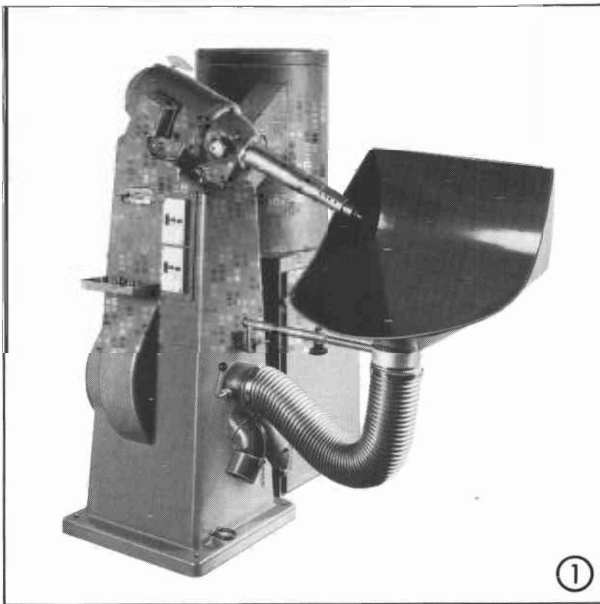




**The Journal of the International Society
for Prosthetics and Orthotics**

Prosthetics and Orthotics International

April 1984, Vol. 8, No. 1



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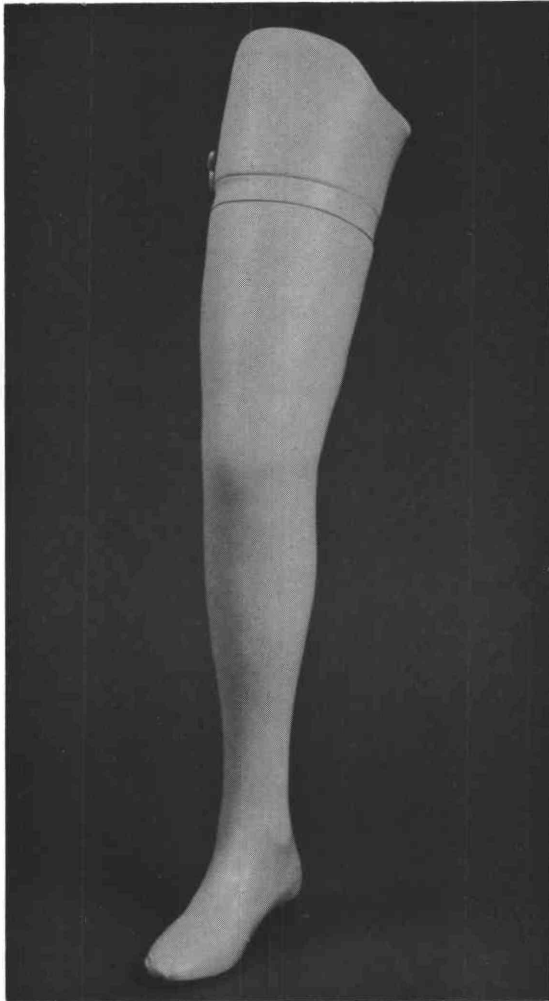
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The Journal of the International Society for Prosthetics and Orthotics

April 1984, Vol 8, No.1

Contents

Editorial	1
Award for the President	3
Obituary—D. S. MCKENZIE	4
I.S.P.O. Accounts	6
The Knud Jansen Lecture—Amputation revisited G. MURDOCH	8
A method for determining the mechanical characteristics of orthotic knee joints R. P. SCOTHERN and G. R. JOHNSON	16
Potential problems of manufacture and fitting of polypropylene ultralightweight below-knee prostheses P. CONVERY, D. JONES, J. HUGHES and G. WHITEFIELD	21
Clinical experience of gait analysis in the management of cerebral palsy J. U. BAUMANN	29
The technique of reciprocal walking using the hip guidance orthosis (hgo) with crutches P. B. BUTLER, R. E. MAJOR and J. H. PATRICK	33
Measurement of skin perfusion pressure by photoelectric technique—an aid to amputation level selection in arteriosclerotic disease J. OVESEN and M. STØCKEL	39
Functional capabilities of lower limb amputees I. C. NARANG, B. P. MATHUR, P. SINGH and V. S. JAPE	43
Technical note—A method for socket duplication using Silcoset R 105 N. J. TOUNG	52
Technical note—R.T.V. silicone insoles D. J. PRATT, P. H. REES and R. H. BUTTERWORTH	54
Technical note—An angular alignment protractor for use in the alignment of below-knee prostheses G. KERR, M. SALEH and M. O. JARRETT	56
Review—Choosing the best wheelchair cushion	58
Calendar of events	59
I.S.P.O. Publications	63

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Editorial

In this issue of the Journal you will find the complete accounts for the fiscal year 1983 as well as this analysis of the accounts for the years 1981, 1982 and 1983.

As indicated in Table 1, the membership fees still constitute the main source of income, the increase being rather constant over the three years.

Contributions apparently increased in 1983 by D.Kr. 60.884, — however this includes D.Kr. 37.500 due at the end of 1982. Interest from bank accounts and bonds has increased to 11% of the total income.

Table 2 indicates changes in the Society's expenses over the three year period. The cost of the Secretariat in Copenhagen as well as Meeting and Travelling expenses increased at a rather constant rate, which is almost equal to that of inflation. The negative expense for the journal indicates an income.

Table 1. ISPO Income 1981,1982 and 1983

Year	Total Income	Membership Fees	Contributions	Interest	Other
1981	472,911 100%	366,229 77.4%	62,393 13.2%	38,890 8.2%	5,399 1.2%
1982	590,136 100%	437,995 74.2%	91,526 15.5%	55,354 9.4%	5,261 0.9%
1983	808,616 100%	517,261 64.0%	152,410 18.8%	89,398 11.1%	49,547 6.1%

Table 2. ISPO Expenses 1981,1982 and 1983

Year	Total Expenses	Secretariat ¹ Copenhagen	Journal ² P/O International	Meetings and ³ Travelling	Other
1981	316,436 100%	200,365 63.3%	27,142 8.6%	86,637 27.4%	2,292 0.7%
1982	385,345 100%	241,724 62.7%	30,230 7.8%	110,851 28.8%	2,540 0.7%
1983	387,397 100%	252,964 65.3%	-40,475	128,396 33.1%	6,037 1.6%

¹Secretariat expenses include: salaries, pension contribution, stationery, printed matter, postage and freight, telephone, data system, repairs and maintenance, auditing and sundries.

²Journal: indicates the deficit for the years 1981 and 1982 and the profit for 1983.

³Meetings and Travel: indicates expenses related to board meetings, participation of board members as representatives of ISPO at meetings of other international organizations as well as travel expenses for the Honorary Secretary connected with his duties in Copenhagen.

Table 3. The Journal of the International Society for Prosthetics and Orthotics
'Prosthetics and Orthotics International' 1981, 1982, and 1983

Year	Total Expenses incl. Air Mail	Income Advertising	Income Subscriptions	Deficit
1981	195,182 100%	91,338 46.8%	76,702 39.3%	27,142 13.9%
1982	213,648 100%	89,721 42.0%	93,697 43.9%	30,230 14.1%
1983	244,387 100%	159,719 65.4%	125,143 51.2%	-40,475 ¹ 16.6%

¹Note that 1983 indicates a profit of 40,475.

