been located distally, and separate perspiration drainage valves have been used for the purposes reported. The disadvantage of a distally placed valve is that one must reach still further to gain access to the pull sock. The advantage is that the tissues are not distorted as they are pulled in as indicated by the authors.

With reference to sitting comfort, as with the problem of oedema, neither of these depend on the double walled socket. Pliability of the socket would contribute to sitting comfort, as would a valve system which relaxed once the amputee was seated. Oedema is strictly related to the pressure differential between the proximal and distal levels. As with sitting comfort, the relaxation of the suction would have positive value in guarding against oedema. Also, flexibility of the socket system might aid this. If the rubber diaphragm valve aided in production of a positive pressure under the end of the stump during stance phase, and helped reduce negative pressure on the stump at the end in swing phase, then it would contribute to protection of the stump against oedema. Roughness of the inner socket surface can contribue to oedema by tending to cling in swing phase and allowing the stump to slip downward in stance phase. A very similar result is experienced when the socket surface is glass-smooth. Then it adheres, typically causing welts at the top edge as well as oedema distally because the stump tissues cannot redistribute themselves between the two phases of walking (swing and stance). The bone and attached tissues move upward while the more peripheral tissues cling to the socket thus putting a severe negative pressure against the free end of the stump against which is a space of small cross sectional area. And finally, the less rigid socket would yield to muscle forces acting against the socket walls so that constrictive forces would be less.

While the origin of ideas is not important, I would like to point out that Dr. T. Canty did the first work on Total Contact Sockets, a concept proposed by Dr. E. Murphy who proposed that sockets should be fitted as intimately as dentures. Each of these people can be located in our literature. Also, my work on the Brim Fitting Equipment and method (1960–62) was to allow easy fabrication of total contact sockets for AK amputees.

Finally, may I comment on the use of the socket as a shrinker socket. Every socket serves that function unfortunately. I personally believe that it is legitimate to shape the stump by means of successive sockets. It would be better of course to have a design which can be adjusted or is self adjusting. Such a prospect is not so far-fetched given modern materials and methods. When the supporting structure and the socket are separate, as in the TC-1 and 2, then such a prospect is more possible than when the socket end itself is used to make the junction with modular components.

This commentary is offered in a positive sense and as a congratulation to the authors for their effort and for sharing it.

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Mr. K. Koike and Dr. T. Imamura reply:

Dear Sirs,

Comment on our article "The TC double socket above-knee prosthesis" from J. Foort was original and beneficial to us.

As pointed out, the originator of the total contact socket is Canty and we pay our respects to many of the innovators who produced considerable achievement in the progress of prosthetics.

We also wished to improve the conventional total contact socket, and attempted to develop a new structure and materials for the socket which would meet the following conditions:

(1) easily modifiable materials to accommodate changes in stump circumference;
(2) as transparent a socket as possible to observe the fitting;
(3) a double socket system to allow the advantages of a detachable socket.

As a natural result, we reached the stage of using thermoplastics in the TC prosthesis, because, although the socket made by lamination is strong, it presents several disadvantages as follows.

1. The laminated socket presents difficulty in modifying the circumference. Even though a thermoplastic, such as acrylic resin, is used to make the socket, modification of the socket shape can be made only partially on a small site, and even then it can only be enlarged, never reduced. Reduction can

be made only be putting additional resin on the inner surface, and this results in rigidity of the socket. On the other hand, thermoplastics used to make the TC socket can be modified easily over the entire surface of the socket, and both enlargement and reduction of the socket shape can be achieved with heat.

2. Using the materials available at the present time, the laminated socket is always opaque due to the inclusion of stockinette and fibreglass. This is inconvenient for observation of the socket fitting. Moreover, the types of material that can be used for making the laminated socket are comparatively limited, but various thermoplastics to make prostheses and orthoses are available. Therefore, we can easily select optimum materials to make the socket, and now replace semitransparent polyethylene with transparent ionomer resin for the internal socket of the TC.

3. There is another reason why we did not adopt the laminating method to develop the new prosthesis. The mating surfaces of the laminated double socket are easily worn away by repeated attaching and detaching action, and the sockets would become loose in a short time, unless a special coating is given to the contacting surfaces.

We would now like to discuss the use of the TC internal socket as a stump shrinker. Since the internal socket is quite similar to the stump in shape and is also light, the amputee can wear it in his bed without disturbance to his sleep. Wearing the socket for a long period contributes to the progress of stump shrinkage. Subsequently the internal socket can be modified easily and frequently with heat, to accommodate the changes in stump circumference. This is a merit of thermoplastics.

Twice recently a course for prosthetists in the manufacturing method of the TC prothesis was held in Japan and many experienced prosthetists attended. Due to the fact that the TC prosthesis has spread steadily throughout the country, we believe that experienced prosthetists value the easily modifiable thermoplastic socket and the wearers appreciate the advantage of the TC.

Finally, we believe that our original attempts have produced successful results from a combination of the different materials or different density of the same materials for making the TC prosthesis.

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Deutsch

Frühzeitige Ueberweisung an Polikliniken für Extremitäten-Fehlbiedungen
V. Angliss
Pros. Orth. Int. **5:3,** *141–143*

Zusammenfassung
Sofortige Hilfe ist notwendig für Eltern mit einem Kind, das mit angeborenen Extremitäten-Missbildungen geboren wurde. Zu dieser Zeit sind die Anegste und Probleme der Eltern am grössten. Um diesen Eltern zu helfen sind besondere, nicht überall vorhandene Kenntnisse notwendig. Spezielle Polikliniken füllen diese Lücke. Erfahrene Therapeuten und Sozialarbeiter sind in der Regel durch den Geburtshelfer oder Allgemeinpraktiker schwer zu finden. In unserer Poliklinik besuchen Arzt, Sozialarbeiter und Therapeut die Eltern und das Kind auf der Geburtsabteilung. Diese frühe Beratung soll eine Entfremdung zwischen Eltern und Kind vermeiden und den Eltern Schuldgefühle und Aengste wegen ihres missgebildeten Kindes nehmen. Fachgerechte Informationen über die Prothesenversorgung, das tägliche Leben und die Zukunftsaussichten für diese Kinder helfen mit zu einer möglichst normalen Beziehung.