As will be seen from Table 3 the income from advertising in the journal as well as income from subscription has now for the first time exceeded the production costs. Our congratulations to the editors, their co-workers and not least to all who have contributed with papers of high quality.

The financial status of our Society is now a healthy one and opens the possibility for increased activity. At its meeting in London, in September 1983, the Executive Board decided to provide financial support to three international seminars on education to take place in Tanzania and Canada in 1984 and in Sweden 1985. In addition it was decided to support the work on Design and Lay Out of Prosthetic/Orthotic units and the publishing of a manual on orthotics for developing countries.

In order to maintain a sound financial basis for the future the Board also decided to maintain a reserve capital of about D.Kr. 750.000 to be invested in bonds.

The Executive Board expresses its gratitude to all our active members including those contributing to the activities of the National Societies.

Erik Lyquist

Vice-President and Honorary Treasurer.

Congratulations to the President



Our President, Professor Dr. Ernst Marquardt, celebrated his 60th birthday on 4th February. The University of Heidelberg marked the occasion with a symposium and presentation which honoured his work. During the proceedings Professor Marquardt was presented with the Albert Schweitzer Medal. Friends and co-workers throughout Europe were in Heidelberg to share the day with him.

We are sure that the membership will join with us in congratulating him and wishing him well in the continuation of his good work.

Obituary

Donald Stewart McKenzie



D. S. McKenzie died peacefully on 29th January, 1984 at the age of 71 after a long and at times very distressing illness. He displayed courage and immense good humour throughout.

Donald Stewart McKenzie or "Mac" as he was known to all, started his medical career in Edinburgh University, graduating MB ChB in 1935. He had a distinguished career in the Royal Army Medical Corps in the Second World War, attaining the rank of Major. It was during this time that he developed his interest in the amputee and prosthetics and he was largely responsible for establishing the Limb Fitting Centre at Poona in India — ISPO held an instructional course there in 1973 and we know that it is still a well organized and very active unit.

From that time he remained in the field of prosthetics becoming successfully Medical Officer and then Senior Medical Officer under the Ministry of Pensions at the Limb Fitting Centre in Roehampton. Thereafter he was appointed Director of the Ministry of Health Research Unit and in 1968 as Director of the newly created Biomechanical Research and Development Unit at Roehampton with the rank of Principal Medical Officer.

In 1961 he was decorated with the Croix de Merité Combattants Chevalier by the French Ministre de Anciens Combattants. He held a number of honorary appointments with hospitals in the London area, and in 1972 in recognition of his services to the amputee was elected a Fellow of the Royal College of Surgeons of England. He was elected Honorary Fellow of the International Society for Prosthetics and Orthotics in 1978 at the end of a career devoted to our cause and our Society.

Mac was one of the founder members of the International Committee for Prosthetics, Braces and Technical Aids, of ICPO and of ISPO itself. He was our first chairman of the Standing Committee on Membership and by his industry, persistence and sensitivity established the system of National Member Societies wherein lies the real strength of our Society.

His standing as a teacher of international repute was largely based on his contribution to the succession of International Courses held in Copenhagen during the late fifties and sixties. Twelve or thirteen lectures during these courses was small beer to "Mac" and his energy and enthusiasm on these occasions went a long way to bridging the gap between medicine and engineering. For me, the contribution he made to the "Dundee" conferences was crucial to their success.

"Mac" savoured the commitment and comradeship within our Society. He clearly enjoyed a visit that Erik Lyquist, Mirak Vitali and I made just after the London Congress. Despite the state of his health, the difficulties imposed by his illness on communication, he was in great humour recalling moments of high drama and low comedy in the history of our Society.

Patients and colleagues throughout the world will mourn his passing. He was essentially a clinician with an enquiring scientific approach thus equipping him for his life's task in promoting the quality of life for the amputee. "Mac", pipe in mouth, with that special twinkle in his eye and his observations on his "Uncle Hamish" will be remembered equally well for the warmth of his personal qualities.

His wife Kay, a boon companion as well as loving spouse, supported him completely in these last years. She will have the comfort and support of "Mac's" four children and eight grandchildren who also survive him.

George Murdoch.

I.S.P.O. Statement of Accounts, 1983

Balance as at December 31, 1983

Income

Membership fees		517.261	
Sponsorship fees		1.537	
Contributions:			
The War Amputations of Canada C\$5.000		39.910	
Society and Home for Disabled		112.500	
Miscellaneous (Literature)		7.150	678.358
<hr/>			
Interest:			
Bonds	1.800		
Bank accounts	104.310	106.110	
<hr/>			
-Paid interest (bonds bought incl. coupon)		16.712	89.398
<hr/>			

Expenditure:

Salary: Aase Larsson		162.808	
A.T.P. and pension		19.814	
Printing Expenses:			
Journal: Prosthetics and Orthotics International:			
Printing cost incl. air mail posting	220.269		
Production service	21.281		
Labels	2.837		
<hr/>			
		244.387	
<hr/>			
Less income:			
Advertising	159.719		
Subscription	125.143	284.862	40.475
<hr/>			

Printing Expenses:

Journal: Deformed Foot			
Less income		385	385
<hr/>			

Stationery and printed matter		11.452	
Postage and freight		20.670	
Meeting and travelling expenses:			
Miscellaneous	11.701		
Executive Boards, incl. meetings			
Copenhagen, London, Glasgow	116.695	128.396	
<hr/>			
R.I. fee 1982 and 1983		6.037	
Telephone		4.998	
Repairs and maintenance		1.234	
Miscellaneous expenses:			
Data system	16.517		
Sundry	7.788		
Auditing	7.683	31.988	
<hr/>			

Surplus as at December 31, 1983		387.397	808.616
		421.219	
		<hr/>	<hr/>
		D.kr. 808.616	D.kr. 808.616

Balance as at December 31, 1983**Assets**

Cash on hand		1.621	
Bank accounts:			
Handelsbanken Chech no. 524.052.	24.211		
Handelsbanken Book no. 856.742	33.677	57.888	
Handelsbanken Book no. 650.591 (Knud Jansen Foundation)			1.933
Debtors: Advertising 1983			29.842
Bonds:			
Nom. kr. 18.000 10% Østifternes Kreditforening 18/2003 (Course 31.12.83: 84¾, value D.kr. 15.255)	12.690		
Nom. kr. 537.000 10% Dansk Statslån S. 1988 (Course 31.12.83: 95¼%, value D.kr. 511.492)	500.831		
Nom. kr. 521.000 10% Dansk Statslån S. 1979/89 (Course 31.12.83: 94%, value D.kr. 489.740)	480.039	993.560	
Stocks: D.kr. 5.000 Kjøbenhavns Handelsbank (Course 31.12.83: 338, value D.kr. 16.900)			16.160
Contributions to: World Congress 1980	97.227		
Less repayment	8.241	88.986	
World congress, London 1983			183.752
Liabilities:			
Creditor:			
Accountant	3.416		
A.T.P., tax and pension	6.228		9.644
Knud Jansen Foundation			1.767
Balance as at January 1, 1983 (Capital account)	941.112		
+ Surplus for the year 1983	421.219		1.362.331
		D.kr. 1.373.742	D.kr. 1.373.742

The above mentioned accounts, which have been examined, are in accordance with the book-keeping for the year 1983.

Bagsværd, February 9, 1984.

GUNNER PETERSEN, H.D.

Registered Accountant,

Denmark.