Analyse des Greifens mit einer mechanisch betätigten Handprothese
C. Fraser und A. W. Wing
Pros. Orth. Int. **5:3,** *151–156*

Zusammenfassung
Das Greifen umfasst sowohl das Bringen der Hand zum Gegenstand und das Oeffnen der Hand kurz bevor der zu ergreifende Gegenstand erreicht ist. Die Bewegungen der künstlichen Hand haben wir verglichen mit denjenigen der gesunden Hand der Gegenseite bei einem geschickten, mit seiner Prothese vertrauten Patienten. Mit der Künstlichen Hand war der Patient etwas langsamer, doch bestand eine affallende Aehnlichkeit beim Oeffnen der Hand und Bewegen des Armes auf beiden Seiten. Die aufallende Aehnlichkeit reichte bis zu den Bewegungen der Finger, obwohl die künstliche und natürliche Hand auf sehr unterschiedliche Weise betätigt werden. Die Erkenntnisse können von Bedeutung sein für die Prothesenschulung.

Doppelwandige Oberschenkelprothese
K. Koike, Y. Ishikura, S. Kakurai und T. Imamura
Pros. Orth. Int. **5:3,** *129–134*

Zusammenfassung
Der übliche Totalkontaktschaft für Oberschenkelprothesen hat verschiedene Nachteile, wie Schwierigkeiten beim Sitzen, beim Einziehen des Stumpfes in den Schaft und Probleme mit dem Schwitzen. Um diese Nachteile zu überwinden haben wir einen doppelwandigen thermoplástischen Schaft entwickelt. Er besteht aus einem äussern festen Schaft und einem abnehmbaren innern Schaft. Er scheint geeignet zu sein, alle Nachteile der herkömmlichen Prothesen zu lösen. Wir nennen sie die TC-Prothese, als Abkürzung für das Tokyo Metropolitan Rehabilitation Center. Das erste Modell dieser Prothese hat ein Metallventil, das seither durch ein Gummiventil ersetzt wurde. Seit 1978 haben wir 295 Amputierte mit dem ersten und seit März 1980 145 weitere Patienten mit dem zweiten Modell versorgt, darunter 9 bezw. 6 doppelseitig Amputierte. Gute Ergebnisse haben wir mit beiden Modellen erreicht.

Die Krukenberg-Operation zur Rehabilitation bilateraler Unterarmamputierter
B. P. Mathur, I. C. Narang, C. L. Piplani und M. A. Majid
Pros. Orth. Int. **5:3,** *135–140*

Zusammenfassung
Die Arbeit befasst sich mit der operativen Technik nach Krukenberg, wie sie ám Amputiertenzentrum in Pune, Indien, angewendet wird. Die Ergebnisse stützen sich auf 95 Amputationen bei 56 Patienten und

berücksichtigen Ursache und Höhe der Amputation sowie die Verteilung nach Alter und Geschlecht. Die Vorteile des Krukienberg-stumpfes bei doppelseitig Amputierten werden besonders besprochen.

Video-Aufnahmen Ein zusätzliches Hilfsmittel für die Gehschulung Beinamputierter
P. Netz, K. Werson und M. Wetterberg
Pros. Orth. Int. **5:3,** *147–150*

Zusammenfassung
Videoaufnahmen wurden verwendet als zusätzliches Hilfsmittel bei der Gehschulung Amputierter. 50 Patienten wurden befragt über ihre Eindrücke, sich am Fernsehschirm zu beobachten. Besonderer Wert wurde auf negative oder depressive Reaktionen gelegt. Doch konnten bei den untersuchten Patienten keine solchen Reaktionen beobachtet werden.

Einheimische Hilfsmittel als Ersatz für moderne Prothesen und Orthesen
T. Abayami Oshin
Pros. Orth. Int. **5:3,** *144–146*

Zusammenfassung
In den meisten Entwicklungsländern fühlen sich körperlich Behinderte oft zurückgesetzt, weil ihnen die Möglichkeiten moderner Hilfsmittel verschlossen sind und damit auch bestimmte Möglichkeiten der Rehabilitation. Am Universitätsspital in Ibadan betrifft dies in erster Linie Kinder mit Poliomyelitis, Hemiplegiker, Amputierte und Paraplegiker. Die Amputierten bewegen sich auf hölzernen Stelzbeinen, angefertigt durch die Ergotherapie, da eigentliche Prothesen in diesem Spital zur Zeit nicht erhältlich sind. Die Physiotherapeuten haben alerdings Mühe, ihren Patienten eine gute Gehschulung zu bieten, da den provisorischen Beinprothesen das Kniegelenk fehlt. Patienten auf dem Lande geben dem Stelzbein den Vorzug, da sie damit durch Wasser und Schmutz waten können. Schienen, Lähmungswinkel für den Fuss, Knieführungsapparate und Rumpforthesen sind notwendig bei 75% der 300 Kinder mit Kinderlähmung und bei einigen Paraplegikern. In Ermangelung von Passteilen, Rohstoffen und Personal sehen wir uns ausserstande, die Anforderungen zu erfüllen. So gut wie möglich behilft sich die Ergotherapie, aber auch einheimische Schuhmacher und Spengler versuchen, mit der Situation fertig zu werden. Aehnlich werden Halskragen aus alten PVC-Eimern hergestellt.

Es ist daher notwendig, vermehrt nach einheimischen Werkstoffen für Prothesen und Orthesen zu suchen. Es ist von Vorteil für die Patienten, wenn sie von ausländischen Passteilen und Werkstoffen unabhängig werden.

Sitzschalen für paralytische Skoliosen Modelle und erste Erfahrungen
B. R. Seeger und A. D. A. Sutherland
Pros. Orth. Int. **5:3,** *121–128*

Zusammenfassung
Die übliche Sitzfläche eines Rollstuhls stützt die Wirbelsäule eines muskelkranken Kindes praktisch überhaupt nicht. Mit zunehmender Muskelschwäche kann sich eine Skoliose entwickeln mit Schmerzen und Einschränkung von Atmung und Kreislauf. Bei schwerer Muskelschwäche ist die Behandlung der Skoliose praktisch aussichtslos. Die Hauptaufgabe besteht aber darin, die Zunahme der Skolise möglichst zu bremsen. Ein geeignetes Hilfsmittel ist nach unserem Dafürhalten ein nach Mass hergestellter Sitz. Dabei liessen sich erhebliche Kosten sparen, wenn solche Sitzschalen aus vorfabrizierten Teilen zusammengesetzt werden könnten.

Die Aufgabe geht von der einfachen Polsterung der Lehne zur Sitzschale nach Mass. Die anfänglich angewendete Vacuumtechnik ergab gute Ergebnisse, war jedoch sehr arbeitsaufwendig und entsprechend teuer. Dies führte uns zu einer billigeren Methode eines standardisierten Systems vorfabrizierter Bestandteile für muskelkranke Kinder im Schulalter. Vorläufige Ergebnisse sind recht erfolgversprechend. Die röntgenologischen Untersuchungen sind noch nicht abgeschlossen.

Español

Las clinicas para deficiencias de extremidades deben usarse lo antes posible
V. Angliss
Pros. Orth. Int. **5:3,** *141–143*

Resumen
Cuando ha nacido un niño con deficiencias en las extremidades, los padres necesitan una ayuda

inmediata. Esta ayuda requiere unos conocimientos que no son fáciles de encontrar en la comunidad. Por ello, es importante que estos niños y sus padres sean enviados por el Doctor que les atienda a dichas clínicas inmediatamente despueś del nacimiento. Los especialistas y los asistentes sociales de esas Clínicas no se encuentran facilmente en la práctica médica en general. El Jefe de la Clínica, el asistente social y el fisioterapeuta atienden a los padres y al niño en el Hospital. Los consejos que les den hacen más estrecha la relación entre padres e hijos. Tambien reduce el sentimiento de culpa de los padres por tener un hijo deforme. Los conocimientos acerca de prótesis, actividades de la vida diaria, las reuniones de padres, etc., ayudan a una forma de vida agradable.

Estudio de la forma de agarrar de una mano artificial por medios mecanicos
C. Fraser y A. W. Wing
Pros. Orth. Int. **5:3,** *151–156*

Resumen

El agarrar un objeto lleva consigo el transporte de la mano hacia el objeto y la abertura de la mano en cantidad suficiente antes de llegar al objeto. Se comparan los movimientos de una mano artificial izquierda con los de la mano derecha natural de un amputado. Aunque el agarrar objetos es mas lento con la mano artificial, hay movimientos similares en ambas manos. Independientemente de unas diferencias mecánicas, los movimientos del pulgar y el índica son similares. Se discute la estrategia del control de la mano artificial empleada por este sujeto relacionada con el entrenamiento de los amputados de brazo.

El encaje tc para protesis por encima de la rodilla
K. Koike, Y. Ishikura, S. Kakurai y T. Imamura
Pros. Orth. Int. **5:3,** *129–134*

Resumen

El encaje convencional de contacto y succión para prótesis por encima de la rodilla tiene varios inconvenientes, tales como la dificultad para sentarse, la dificultad de distribuir los tejidos blandos del muñón y el evitar los problemas de la piel del muñön. Tratando de resolver estos problemas, se ha desarrollado, en el Centro de Rahabilitación Metropolitan de Tokio, una prótesis con doble encaje termoplástico. El doble encaje se compone de un encaje externo desmontable sujeto a las partes bajas y otro interno desmontable que parece que resuelve todos los problemas de las prótesis convencionales. Esta prótesis se llama TC, abreviatura del Centro de Rehabilitación Metropolitan, de Tokio. El primer modelo de esta prótesis (TC–1) tiene una válcula de metal. En la prótesis TC–2 se ha desarrollado una nueva válvula con una plancha de goma, para evitar los inconvenientes de la de metal. Desde Noviembre de 1978 se han adaptado a 295 amputados por encima de la rodilla prótesis TC–1, incluyendo 9 bilaterales y desde Marzo de 1980 se ha adaptado la TC–2 a 145 amputados con 6 amputados bilaterales. Se han conseguido resultados satisfactorios con los dos tipos de prótesis.

Rehabilitacion del amputado bilateral por debajo del codo por el procedimiento de krukenberg
B. P. Mathur, I. C. Narang, C. L. Piplani y M. A. Majid
Pros. Orth. Int. **5:3,** *135–140*

Resumen

Se describe la técnica quirúrgica según el procedimiento de Krukenberg, habiendo sido aplicada en el Centro de Prótesis Artificiales, Pune, India. Los resultados de las 95 amputaciones en 56 pacientes se han examinado según la causa, edad, sexo y nível de amputación. Se discuten los beneficios de esta amputación en los amputados bilaterales.

Informacion videotape—una ayuda complementaria para el entrenamiento de la marcha en los amputados por debajo de la rodilla
P. Netz, K. Wersen y M. Wetterberg
Pros. Orth. Int. **5:3,** *147–150*

Resumen

La información con el Videotape se usó como una ayuda adicional en el entrenamiento de la marcha en amputados por debajo de la rodilla. Se solicitó información de 50 pacientes acerca de su reacción, viéndose ellos mismos en un monitor de TV, especialmente con respecto a los sentimientos negativos o depresivos resultantes de las sesiones de TV. Entre los pacientes examinados no se obtuvo ninguna reacción en ese sentido.

Sustituciones locales de las modernas protesis y aparatos
T. Abayomi Oshin
Pros. Orth. Int. **5:3,** *144–146*

Resumen

En la mayor parte de los paises en desarrollo, el disminuido físico notiene el oportuno tratamiento por no tener las modernas ayudas técnicas para su rehabilitación y que da como resultado no poder conseguir los mismos fines. Entre los pacientes que requieren rehabilitación en el Hospital del University College, de Ibadan, figuran los poliomielíticos, hemipléjicos y parapléjicos. Los amputados usan pilones o prótesis de madera fabricados por el fisioterapeuta, ya que no existen prótesis modulares ni P.T.B. Por tanto, los fisioterapeutas tienen problemas para conseguir una marcha correcta y otras actividades funcionals, al no tener articulaciones de rodilla. Los amputados en el campo usan pilones que les permiten pasar sobre suelo con agua o barro.

Se necesitan prótesis de pierna, antiequinos y corses para el 75% de los 300 niños con poliomielitis y para los parapléjicos que se tratan en el Hospital.

Debido a la falta de productos importados, materiales y mano de obra especializada, no es posible hasta ahora cubrir las necesidades. El Departamento de Terapia ocupacional, los fabricantes de zapatos y los soldadores resuelven en parte estos problemas.

Es necesario que se lleve a cabo una investigación sobre el uso de los materiales disponibles localmente para prótesis y ortesis y es necesario solventar los problemas de importación de piezas prefabricadas y materiales, en beneficio de los pacientes.