THE KNUD JANSEN LECTURE

Amputation revisited

G. MURDOCH

Department of Orthopaedic and Traumatic Surgery, University of Dundee, Scotland

Introduction

This lecture was created to honour our founder President Knud Jansen. In New York the Knud Jansen lecture was presented by Charles Radcliffe (1977) and in Bologna by Ernst Marquardt (1980; 1981). The author is very conscious of the honour paid to him and of the distinguished company he joins.

Knud was a fine surgeon and a great teacher. Moreover, with his vast knowledge of the literature always presented his material against a historical backcloth. It is therefore, the authors intention to present the subject of amputation surgery in the same way under the following headings:

- Epidemiology
- Amputation levels
- Pre-operative phase
- Anaesthesia
- Amputation procedure
- Stump environment
- Individual amputations
- Rehabilitation and prosthetic fitting

Epidemiology

In ancient times, so far as can be seen from archaeological remains and such pictures that exist, amputation was usually the result of unspecified gangrene or trauma. It might have been accidental or from fighting, was occasionally associated with practices in magic, with ritual sacrifice or with punishment: indeed, to this day in some parts of the world the ablation of one or both hands is still used as a punishment for theft. In the Middle Ages huge numbers of

amputations were performed, largely because of the invention of the cannon used first at Crecy, 1346 and the half pound gunshot at Perugia, 1364. At the same time Hansen's disease i.e. leprosy was endemic and responsible for large numbers of amputations. The fungus ergot found in rye and therefore in rye bread caused epidemics of poisoning due to the alkaloid mix of LSD as a hallucinogen and ergotamine as a vaso-constrictor. Many died, 40,000 in the South of France in 994, many presumably died happy, but not a few survived with gangrenous limbs. When potatoes and wheat replaced rye the epidemics diminished—the last major outbreak being in Russia in 1929 and the last minor in Pont St. Spirit in France in 1951 when four people died.

In the nineteenth century because of the urban disease of hospital sepsis, amputation became one of the most commonly performed operations.

Today the causal conditions for amputations vary considerably from one part of the world to another; surprisingly in countries such as Nigeria and Zambia the motor car is probably the commonest cause of amputation. Leprosy still features in some of parts of the world as it did in the Middle Ages and is responsible for a number of amputations.

However, in Northern Europe, the picture is quite clear, 85-86% of primary amputations resulting directly from vascular disease whether it be atherosclerosis, diabetes or a combination of both. The other causal conditions such as trauma, tumour, congenital deficiency and the rest constitute no more than 15%.

Most of the amputations performed in Europe and North America are because of vascular disease and the patients are elderly with multiple

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handicaps. For a variety of reasons it is only in the last few years that a large proportion of these patients have been successfully rehabilitated. One of the main reasons for this success has been the ability to ally the clinical signs to increasingly accurate methods of ancillary investigation. Holstein (1982) has shown that by employing skin perfusion pressure measurements it is possible to predict wound healing in over 90% of cases, taking a level of 30 mm Hg as the main guideline. Equally good results have been reported using Doppler ultrasound and thermography.

Where diabetes is a feature even more knee joints can be saved. Indeed, Syme's amputations and partial foot procedures become possible. A number of feet can be saved entirely from any amputating procedure by careful surgery, excision of dead tissue, opening up of infected areas and by careful application of pressure dressings.

In trauma the long established principles hold in this group, namely to conserve all viable tissue. The judgement as to whether tissue is viable or not may be difficult, but one should err on the side of conservation. Wounds should be closed when feasible. If the tissue is doubtfully viable then open flaps should be used. Stump reconstruction can be performed later if required especially in view of a long life expectancy. Philosophically the situation here is decidedly different from that of an elderly patient with vascular disease and a short expectation of life.

Osteosarcoma is perhaps a good model for considering the management of tumours. Until a few years ago amputation was commonly performed, usually between the ages of 10 to 20 years and with a 5 year survival rate of no more than 20%. The place of radiotherapy has waxed and waned and the situation has become even more complicated with a range of chemotherapeutic agents. The reports by Jaffe (1972) and Jaffe and Watt (1976) on the use of high dose methotrexate with citrovorum factor and other agents have stimulated many workers in the use of these agents and has increased hopes that there will be decided improvements in survival rates. However, an enlarged experience is required before secure judgements can be made about the situation and large scale projects such as the United Kingdom Medical Research Council trial presently in progress are

to be commended. Such information as there is suggests that amputation will continue to have a principal place in the management of these malignant tumours. Equally there is evidence that chemotherapy permits amputations through the affected bone provided the amputation site is some 10cm above the most proximal area of bone reaction as seen on the bone scan. An increasing number of reports indicate, at least in the soft tissue sarcomas of the extremities, that radical local re-section and internal prosthetic replacements may obviate the need for limb amputation.

Children with congenital limb deficiencies were shunned from society in the past. Today society is more caring about these children, but the incidence is particularly rare in the experience of any one surgeon and in the author's view the management of these cases is best undertaken by those with an accumulated experience. The distillation of these larger experiences will become easier now with the International Society for Prosthetics and Orthotics system of nomenclature and classification (Kay, 1974) reaching the stage of a draft standard for the International Standards Organisation. Two points can perhaps be made. The consensus view that congenital absence of fibula is best treated by ablation of the foot at 10 months is largely confirmed by the experience of Westin et al, (1976). As for the many other deformities discovered at birth the surgeon must take more care and seek such advices as he can before proceeding to ablation of any part of an already deformed limb.

Patients presenting with limb discrepancy, paralysis and deformity derived from a broad group of disease and disability categories provide very difficult decisions as amputation, if used, is not a life saving procedure. Very careful analysis is required and very often amputation is performed in conjunction with osteotomies, joint replacement and the like.

Amputation levels

The ancients performed their amputations below, at, or just above the level of the gangrene, wherever that may be. A huge variety of procedures are listed in the literature but the most significant contributions were made by Ambroise Paré (1564, 1951) in the sixteenth century. He was the first surgeon to chose an amputation site well above the gangrenous area

and specifically at a level which he considered to be suitable for fitting with a prosthesis.

Today we should concern ourselves not only with the pathology but with the anatomy at the proposed level of section along with the management of the tissues at that particular level. Equally we should consider what prostheses are available.

Finally we should not forget the very personal factors such as age, sex and occupation. For example, care is required in considering the use of knee disarticulation and Syme's procedures in the young woman because of the bulbous nature of the stumps. Proper consideration of all these factors will point the surgeon to the most appropriate procedure depending on the circumstances.

Pre-operative phase

In the preparation of the patient for amputation history reveals a variety of different approaches. About A.D. 25 Celsus (1938) suggested that "the surgeon should have an intrepid mind, devoid of all tenderness and pity and entirely deaf to the shrieks and outcries of the suffering patient".

In the fourteenth century Guy de Chaulac, for his time a very sophisticated and sensitive man, recommended that "the surgeon be well educated, skilled ready and courteous; let him be bold in most things that are safe, fearful of those that are dangerous, avoiding all evil methods and practises; let him be tender with the sick, honourable to men of his profession, wise in his predictions, chaste, sober, pitiful, merciful, not covetous or extortionate but rather let him take his wages in moderation according to his work and the wealth of his patient".

A book called the *Surgions Mate* (Woodall, 1617), much valued by the military surgeon, commends the following—"Let first your patient be well informed, prescribe him no certainty of life—with his own free will and request and not otherwise—let him prepare his soul by earnest prayer" and recommends also that the surgeon seek mercy and help as "it is no small presumption to dismember the image of God".

It is, of course, our duty today whenever possible to explain the nature of the proposed operation, the various events attendant to it and finally the procedure itself. We should explain the phantom phenomenon but not indulge in a

discussion on phantom pain, explain when pain is likely to be felt and what will be done about it, what the rehabilitation programme will be and something about the prosthesis. It is very often useful for a patient to talk to an amputee who has gone through the various events described.

Anaesthesia

We know from the Talmud (1938) and contemporary Arab writings that patients were given potions to induce sleep and reduce pain; Theodoric in the thirteenth century recommended the use of a soporific sponge employing opium and mandrake (Taylor, 1933). As ever, the lessons of the past were forgotten and we find a respected German surgeon called Heister in 1718 recommending that six assistants be used to hold and keep the patient quiet while the amputation was being performed.

There can be no doubt that the use of general anaesthesia as advocated by Morton (1847) (ether), Wells (1847) (nitrous oxide) and, of course, Simpson (1847) (chloroform) in Edinburgh, revolutionized all surgery. Modern anaesthesia has even permitted advances in the ancient and humbling operation of amputation. It is our practice to use spinal anaesthesia; ensuring no pain for 1-2 hours hence less confusion, fewer problems with hypotension (unilateral), fewer chest complaints and, in diabetes, liquids and a light diet can be given much sooner.

Amputation procedure

Developments in amputation surgery have inevitably been bound up with other developments, such as anaesthesia. In its absence, speed of operation was absolutely essential as embodied in the "tour de maitre" using one sweep of the knife to cut through all the soft tissues. Liston of Edinburgh and London, mentor and later implacable enemy of James Syme, was an expert. Another charismatic figure of not so long ago, Sir Reginald Watson-Jones, when demonstrating this technique, used one of the knives from the Royal College of Surgeons and in his enthusiasm almost committed a self-amputation. At any rate he was taken limping from the lecture hall bleeding profusely and with a monstrous laceration through an elegantly tailored trouser leg of the best cloth.

Other technical innovations played their part,

for example, the invention of the rubber bandage by Esmarch in 1873 and, of course the development of a variety of surgical instruments.

During the Greek period from 400 B.C. amputation was carried out through gangrenous tissues and in many cases secondary removal of necrotic bone was required. Celsus (1938), in about A.D. 25 employed circular cuts through the leg down to bone. The skin was drawn proximally first, then the soft tissues retracted and divided and finally the bone cut. He made a particular point of using a rasp to smooth off rough bone margins—almost 2000 years later this fundamental element of amputation appears to have been forgotten by some surgeons. The tissues were then allowed to come down to cover the stump of the bone.

The next significant contribution was from Leonides about A.D. 200 (Taylor, 1933). He employed a simple circular incision cutting the soft parts where there were no large vessels. The muscle and skin was retracted upwards with a linen cloth and the bone severed. The remainder of the tissues including the blood vessels, were then divided with a cautery.

There followed a number of modifications through the centuries relating mainly to the treatment of bleeding or its prevention, using constricting bandaging. The most notable contribution of all came from Ambroise Paré (1564, 1951) that French military surgeon of great experience, humanity and innovation. He retracted the skin upwards using a tight haemostatic bandage above the operation site.

He then employed a circular incision of the soft parts down to bone, ensuring there was enough soft tissue to cover the bone end. He divided the bone with a saw but only after the periosteum had been stripped upwards. The vessels were secured with his crow's beak forceps and ligated. The wound edges were approximated with four loosely placed sutures. It is to be regretted that for several hundred years most of his techniques and devices, based on what was undoubtedly the largest single surgical experience in Europe, were forgotten.

The next significant advance related to the use of flaps to ensure coverage of the bone. Lowdham of Oxford employed a single flap, cutting from within out after severing the bone, and 100 years later in 1768, Ravaton employed a double flap (Taylor, 1933). In the eighteenth

and early nineteenth century there was a reversion to former practices.

By this time in urban hospitals sepsis was rampant. Compound fractures of the femur proved fatal in 80% of cases; and, in those of the tibia, in 50%. Speed was of the essence and the "tour de maitre" became an absolute requirement in the practice of the great surgeons of the day.

Lister's use of antisepsis and modern aseptic techniques have paved the way for modern practice which is based on principles of tissue management.

The management of *skin* is basic to the success of any amputation. The higher the ratio of the base to the length of the flap the better the chance of primary wound healing. Equally important is gentle handling and the close abutment without tension at the skin edges.

There have been many different fashions in the management of *muscle*. The early German workers attempted to cover the bone end to produce a muscle pad. In more recent times Dederich (1967), Berlemont (1961), Weiss (1969), Burgess and Romano (1968) and others have emphasized the need to attach the muscles in some way to the end of the stump. Dederich (1967) demonstrated improved vascular supply to the stump end after myoplastic revision and Hansen-Leth and Reimann (1972) demonstrated in laboratory female rabbits a better blood supply to the stump end when muscle stabilization was used.

Management of the divided *nerve* has been the subject of controversy for a very long time. It is believed that the generally accepted practice now is to perform a high clean cut to ensure that the inevitable neuroma is located in such a situation that it is not in direct contact with distal scar tissue and thus neither interferes with prosthetic fitting nor produces significant symptoms.

When *bone* is transected it must be sculpted to avoid high concentrations of the forces involved in walking. This is particularly applicable in below-knee amputation but may also be required in the shape of rounding off the anterior edge of a cut femur. Where feasible the medulla should be closed off by a periosteal flap to retain normal intramedullary pressures.

Stump environment

The environment in which the stump is placed

immediately following operation may be critical to wound healing and the survival of the stump. The problem has interested clinicians for a very long time. In the Peloponnesian war 431–404 B.C. cautery of the stump and cover was achieved by applying a small bucket of tar. Our friend Celsus (1938) used a variety of techniques including a sponge moist with vinegar which he applied to the stump. If there was much bleeding he elevated the part and used cold and hot applications. Gersdorff in (1517) employed rabbit's fur and egg white in a pig's bladder (Taylor, 1933). Heister (1847) used a dry lint dressing again with a pig's bladder.

The essence of the problem is that the effect of surgical trauma is to produce a tissue response resulting in the clinical phenomenon of oedema and the effect is greater the more distal the wound. The responsibility of the surgeon is to ensure that this response does not affect adversely the blood supply. If oedema is permitted to develop interstitial pressure may rise sufficiently to depreciate an already precarious blood supply. This subject is discussed by Murdoch (1983) with a personal recommendation for the use of the rigid cast and controlled environment treatment.

Individual amputations

In amputation through the thigh, tissue management follows the principles already referred to. If we set aside the pathology and its influence then amputation should be carried out ideally 12–13 cm above the knee joint as most of the adductors have found their attachment by then and the major neurovascular bundles have arrived at their destination. The method advocated by the author (Murdoch, 1968) is division of the medial and lateral hamstrings and any adductors at the level of the severed bone and then attachment via drill holes. The medulla is closed off with a periosteal flap and the whole of the quadriceps complex is drawn over the end of the bone and sutured to the aponeurosis of the hamstrings and the adductors. This technique ensures a stump of notably smooth contours, of stable shape and volume and avoids the gross changes of shape and displacement of bone in stumps where muscle attachment has not been secured. Following above-knee amputation no circular bandage is used but instead a simple dressing with vertical strips of Elastoplast is employed.