Asientos modulares para escoliosis paraliticas diseno y experiencias iniciales
B. R. Seeger y A. D. A. Sutherland
Pros. Orth. Int. **5:3,** *121–128*

Resumen

Los tirantes convencionales que tienen las sillas de ruedas no proporcionan ninguna sujeción de la columna vertebral de un niño con debilidad muscular miopática o neurogénica. Cuando los músculos de la columna son débiles, puede desarrollarse una escoliosis con deformidad, dolor y restricción de su función cardio-respiratoria. Si la debilidad muscular es muy intensa, la deformidad que se produce es virtualmente imposible de tratar; por tanto, lo más importante es retardar el desarrollo de la deformidad. Esta comunicación está basada en la hipótesis de que los asientos hechos con molde del paciente pueden resultar más cómodos y retrasar el desarrollo de las curvaduras de la columna vertebral de los niños con escoliosis paralítica y, más adelante, con una fabricación en serie pueden conseguirse estos objetivos a menor coste.

Se empezó por almohadillar los apoya-brazos, con objeto de distribuir fuerzas sobre la caja torácica y después con asientos adaptados al molde obtenido del paciente, por medio de bolsas de plástico con pequeñas bolitas, dándole la forma sobre el paciente por medio de vacío de las bolsas, lo que produjo varios asientos cómodos, aunque este método es costoso en tiempo y dinero. Esto nos llevó a intentar desarrollar un método que produjera un asiento confortable, que nos permitiera controlar la deformidad, a un precio razonable para los niños en edad escolar, con debilidad muscular miopática o neurogénica. Los primeros resultados indican que esta técnica puede tener ventajas sobre otros métodos de tratamiento y seguimos controlando los pacientes radiológicamente.

Français

Transfert précoce dans une clinique spécialisée en malformations des extrémités
V. Angliss
Pros. Orth. Int. **5:3,** *141–143*

Résumé

Les parents d'un enfant né avec une malformation des membres ont besoin d'aide immédiate, lorsque leurs craintes et problèmes sont des plus importants.

Ainsi il est très important que ces enfants et leurs parents soient transmis à une clinique spécialisée par leur médecin de famille dès après la naissance. Des thérapeutes expérimentés, des assistants sociaux attachés à ces cliniques ne sont en général pas présents dans les services d'obstétrique et chez les practriciens. Le médecin de service, l'assistant social et le

thérapeute rendent visite aux parents et à l'enfant à l'hôpital. Le contact précoce facilite la création d'un lien entre les parents et l'enfant. Il diminue aussi le sentiment de culpabilité et de détresse des parents d'avoir un bébé anormal. Des conseils adéquats concernant les prothèses et la vie quotidienne, des discussions de groupe de parents, des projets pour ces enfants contribuent à leur assurer une qualité de vie satisfaisante.

Étude de la préhension avec une prothèse de main mécanique
C. Fraser et A. W. Wing
Pros. Orth. Int. **5:3,** *151–156*

Résumé
La préhension suppose aussi bien le trajet de la main vers l'objet que son ouverture avant son arrivée vers l'objet. Les mouvements d'une prothèse de main gauche sont comparés à ceux de la main droite saine d'un amputé habitué à sa prothèse. Bien que le mouvement ait été plus lent avec la main artificielle, des similitudes d'ouverture et de transport ont été observées. Malgré les différences énormes entre la main mécanique et la main saine, les mouvements séparés du pouce et des doigs étaient semblables.

La manière d'utilisation par ce patient est discutée et utilisée pour la rééducation de nouveaux malades.

Prothèse de cuisse à double paroi
K. Koike, Y. Ishikura, S. Kakurai et T. Imanmura
Pros. Orth. Int. **5:3,** *129–134*

Résumé
La prothèse usuelle de cuisse, avec contact complet a divers désavantages, p.ex. pour s'asseoir, pour enfiler le moignon dans la prothèse et à cause de la sueur. Pour palier à ces inconvénients nous avons développé un fût thermoplastique et à double paroi. Il est fait d'une paroi externe fixe et d'une paroi interne amovible. Il semble adéquat à palier aux désavantages de la prothèse conventionelle. Nous l'avons baptisée TC, soit l'abréviation de Tokyo Metropolitan Rehabilitation Center. Le premier modèle TC–1 a une a une valve en métal. Le deuxième modèle a été construit avec une valve plate en caoutchouc pour parer aux désavantages de la valve métallique. Depuis novembre 1978, nous avons appareillé 295 amputés de cuisse y compris 9 amputés bilatéraux avec la TC–1 et depuis mars 1980, 145 amputés de cuisse (y compris 6 amputés bilatéraux) avec la TC–2. Avec les 2 types de modèles, nous avons obtenu des résultats satisfaisants.

Rééducation de l'amputé de l'avant-bras bilatéral par l'operation selon krukenberg
B. P. Mathur, I. C. Narang, C. L. Piplani et M. A. Majid
Pros. Orth. Int. **5:3,** *135–140*

Résumé
Cet article décrit la technique chirurgicale selon Krukenberg utilisée au centre des membres artificiels de Pune en Inde. Les résultats sont étudiés sur 95 amputations à 56 patients tenant compte de la cause, de l'âge, du sexe et de la hauteur de l'amputation. Les avantages de cette amputation sont discutés, spécialement concernant les amputés bilatéraux.

Videofilm—un moyen complémentaire de rééducation à la marche pour amputés
P. Netz, K. Wersen et M. Wetterberg
Pros. Orth. Int. 5:3, 147–150

Résumé
Des films vidéo ont été utilisés comme moyen complémentaire d'éducation à la marche chez des amputés de la jambe. Nous avons interrogé 50 patients sur leurs réactions de se voir eux-mêmes sur le petit écran et spécialement sur leurs réactions—éventuellement dépressives aprés les séances de TV. Aucun des patients ne présenta de telles réactions négatives.

Moyens auxilliaires indigènes au lieu de prothèses et d'orthèses modernes
T. Abayomi Oshin
Pros. Orth. Int. **5:3,** *144–146*

Résumé
Dans la plupart des pays en voie de développment, les handicapés physiques ont souvent d' énormes problèmes de rééducation par manque de moyens auxilliaries modernes, ce qui les empêchent de reprendre leurs activités quotidiennes. Enfants poliomyélitiques,

hémiplégiques, amputés et paraplégiques sont en premier lieu les patients venant demander de l'aide à l'hôpital universitaire d'Ibadan. Les amputés marchent sur des jambes de bois faites dans l'atelier de thérapie car les prothèses modernes usuelles ne sont pas obtenables dans notre hôpital. Les physiothérapeutes rencontrent donc des problèmes d'éducation à la marche et à d'autres activités puisque, pour les amputés de cuisse, manque l'articulation de genou. Les habitants des campagnes préfèrent ces pilons pour marcher dans l'eau et la boue.

Gouttières, attelles et corsets sont nécessaires à 75% des 300 enfants polio et à certains des paraplégiques jouissant de physiothérapie. Il nous est impossible de faire face à la demande par manque de pièces importées, de matériel et de personnel expérimenté. Notre ergothérapie, mais également des cordonniers et des ferblantiers indigènes nous dépannent le plus possible. De même des supports de tête sont faits avec de vieux baquets plastics.

C'est pourquoi il est nécessaire d'intensifier la recherche d'utilisation de matériaux indigènes pour les prothèses et les orthèses. C'est offrir un grand avantage au patient que de le rendre indépendant des pièces de rechange étrangères.

Siège-coquille pour scoliotique sur paralysie: premières expériences

B. R. Seeger et A. D. A. Sutherland

Pros. Orth. Int. **5:3,** *121–128*

Résumé

La chaise roulante conventionnelle a un dossier qui ne soutient que peu ou pas la colonne vertébrale d'un enfant, dont la musculature est malade. Avec l'augmentation de la faiblesse musculaire s'accentuent la scoliose et ses conséquences, déformité, douleur et restriction de la fonction cardio-pulmonaire. Si la faiblesse musculaire est très importante, le traitement de la scoliose est quasi impossible. Le meilleur but est de ralentir l'augmentation de la déformité. Notre travail a pour hypothèse qu'un siège-baquet peut augmenter le confort de l'enfant et limiter la progression de la scoliose et dans un 2e temps qu'une série de sièges standard peut compléter ce programme à moindre frais.

Un travail antérieur prévoyait tout le cheminement allant du simple rembourage des accoudoirs pour mieux distribuer les forces agissant sur la cage thoracique au siège-coquille sur mesure.

Nos premiers travaux sur les sièges-coquilles, faits sur mesure par méthode sous vide ont produit des sièges confortables. Cependant la méthode exigeait un travail intensif et donc un prix de revient élevé. Nous avons donc cherché une autre méthode ayant un pris raisonnable pour les mêmes avantages orthopédiques. La publication décrit le design d'une chaise standardisée adaptée aux enfants en âge scolaire souffrant de faiblesse musculaire myo- ou neurogène. Les premiers résultats paraissent indiquer certains avantages par rapport à d'autres méthodes de traitment. Les contrôles radiologiques continuent.

Italiano

Dismelia congenita: un ricovero tempestivo presso cliniche specializzate.

V. Angliss

Pros. Orth. Int. **5:3,** *141–143*

Abstract

La nascita di un bambino affetto da dismelia congenita è sempre fonte di gravissimi problemi e timori per i genitori. E' quindi necessario mettere questi ultimi in condizione di avvelersi di un sostegno immediato, costituito da forme diverse di assistenza specialistica non sempre disponibili in seno alla comunità. Perciò è importante che questi bambini ed i loro genitori vengano inviati dal proprio medico presso Cliniche Specialistiche fin dal momento della nascita. I medici generici e gli ostetrici non si possono infatti normalmente avvalere della competenza dei qualificati terapisti ed assistenti socio-sanitari che prestano invece la loro opera in tali cliniche. Il direttore sanitario della Clinica, l'assistente sociale ed il terapista visitano i genitori ed i loro figli in ambito ospedaliero. Questa tempestiva forma di consulenza favorisce l'instaurarsi dei legami fraigenitori ed il bambino e contribuisce a ridurre il senso di colpa e l'angoscia dei genitori nei confronti del loro figlio malformato. Un'adeguata consulenza fornita a questo livello circa l'impiego di protesi, le attività quotidiane, le discussioni di gruppo in cui sono coinvolti i genitori e le prospettive per il futuro di questi bambini possono garantire loro un'esistenza soddisfacente.

Studio di un caso di prensione con mano protesica a comando manuale.

C. Fraser e A. W. Wing

Pros. Orth. Int. **5:3,** *151–156*

Abstract

La prensione implica sia il trasporto della mano in direzione di un determinato oggetto sia l'opportuna apertura della mano stessa prima che questa raggiunga l'oggetto in questione. Si sono paragonati i movimenti di una mano sinistra protesica a comando manuale con quelli della mano destra sana di un paziente con buona funzionalità della mano protesica. Benché la raccolta degli oggetti avvenisse più lentamente quando fosse effettuata con la mano protesica, le due mani hanno mostrato una certa similitudine nei movimenti di apertura e di trasporto. Nonostante le notevoli differenze riscontrate nei meccanismi coinvolti nel movimento della mano naturale e di quella protesica, le affinità si estendevano ai movimenti separati del pollice e delle altre dita. Nel presente report si analizza la strategia che presiede al comando della mano protesica utilizzata dal soggetto esaminato e la si pone in relazione alla rieducazione dei nuovi protetizzati con mano artificiale.

Protesi tc a doppia invasatura per amputati di coscia

K. Koike, Y. Ishikura, S. Kakurai e T. Imamura

Pros. Orth. Int. **5:3,** *129–134*

Abstract

La tradizionale protesi di coscia a contatto totale presenta numerosi inconvenienti, quali difficoltà nell'indossare la protesi in posizione seduta, difficoltà nell'ottenere un'adeguata dispozione dei tessuti molli del moncone all' interno dell'invasatura e difficoltà nell'evitare problemi relativi alla traspirazione del moncone. Nel tentativo di ovviare a tali inconvenienti, al Centro Rieducazione per Hanicappati Fisici e Mentali della città di Tokyo è stata messa a punto una nuova protesi per amputati di coscia dotata di una doppia invasatura termoplastica. Tale doppia invasatura si compone di un'invasatura esterna fissata nella parte inferiore e di una invasatura interna amovibile, e sembra in tal modo risolvere i problemi solitamente posti dalle protesi tradizionali. Questa protesi viene chiamata protesi TC, un'abbreivazione di Tokyo Metropolitan Rehabilitation Center. Il primo modello di una protesi di questo tipo (TC–1) presenta una valvola metallica, che tuttavia dava luogo a numerosi inconvenienti, per ovviare ai quali nella protesi TC–2 è stata messa a punto una valvola di gomma in fogli. A partire dal novembre 1978, la TC–1, è stata applicata a 295 amputati di coscia, compresi 9 amputati bilaterali, e dal marzo 1980, la TC–2 è stata invece applicata a 145 amputati di coscia, di cui 6 bilaterali. Entrambe le protesi hanno dato risultati soddisfacenti.

Rieducazione dell'amputato bilaterale dell'avambraccio secondo il metodo krukenberg.