The supracondylar and transcondylar amputations such as those described by Callander (1935), Slocum (1949), Gritti (1857) and Stokes (1870) have all had their protagonists, usually because of a good reputation for primary wound healing. One suspects that it is achieved at the expense of losing a number of knee joints. Whatever attributes they may have, the stumps produced are not end bearing to any significant degree and there is insufficient room in the prosthesis for artificial knee mechanisms.

The knee disarticulation procedure provides a stump capable of true end bearing with good proprioception, excellent rotational stability between stump and socket and which, because of its bulbous end, ensures excellent suspension. It is a valuable procedure in childhood as it retains the epiphysis and in the elderly if a below-knee amputation cannot be performed. Syme advocated a posterior flap for this procedure but later condemned it because of poor wound healing. For many years the long anterior flap technique was employed but in the past ten or more years disarticulation employing lateral and medial flaps has become more prevalent. First advocated by Velpeau (1830) in France and Smith (1825) of the United States it is increasingly popular especially in Scandinavia under the advocacy of Kjølbye (1970) and now Jansen and Jensen (1983). The procedure is simple and non-traumatic, few muscles are cut and haemostasis is easily obtained. It is important to ensure that when the operation is complete there is no tension at the suture line, which should be in the sagittal plane lying between the condyles. It is, therefore, very important that the medial flap is fashioned in such a way that it is capable of covering comfortably the larger medial condyle. Jansen and Jensen (1983) advise a circular incision 10 cm below the level of the knee with tailoring of the flaps at the end of the operation—a reversion to Velpeau's technique. It is important that tissues remaining are left undissected. They emphasize division of the heads of the gastrocnemius at 2 or 3 cm below their attachment to ensure the survival of the superior genicular vessels. The patellar tendon is sutured to the divided cruciate ligaments, but the patella should not be dragged down too far into the intercondylar notch.

In the below-knee amputation which is being

performed for conditions other than vascular deficiency, osteomyoplasty as described by Ertl (1949) is strongly recommended. For those patients with vascular deficiency the posterior flap amputation should be used. Increasing experience is likely to demonstrate the value of techniques such as the sagittal flap of Persson (1974) and others designed individually for the patient.

The philosophy behind osteomyoplasty is to produce a bony bridge between the tibia and fibula and to secure both anterior and posterior muscle groups over the bridge. This results in a particularly tough organ of locomotion subject to little change in volume and retaining muscles which demonstrate very satisfactory phasic muscle activity. The procedure as described by Ertl (1949) requires no modification in this author's view.

The level of the posterior flap operation is to a large extent dependent on the pathology. As outlined there are now several excellent ancillary methods of assessing levels of viability available to us including Doppler ultrasound, skin perfusion pressure and thermography. In a slim patient and with a competent prosthetist it is possible by this method to make good below-knee stumps which are no longer than 4 or 5 cm although the preferred length is about 10–13 cm. The anterior flap is no more than 1 cm and the posterior flap must, of course, be long enough to cover the end of the stump. The antero-lateral group of muscles are exposed and divided giving access to the neuro-vascular bundle and the fibula. Both bones are divided either with a Gigli saw or a power saw and the fibula cut no more than 1 cm shorter than the tibia. Practice varies in relation to the posterior flap. The author advocates excision not only of the deep posterior muscles but also the whole of the soleus as well because of the large venous sinus. Other surgeons use a shelving cut running obliquely through the soleus to the end of the flap.

Syme's amputation (Murdoch, 1976), first described in a series of articles dating from 1843–1857, remains a useful procedure and produces a stump which in the child retains the distal tibial epiphysis and at all ages provides for a large measure of end bearing if required. Both incisions, dorsal and plantar, are made from the lateral malleolus to just below and behind the medial malleolus. Both are carried down to bone and dissection is thereafter developed

throughout with the knife against bone thus ensuring the integrity of the heel flap. The bones are divided at the dome of the ankle joint with the saw cut parallel to the ground and the heel flap must be placed precisely over the cut end of the bone and secured in position.

Over the years since Syme first described this procedure, various modifications have been recommended. Few have stood the test of time. In particular the procedure advocated by Elmslie in an attempt to improve cosmesis and requiring higher bone division is doomed to failure because of the reduced area presented by the bone and the inability to locate the heel pad. The resultant stump from the Syme amputation has one defect and that stems largely from the large medio-lateral diameter which leads to poor cosmesis. The close fitting modern Syme prosthesis does not permit the stump to be wholly end bearing and accordingly it seems entirely proper to remove the malleolar projections provided the level of amputation is not changed.

A variety of partial foot amputation procedures have been described over the years. Pirogoff's procedure retains part of the os calcis and its associated heel pad and provides excellent end bearing properties (Pirogoff, 1854). However, it requires that bony union takes place between the os calcis and the cut end of the tibia and the resultant stump is so long that a modern prosthesis cannot be fitted. Even so within certain cultures it may remain a valuable procedure.

Chopart's procedure located at mid-tarsal level has few adherents today because of the tendency of the stump to become inverted and plantar flexed even with tendon fixation (Fourcroy, 1792). The stump is very short and difficult to fit.

In Lisfranc's procedure the forefoot is disarticulated along the tarso-metatarsal line (Lisfranc, 1815). This operation has few adherents today again because of the short stump and because of its poor cosmesis.

The transmetatarsal amputation is widely used in a variety of situations, for example in trauma and diabetes. It is essential that there should be an adequate plantar flap sufficient to cover the divided and sculptured metatarsal bones.

Amputation of all five toes remains a valid procedure. It provides a stump which requires

not more than a special insole incorporating an arch support and toe spacer within normal footwear.

Rehabilitation and prosthetic fitting.

A prosthesis dating from 300 B.C. and apparently intended for a below-knee amputation and demonstrating a remarkable level of workmanship was on display in the Royal College of Surgeons of England; unfortunately it was lost in a fire in 1941. That was the earliest example of a prosthesis known to be in existence. Several varieties of the peg leg were used over many centuries and it is still used today. During the fifteenth, sixteenth and seventeenth centuries, prostheses were mainly made for military persons who were usually mounted, the prosthesis being intended primarily to conceal the amputation. Paré's prosthetic designs, developed with the help of his armourers, survived with little fundamental modification until the Second World War. For the most part, so far as the stump and socket interface is concerned, little change took place over the centuries. Sockets tended to be little more than conical pots. No doubt the adaptability of sweat soaked leather helped in the fit. Conical sockets, of course, demanded conical stumps and accordingly the surgery and stump management with aggressive bandaging programmes were designed to meet this situation.

The modern prosthesis at whatever level is now being designed on an increased understanding of biomechanics. The introduction of the patellar tendon bearing prosthesis for the below-knee amputee by Radcliffe and Foort (1961) has emancipated the knee joint and permitted the rehabilitation of patients not capable of rehabilitation in the past. Mazet et al, (1959) and Olejniczak (1967) indicate that as recently as 25 years ago some 90% of patients above the age of 55 had above-knee amputations performed and only some 10% were rehabilitated. The increasing accuracy and discrimination of ancillary methods of assessment, the rapid containment of oedema, the patellar tendon bearing below-knee prosthesis and aggressive rehabilitation procedures across the board have completely revolutionized amputation in the elderly.

Conclusion

My experience has taught me that most

amputating surgeons need no longer be regarded as they were by Guy Patin in the seventeenth century.

"Mere booted lackeys—a race of extravagant coxcombs who wear moustaches and flourish razors".

The surgery is now more considerate and more in tune with the patient's needs. Indeed the surgeon involved in amputation surgery is perhaps more sensitive to solutions other than amputation because of his awareness of the life of the amputee.

Equally increasingly, where replantation teams have been organized and micro-surgical competence is established, the completely severed limb with little local tissue damage may be considered for replantation.

This field of scientific endeavour covers the whole range of disciplines in medicine and the physical sciences and it is now clear that the rehabilitation of the amputee does not depend only on the surgery and the prosthetic procedures but that a team approach is necessary if the amputee is to be rehabilitated to his home and work place. Historically the team approach may prove to be the most important advance of modern times.

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A method for determining the mechanical characteristics of orthotic knee joints

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Abstract

All orthotic equipment must operate at the highest possible standards of safety and, should structural failure of a loaded component occur, there must be a minimal possibility of injury to the user. Because of the lack of definitive data on the in-service loading of lower limb orthoses it is not possible to base a test procedure on "real" loading conditions. In this paper a method of destructive testing, based on the assumption that the predominant loading consists of bending about the medio-lateral and anterior-posterior axes, is described. This method makes it possible to measure the bending strength of a knee joint side member assembly and to define the brittleness of the failure. It is suggested that the latter definition makes it possible to predict the potential safety of a particular knee joint should in-service failure occur. Some laboratory failures are described and recommendations, based on the test programme, are made for new joint designs.

Introduction

Any item of equipment supplied to a patient must operate at the highest possible standards of safety. In particular, this implies that any load bearing component, should it fail, must not do so in such a way as to cause injury. This requirement is of particular importance in the case of lower limb orthoses which, in many cases, must carry substantial loads in order to support the patient during gait and other activities such as stair climbing. In addition they must operate under the more severe conditions imposed, for instance, by the patient tripping or stumbling. It is essential, therefore, that the load bearing components in such orthoses should be designed in such a way as to avoid catastrophic failure.

At present, few data exist on the in-service loading of orthotic knee joints, although information at present available suggests that a major part of the loading of a knee-ankle-foot orthosis (KAFO) consists of bending moments about medio-lateral (ML) and anterior-posterior (AP) axes (Trappitt and Berme, 1981). However, the magnitude of these loads cannot, at present, be estimated for the wide range of possible uses and prescriptions of a KAFO.

Until such data become available, useful information on the mechanical properties of existing designs can be acquired by laboratory testing. Potentially such tests can provide data on static mechanical strength and mode of failure, stiffness and fatigue strength. This paper is concerned with a programme of destructive testing to identify the strength and mode of failure of orthotic knee joints under the action of bending moments in the AP and ML directions. This particular type of test was chosen because it approximated to the loading pattern discussed above.

Testing equipment and procedure

In order to interpret the results of a bending test, it was necessary to determine the angular deflection versus bending moment relationship for the knee joint and side member assembly under test. In order to make realistic comparisons between a variety of sizes and types of joint it was decided that a test section incorporating the joint itself together with a portion of each side member should be loaded under a uniform bending moment. This can be achieved by the 4 point bending method illustrated in Figure 1. The simple loading system illustrated will only produce a constant bending moment if the deflections are small and the forces acting remain parallel and at right angles to the test section. However, because of the relatively low bending stiffness of the side members and the need to test to destruction, the

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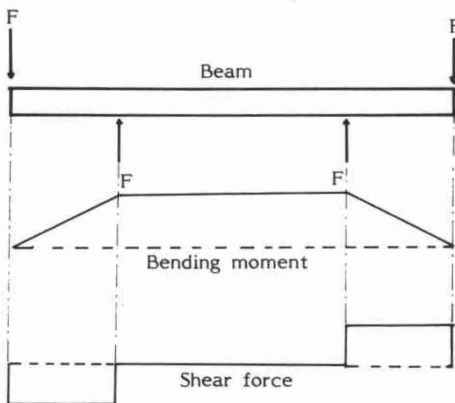


Fig. 1. Four point bending of a beam.

resulting deflections of knee joint assemblies are likely to be large. It was necessary, therefore, to redesign the test rig using the arrangement of Figure 2 in which the knife edges were replaced by rollers which were mounted in pairs on the faces of two pulleys. Equal and opposite torques were then applied to the pulleys by cables attached to a pivoted cross beam which was then connected to the hydraulic jack of a test machine via a load measurement cell. The angular deflection of the joint assembly under test was measured using a Linear Variable Differential Transformer (LVDT) displacement transducer coupled to one of the pulleys by a thread whose change of length was proportional to angle of rotation. A schematic drawing of the test rig can be seen in Figure 3.

Test procedure

After selection of the direction of testing, the joint was placed in the test rig with the lock mechanism in the centre of the test region. In order to prevent the joint from moving during the test, one end only was lightly clamped to the pulley (Fig. 3). Load was then applied to the rig and the resulting moment - deflection graph was

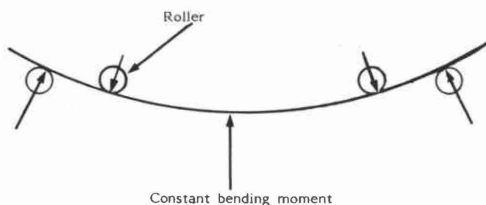


Fig. 2. Four point bending with large deflections.

recorded on a pen recorder. The load was slowly increased until one of the following events occurred:

- (a) Any part of the joint assembly fractured.
- (b) The mechanism of the lock opened.
- (c) The deflection of the specimen became so great that the loading geometry was adversely affected, the mechanism became unsafe or one pulley had rotated through an angle greater than 25°.
- (d) The deflection of the specimen continued to increase with the bending moment remaining constant.

Each type of joint in the study was tested in 4 directions.

- Flexion
- Extension
- ML bending (2 directions)

Interpretation of results

When mechanical testing of engineering components is carried out it is normally relatively straightforward to relate the applied loads and the stresses to the intended use. However, as has already been discussed, these data do not exist for orthotic components. It is suggested that two parameters may be used to compare one joint with another and to describe the mode of failure in the laboratory. In order to discuss the method derived here it is necessary, first, to examine a typical moment versus deflection curve produced during the bending test (Fig. 4). This graph can be divided into two regions.

- (a) Elastic, during which any deflection is totally recoverable after removal of the load. This region ends at the limit of proportionality after which the graph is in the plastic region.
- (b) Plastic, in this region permanent deformation of the assembly is occurring.

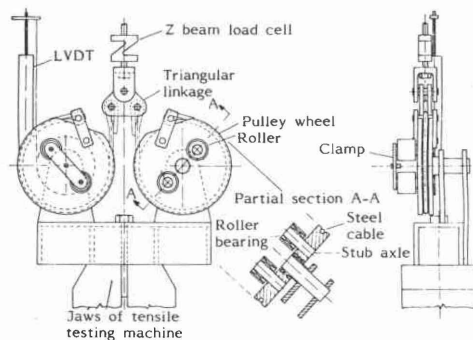


Fig. 3. Four point bending apparatus.

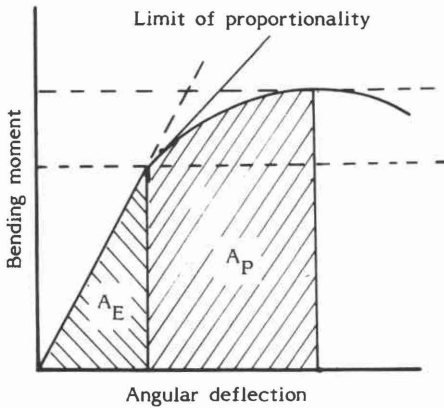


Fig. 4. Typical bending moment - deflection curve.