B. P. Mathur, I. C. Narang, C. L. Piplani e M. A. Majid

Pros. Orth. Int. **5:3,** *135–140*

Abstract

Nel presente report viene illustrata la tecnica chirurgica Krukenberg che viene applicata presso il Centro Arti Artificiali di Pune, in India. Vengono presi in esame i risultati di 95 amputazioni effettuate su 56 pazienti, in riferimento alla loro distribuzione per sesso e per età, ed alle cause e ai livelli di amputazione. Vengono infine analizzati i benefici apportati da tale amputazione all'amputato bilaterale.

Videoregistrazione-un ausilio supplementare per la rieduca zione deambulatoria degli amputati degli arti inferiori.

P. Netz, K. Wersen e M. Wettenberg

Pros. Orth. Int. **5:3,** *147–150*

Abstract

Si è impiegata la registrazione su videocassette come ausilio supplementare per la rieducazione deambulatoria degli amputati degli arti inferiori. Sono stati intervistati 50 pazienti, cui è stato chiesto di descrivere le proprie reazioni nell'osservare se stessi su un monitor televisivo, tenendo particolarmente conto di eventuali sensazioni negative o depressive conseguenti alle sessioni televisive. Nei pazienti esaminati non è stato possibile osservare alcuna reazione di questo tipo.

Surrogati locali delle moderne protesi ed ortesi.

T. Abayomi Oshin

Pros. Orth. Int. **5:3,** *144–146*

Abstract

Nella maggior parte dei paesi in via di sviluppo,

gli handicappati fisici incontrano spesso notevoli problemi a livello rieducativo, quali per esempio la mancata disponibilità di moderni presidi per la rieducazione, e ciò può ostacolare o addirittura impedire il conseguimento degli obiettivi desiderati nell'ambito delle attività quotidiane. Ibambini poliomielitici, gli empliegici, gli amputati ed i paraplegici sono fra i pazienti che maggiormente necessitano delle cure rieducative praticate presso l'University College Hospital di Ibadan. Poiché le protesi modulari P.T.B. non sono attualmente disponibili presso tale ospedale, gli amputati devono fare ricorso ad arti in legno o in metallo realizzati dal reparto di terapia occupazionale. I terapisti si trovano dunque di fronte a notevoli difficoltà nell'insegnare all'amputato di coscia le corrette configurazioni deambulatorie ed altre attività funzionali, in quanto vengono a mancare le articolazioni del ginocchio. Gli amputati dediti ad attivatà agricole nelle zone rurali impiegano arti in metallo, con cui possono guadare attraverso l'acqua qua ed il fango degli ambienti in cui vivono.

Il 75% dei 300 bambini affetti da poliomielite ed alcuni dei paraplegici sottoposti a terapia fisica in questo ospedale necessitano di tutori, de meccanismi per l'estensione delle dita dei piedi, di ortesi per il ginocchio e di ortesi spinali.

A causa della scarsezza di componenti di fabbricazione straniera, nonché di materiali e di personale qualificato, non è stato possibile soddisfare questo tipo di esigenze. Il reparto di terapia occupazionale, ed i calzolai e saldartori locali fanno tutto il possibile per migliorare la situazione, per esempio ricavando collari cervicali da secchi in PVC.

Sedile modulare per pazienti affetti da scoliosi con paralisi: design e prime esperienze.

B. R. Seeger e A. D. A. Sutherland

Pros. Orth. Int. **5:3,** *121–128*

Abstract

L'imbracatura del modello tradizionale di sedile per sedia a rotelle offre un sostegno scarsissimo o addirittura nullo alla spina dorsale dei bambini affetti da miopatia o da ipostenia muscolare neurogena. Con la progressiva ipostenia dei muscoli spinali può verificarsi l'insorgenza di una scoliosi associata a malformazioni, sintomatologia algica e alla compromissione delle funzioni cardiorespiratorie. Qualora l'ipostenia muscolare si presenti in forma grave, la piena malformazione che ne risulta appare praticamente incurabile. Nel trattamento di questi casi, le maggiori speranze vengono perciò riposte in un rallentamento della velocità a cui la malformazione stessa si sviluppa. Nel presente report viene considerata l'ipotesi che la realizzazione di un sedile specificamente conformato all'anatomia del paziente che ne fa uso possa aumentarne la confortevolezza in posizione seduta, rallentando altresì la progressione della curvatura della spina dorsale nei bambini affetti da scoliosi con paralisi, unitamente alla possibilità che la creazione di un'interagamma di sedili standard o modulari sia in grado di raggiungere gli stessi obiettivi ad un costo inferiore.

Gli studi precedentemente dedicati a questo problema hanno contemplato diverse soluzioni, dalla semplice imbottitura del bracciolo per distribuire la forza sulla gabbia toracica, fino alla creazione del sedile personalizzato. Le nostre prime esperienze in questo senso, compiute ricorrendo alla tecnica della "bean bag evacuation and consolidation", hanno dato luogo alla realizzazione di numerosi modelli di sedili confortevoli, ma il largo impiego di manodopera e di conseguenza il costo che tale tecnica comportava ci ha indotto a mettere a punto una nuova metodologia che consentisse di fabbricare un sedile confortevole in grado di controllare le malformazioni spinali ad un costo ragionevole. Vengono qui illustrate le caratteristiche del design di un modello standard per bambini in età scolare affetti da miopatia o da ipostenia muscolare neurogena. I risultati preliminari sembrano indicare che questa tecnica presenta dei vantaggi rispetto a metodi di trattamento alternativi. La ricerca radiologica è ancora in atto.

Prosthetics and Orthotics International, 1982, 6, 64–66

Calendar of events

New York University Medical Center
Prosthetics and Orthotics

Short-Term Courses
Courses for Physicians and Surgeons

744B Upper Limb Prosthetics and Orthotics; 21–25 June, 1982.

Courses for Therapists

742C Lower Limb Prosthetics; 10–21 May, 1982.
757 Upper Limb Orthotics; 7–11 June, 1982.
745 Upper Limb Prosthetics; 14–18 June, 1982.

Courses for Orthotists

758 Upper Limb Orthotics; 1–11 June, 1982.
753 Lower Limb Orthotics; 6–23 July, 1982.

Courses for Prosthetists

743 Above-Knee Prosthetics; 14 June–2 July, 1982.

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

North Western University Medical School

Short Term Courses
Courses for Physicians, Surgeons and Therapists

702C, 703C Spinal, Lower and Upper Limb Orthotics; 24–28 May, 1982.
602G, 603G Lower and Upper Limb Prosthetics; 7–11 June, 1982.

Course for Physicians and Surgeons

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

Course for Physical Therapists

622B Lower Limb Prosthetics; 17–21 May, 1982.