The end of the plastic region was defined as one of the following events:

- (i) Fracture of any component.
- (ii) The point of maximum bending moment.
- (iii) If neither of the above has occurred, then the point corresponding to a rotation of 25° of one pulley.

Within the elastic region, energy is stored with increasing load whereas in the plastic region energy is dissipated in the permanent deformation of the specimen; the energy associated with the two regions of the graph may be calculated from the areas A_E and A_P . A full description of the test procedure may be found in the draft standard from the British Standards Institute (1983).

It will be noted that these definitions of energy differ, in certain respects, from those to be found in engineering textbooks. The present definitions were necessarily adopted to accommodate the differences between the present test procedure and the standard tensile test on which the more normal definitions are based.

The bending strength and a measure of brittleness of the failure were obtained from the moment versus deflection curve in the following manner.

Bending strength

It is reasonable to assume that any permanent deformation—even if small—is unacceptable for an orthosis in use. This requirement implies that the bending moment during use must not exceed the limit of proportionality. The bending moment at this point was defined as the bending strength.

Brittleness

If an orthosis fails as a result of the user falling or stumbling then it is reasonable to assume that, immediately prior to the fracture, some of the available potential energy of the wearer will have been used to deform the structure. If fracture occurs, any elastic energy in the orthosis will be released and will be available to injure the user, whereas any plastic deformation will have absorbed energy. Therefore, the more ductile the failure (i.e. the more plastic deformation which has occurred) the smaller the chance of injury to the user. In Figure 4 the ratio A_P/A_E represents the degree of ductility of a failure and from now on will be referred to as the PE ratio. The higher the value of this ratio, the more ductile the failure and, from the argument above, the smaller will be the chance of injury to the wearer. The remainder of the paper will be concerned with the measurement and use of the PE ratio as a criterion for safe design.

Justification of PE ratio as a measure of ductility/brittleness

While the technical justification for the use of the PE ratio has already been presented, it was felt to be important to examine the correlation between some measured ratios and subjective assessments of mode of failure made by an engineer. In the first instance, it is only on this basis that the threshold between acceptable and unacceptable failures can be set. For this purpose a group of results was classified as acceptable or unacceptable prior to the calculation of PE ratios. Figure 5 shows the subsequent distribution of the ratios for the two groups where it can be seen that the "unacceptable" group is dominated by low ratios and vice versa. From these results it was decided,

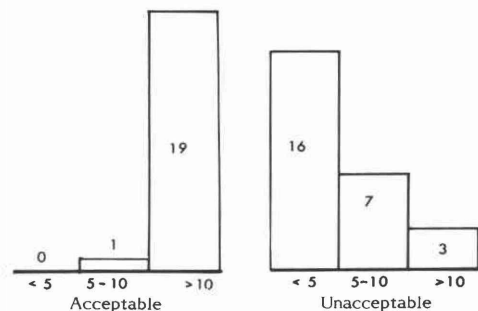


Fig. 5. Distribution of PE ratios of acceptable and unacceptable failures.

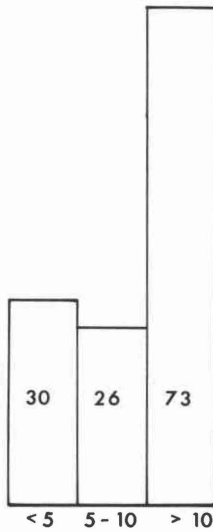


Fig. 6. Distribution of PE ratios for all joints tested.

arbitrarily, that a ratio of less than 5 represented a totally unacceptable failure, 5-10 represented a failure requiring further investigation and a ratio greater than 10 represented an acceptable failure. The distribution of ratios for all the joints tested is shown in Figure 6.

Some test results

While this paper is not intended to be a critique of different available joints, some failures which occurred during the test programme illustrate the relevance of the method. For the interested reader detailed discussion of a large range of results is presented in Scothern (1982).

Ring lock

Figure 7, top, illustrates a failure of a ring lock which occurred when loaded in flexion. Because of insufficient contact area between the male tongue and the ring, plastic deformation of both of these components occurred and allowed the joint to open under load. While this is not, technically, a brittle failure, it was associated with a low PE ratio because failure of the lock occurred before any appreciable yielding of the structure. It was without doubt, an unacceptable failure. PE ratio=4.

Barlock

Figure 7, centre, illustrates a failure of a barlock joint when loaded in flexion. Because this type of joint uses a short strong link as the locking member, the weakest component, in flexion, becomes the hinge pin loaded in double

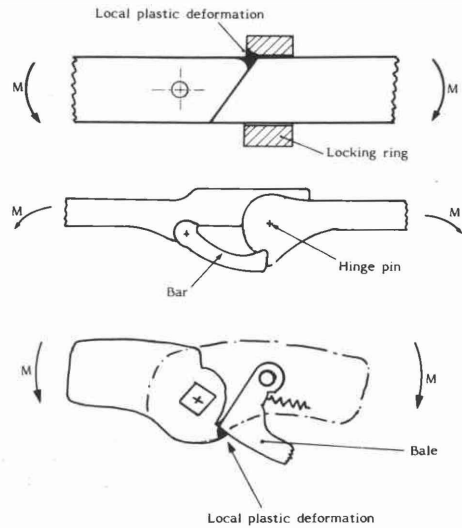


Fig. 7. Undesirable failures. Top, failure of a ring lock. Centre, failure of barlock. Bottom, failure of a bale lock.

shear. On one particular joint under test, double shear failure of this pin occurred before any plastic deformation of the structure. Because of the typical brittle nature of the double shear failure, the mode of failure was unacceptable. PE ratio=4

Bale lock

Tests on a particular design of bale lock illustrated two related types of undesirable failure, the first of which is illustrated in Figure 7, bottom, showing the lock only partly engaged. This particular joint had previously been adjusted to ensure that no free play was present when the joint was locked—a condition which was achieved as soon as the bale contacted the locking flat. The locking spring was not sufficiently strong to push the bale fully home. Under load there was a local bearing failure of the locking flat which originated at the point of contact and progressed outwards. As a result of the deformation to the tongue the resultant contact force lay to the right of the pivot and this tended to rotate the bale outwards and so unlock the joint. The PE ratio for this failure was 1.0. A variation of this failure occurred with the bale fully engaged. In this case a large wedge of material, extending across the flat, was sheared off.

What are satisfactory failures?

Satisfactory failures are associated with ductility. This requirement implies that, in most

circumstances, the first component to fail should not be a casting. Also, as has already been demonstrated, double shear failure of loaded pins should be avoided. Ductile failures are most likely to consist of the bending of wrought components which, in this instance, will probably be side members. It is for this reason that nearly all of the failures in the ML direction, where the side members are relatively weak, were ductile. Similarly, the majority of failures associated with joints machined from wrought material were satisfactory. It can be seen, therefore that ductility can be "built in" at the design stage by ensuring that the joint head will not fail, under conditions of bending, before the side members. For most designs this will mean that the strength of the joint will be determined by the side member dimensions and the joint mechanism will always be designed to be the strongest link in the load path.