Courses for Rehabilitation Personnel

761 Certificate Programme in Orthotics; 1 February–15 June, 1982.
631, 632, 633 Management of the Juvenile Amputee for Physicians, Surgeons, Therapists and Prosthetists; 10–13 May, 1982.
801 Pedorthic Management of the Foot; 14–18 June, 1982.

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

10–13 May, 1982
ISPO Advanced course on below-knee and through-knee amputations and prosthetics, Hotel Hvide Hus, Køge, near Copenhagen.
Information: ISPO Secretariat, Borgervaenget 5, DK 2100, Copenhagen Ø, Denmark. Tel. (01) 20 72 60. Telegrams: INTER.

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

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

14–18 June, 1982
5th European Conference on Electro-technics, Lyngby, Denmark.
Information: Dieu, Danish Engineers' Postgraduate Institute. The Technical University of Denmark, Bldg 208, DK–2800 Lyngby, Denmark.

22–25 June, 1982
Orthopädie-Technik International Congress, Wiesbaden, Germany.
Information: The Secretary, Bundesinnungsverband für Orthopädie-Technik, Reinoldstr. 7–9, D–4600, Dortmund 1, Germany.

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

12–14 July, 1982
Biomedical Polymers, Durham, England.
Information: Biological Engineering Society, Royal College of Surgeons, Lincoln's Inn Fields, London WC2A 3PN.

13–16 July, 1982
4th World Congress of International Ostomy Association, Munich, Federal Republic of Germany.
Information: Deutsche Ilco, Kammergasse 9, D–8050 Freising, Federal Republic of Germany.

28–30 July, 1982
Pan-Pacific International Symposium on Biomaterials, Vancouver.
Information: Dr. R. H. Roydhouse, Secretariat Biomaterials '82 1704. 1200 Alberni St., Vancouver, B.C. Canada V6E 1A6.

9–27 August and 17 September
Spinal manipulation (basic course) Bath, England.
Information: Chartered Society of Physiotherapy, 14 Bedford Row, London WC1R 4ED.

15–18 August, 1982
9th Canadian Medical and Biological Engineering Conference and Exposition, University of New Brunswick, Fredericton, N.B., Canada.
Information: The Conference Secretariat, Bio-Engineering Institute, University of New Brunswick, P.O. Box 4400, Fredericton, N.B., Canada E3B 5A3.

30 August–2 September, 1982
50th Anniversary Conference, Engineering in Orthopaedic Surgery and Rehabilitation, Edinburgh, Scotland.
Information: Conference Secretariat (OBEU), Princess Margaret Rose Orthopaedic Hospital, Fairmilehead, Edinburgh EH10 7ED, Scotland.

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

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

8–10 September, 1982
Second Annual Advanced Course on Lower Extremity Prosthetics, New York.
Information: Dr. L. W. Friedmann, Chairman, Department of Physical Medicine and Rehabilitation, Nassau County Medical Centre, 2201 Hempstead Turnpike, East Meadow, New York 11554, U.S.A.

6–8 October, 1983
1st European Congress on Scoliosis and Kyphosis, Dubrovnik, Yugoslavia.
Information: Prof. Dr. Marko Pecina, Dept. of Orthopaedics, University of Zagreb, Salata 6, yu–41000 Zagreb, Yugoslavia.

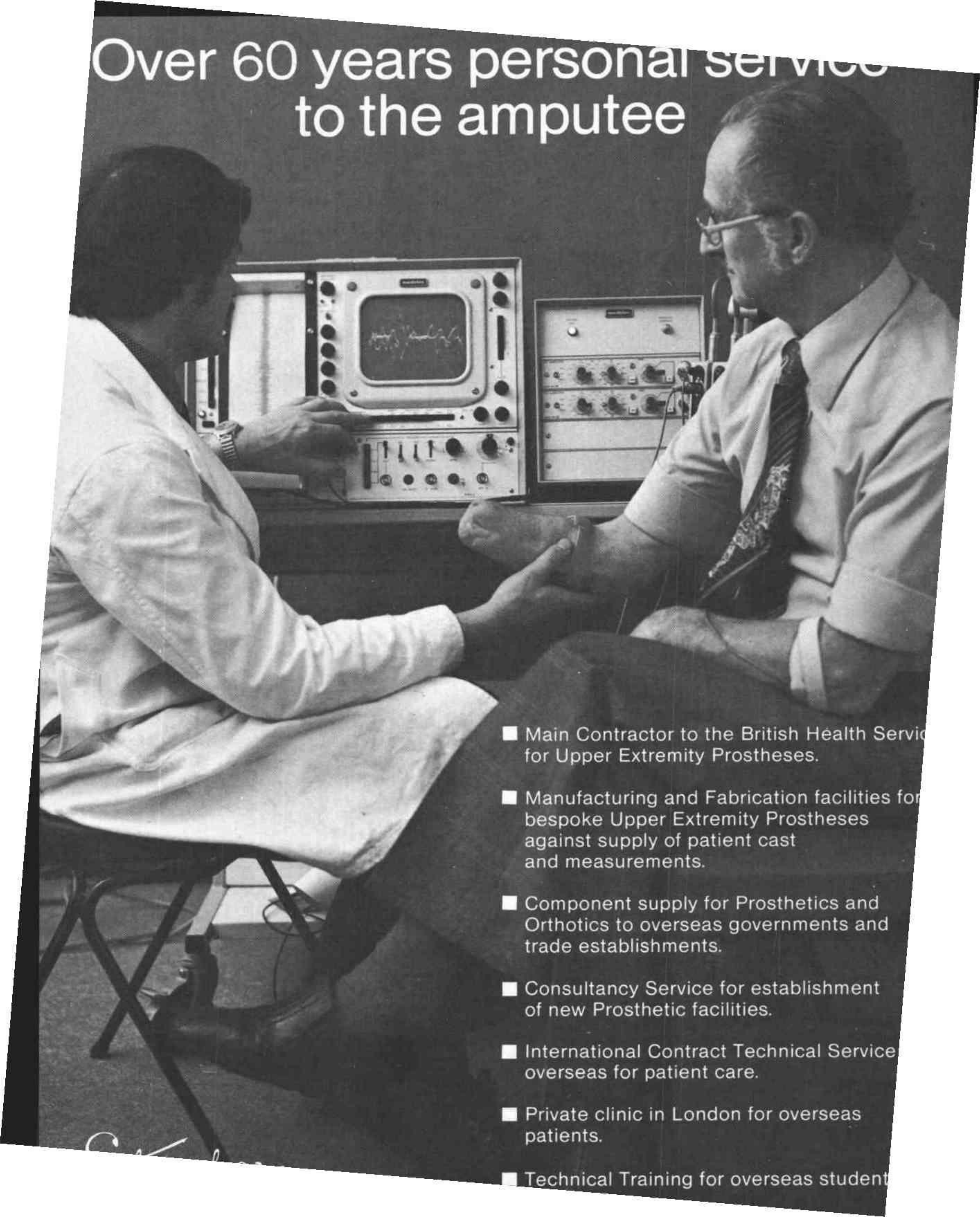
13–15 October, 1982
Naidex '82, National Aids for the Disabled Exhibition and Conference, London.
Information: The Conference Officer, RADAR, 25 Mortimer Street, London W1N 8AB, England.

31 October–6 November, 1982
3rd Far East and South Pacific (FESPIC) Games for Physically Disabled to be held in Hong Kong.
Information: Joint Council for the Physically and Mentally Disabled, G.P.O. Box 474, Wanchai, Hong Kong.

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

5–9 September, 1983
I.S.P.O. Fourth World Congress, London.
Information: Conference Services Ltd., 3 Bute Street, London.

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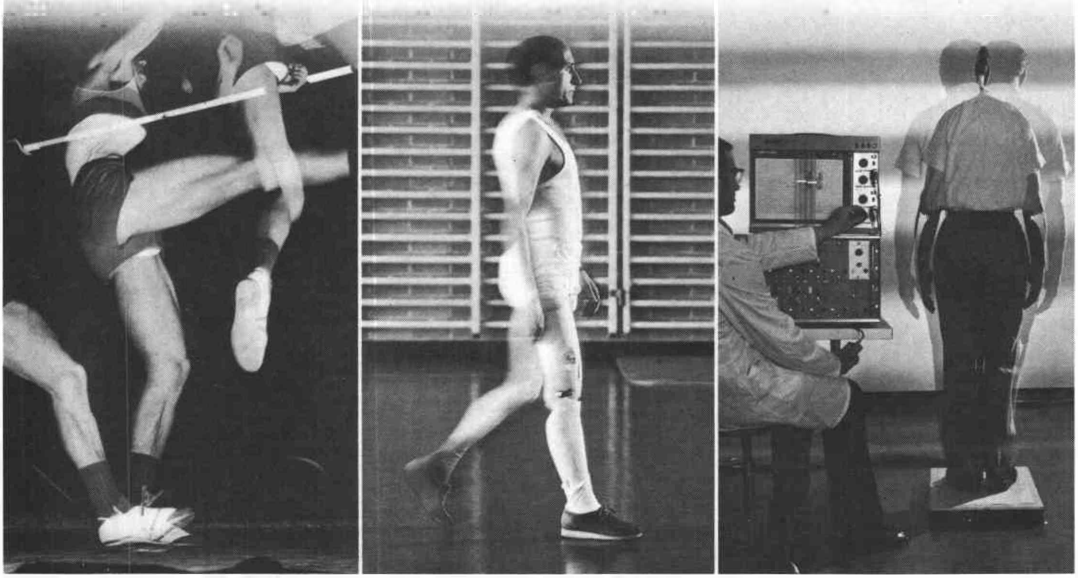

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The Department of Physical Medicine & Rehabilitation
of the Nassau County Medical Center
September 8, 9, 10, 1982

LECTURES

What Below-Knee Suspension for what Patient?; Nonquadrilateral Above-Knee Sockets; The Adult Problem Stump—Revise or Fit?; The Conservative Treatment of Osseous Overgrowth; Special Problems of Amputation During the Growing Period; Are Prostheses and Training of the Hip Disarticulaton Patient Adequate?; Above-Knee Gait Deviations and their Correction; Sensory Implications of Lower Extremity Amputation; Femoral Defects (PFFD)—Total Rehabilitation; American Methods for Treating the Child Lower Limb Amputee; Amputation in Art Before Columbus; The Patient's Decision to Accept or Reject the Limb; Is Cosmesis Important for the Lower Extremity Amputee?; A Woman's Reactions to Prosthetic Design; Tibial Defects and their Rehabilitation; Fibular Defects and their Rehabilitation; Bone and Joint Problems; Skin, Muscle and Nerve Problems; Geriatric Legs; Legs for Heavy Work; Newer Feet and Ankles (S.A.F.E., Mauch, Haberman, etc.); Sport Prostheses; Sexual Implications of Leg Amputation; Mourning by Amputees; The Multiple Amputee—Total Rehabilitation—"The Adult"; The Multiple Amputee—Total Rehabilitation—"The Child".

SPEAKERS

Victor Cummings, M.D., Prof. of Rehab. Med., Albert Einstein College.
James T. Demopoulos, M.D., Dir., Dept. of Rehabilitation, Hospital for Joint Diseases-Orthopaedic Institute, Prof. of Rehabilitation Medicine, Mt. Sinai School of Medicine.
Malcolm Dixon, R.P.T.
Mary Dorsch, CPO
Donald H. Eisenberg, Executive Director, Nassau County Medical Center.
John Eschen, CPO.
Lawrence W. Friedmann, M.D., Chairman, Dept. of Physical Med. & Rehab., NCMC also Professor of Rehabilitation Medicine, SUNY at Stony Brook, Health Sciences Center.
Liesl Friedmann, OTR, Institute of Rehabilitation Medicine, NY University.
Selene Jaramillo, M.D., Institute of Rehabilitation Medicine, NY University.
Elizabeth Kolin, Ph.D., Clinical Psychologist, Nassau County Medical Center.
H. Richard Lehneis, CPO, Ph. D., Dir., Prosthetics & Orthotics, Institute of Rehabilitation Medicine, New York University School of Medicine.
Prof. Dr. Med. Ernst Marquardt, M.D., University of Heidelberg, Germany.
Clifton S. Mereday, RPT.
Alvin Pike, CPO.
Francis T. Purcell, County Executive, Nassau County.
Gustav Rubin, M.D., Orthopedic Surgeon & Consultant, Veterans Administration Rehabilitation Engineering Center.
Daniel Shapiro, M.D., Asst. to Chairman, Dept. of Physical Medicine & Rehabilitation, Nassau County Medical Center.
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References

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References to articles in books should include author, year of publication, article title, book title edition, editor (if different from author) first and last pages, publisher and place of publication. For example, Hughes, J. (1975). Recent developments in prosthetics and orthotics. Recent Advances in Orthopaedics (2) Ed. McKibbin, B., 196–216, Churchill Livingstone, Edinburgh.

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