Conclusions

A method has been presented for the assessment of orthotic knee joints both from the point of view of mechanical strength and with regard to mode of failure. While both of these measurements provide new information on the potential safety of orthotic components, interpretation may be difficult in view of the almost total lack of information on the loads to be carried by the complete orthosis in service. Before this information becomes available it is important that the tests described in this paper should be carried out on the widest possible variety of knee joints. An additional task, which must be carried out, is the systematic collection of data on mechanical failure of orthotic components in use. While it may often be suggested that such occurrences are rare it is believed by the authors that a wide variety of unreported failures do occur. In many cases these may not be regarded by the orthotist as failures and may consist, for instance, of an orthosis having to be realigned at regular intervals. Such realignment is probably only necessary because of yielding (i.e. failure) of loaded components. Fortunately, catastrophic

failures appear to be far less common. When it is realised that a large number of orthoses are assembled from components which could, potentially, fail in a brittle manner, it must be concluded that the majority of orthoses are over-designed i.e. they contain more metal than is required to carry the imposed loads.

It is suggested that if components, which could only fail in a ductile manner, were to be used exclusively in orthotic construction then it would be possible for the orthotist to supply a lighter orthosis without risk of catastrophic failure. Furthermore, although data on in-service loading is not yet available, the availability of strength data on available orthotic knee joints will give the orthotist information for the comparison of different designs and he may be able, to a limited extent, to relate these strength figures to his knowledge of the patient's weight and activity pattern.

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Potential problems of manufacture and fitting of polypropylene ultralightweight below-knee prostheses

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Abstract

The clinical evaluation of an ultralightweight polypropylene below-knee prosthesis conducted by the University of Strathclyde identified a number of potential problems which can arise from the use of polypropylene. This paper describes the problems associated with manufacture, loss of alignment and fitting, and indicates handling techniques to minimize these problems.

Introduction

The concept of an ultralightweight below-knee (BK) prosthesis was developed at the Moss Rehabilitation Hospital (MRH) (Wilson and Stills, 1976; Wilson et al, 1978) and at the Rancho Los Amigos Hospital (RLAH) (Quigley et al, 1977). The original MRH design incorporated a completely hollow polypropylene foot extending to the toes and a SACH type heel wedge. In the RLAH design, an external keel SACH foot was chosen with the keel portion replaced by a hollow polypropylene shell. Other institutions around the world have introduced modifications to these designs.

The primary expectation when these ultralightweight limbs are prescribed is that the metabolic energy requirement of the amputee will be minimized whilst keeping a high quality of individual limb supply. With persons who became amputees due to peripheral vascular disease, a reduction in energy expenditure would be desirable. However, the significance of the weight saving has not been demonstrated in clinical results so far. Furthermore, these

designs have not gained widespread acceptance because of difficulty in fabrication and doubts regarding durability and strength (Leimkuehler, 1982).

The National Centre for Training and Education in Prosthetics and Orthotics has been conducting a clinical evaluation of an ultralightweight BK prosthesis. Before providing these limbs to evaluate their relative merits, it was essential to be able to manufacture them to acceptable standards. An array of manufacturing problems delayed progress to the clinical trial phase. This paper describes the method of problem identification of the currently used design and outlines the potential problems which can arise from the use of polypropylene, indicating the necessary handling techniques.

Problem identification

As will be described, the final limb design incorporates a supracondylar, polypropylene socket with a soft Pe-Lite liner. The socket is mated to a hollow polypropylene calf and keel which is bonded to the flexible soleplate of an Otto Bock IS19 foot. A cosmetic cover is fitted.

"Success" of manufacture was judged by the quality of socket fit, and a patient gait and fitting described as satisfactory. The dimensional stability or "alignment" of each test limb was monitored by using a three dimensional measurement jig (Berme et al, 1978). This jig (Fig. 1) was used to track the positions, in three dimensions, of reference points placed in arbitrary positions on the limbs. By observing the relative movement of these points at every stage of manufacture, the factors contributing to loss of alignment were identified and systematically dealt with.

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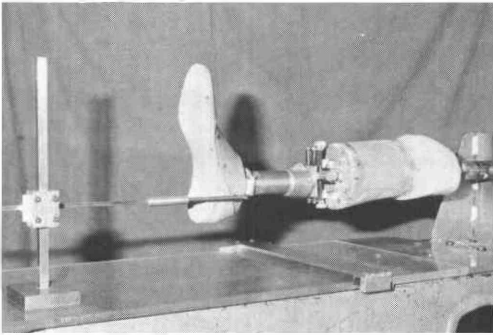


Fig. 1. Alignment measurement jig.

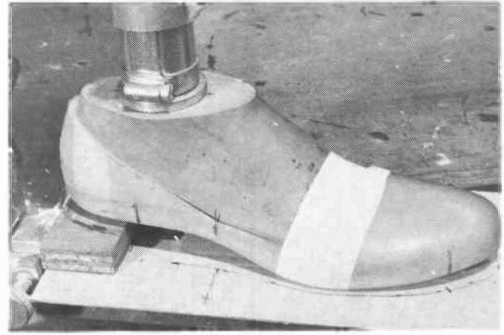


Fig. 2. Transfer jig base with profile plate in position.

Manufacture of the final limb design

The process starts with a suitably rectified supracondylar BK cast over which a Pe-Lite liner is formed. The socket is formed by draping a hot polypropylene sheet over the cast and liner with vacuum assistance. Any excess material is trimmed off leaving a web of about 3cm. The result of this process is a socket with a posterior seam and a Pe-Lite liner. Build-ups on the liner in the supracondylar area provide for suspension of the limb.

A Pedilen foam extension is formed on the end of the socket ready for the attachment of the alignment unit. An Otto Bock IS19 foot is used. The keel and soleplates are separated, the breakpoints are marked and matched up and the soleplate is then reattached. The limb is now ready for fitting.

Following fitting, the limb minus the keel and soleplate is secured in a Hosmer vertical transfer jig at the ankle adaptor. A mandrel is inserted in the socket parallel to the axial guide and fixed in place with plaster of Paris. All the jig adjustment screws can be locked and the overall axial length of the limb can be read on the jig scale. The ankle adaptor can then be released, the foot temporarily replaced and a profile plate positioned as shown (Fig. 2). The soleplate and keel positions, and in particular the keel breakpoints, are traced onto this plate. The profile plate is then removed. The keel is removed and the ankle adaptor is reattached to the jig base. Transfer out of the alignment unit and tube can now take place.

The foaming of the calf section can now proceed and is facilitated by the use of an ankle block with a steel reinforcing tube. As will be described later, this was required to prevent loss

of alignment. The effective length of the prosthesis is increased by some 4 to 5mm to compensate for problems created by polypropylene drape of the calf and keel. The foamed calf is dressed and realigned with the keel.

A 5mm sheet is introduced between the keel and soleplate to allow for the polypropylene drape. The keel trim line is marked in preparation for the dressing of the anterior and dorsal portion of the keel. The final shaping of the foam calf allows for the additional thickness of the polypropylene which can now be draped over it with vacuum assistance. As will be described later the hot polypropylene creates a shrinkage of the foam calf section. The increased axial allowance of 4 to 5 mm referred to earlier was chosen after monitoring the shrinkage of a number of sample prostheses.

The cool polypropylene prosthesis can now be split at the posterior seam and the foamed calf removed. The socket and liner are thereby recovered. The vertical transfer jig is now used with the profile plate repositioned to minimize alignment errors during welding of the socket to the hollow polypropylene calf (Fig. 3). Tack welds are first used in anterior and posterior, followed by medial and lateral positions. Welding of the plantar and posterior seam can now be completed. The profile plate is used as a final check of the alignment.

After dressing the weld areas, it remains to match and bond the keel to the soleplate. The reference marks for the breakpoint are used to achieve this. Some care must be taken because a small error here has a significant effect on the final alignment.

The process which has been briefly described

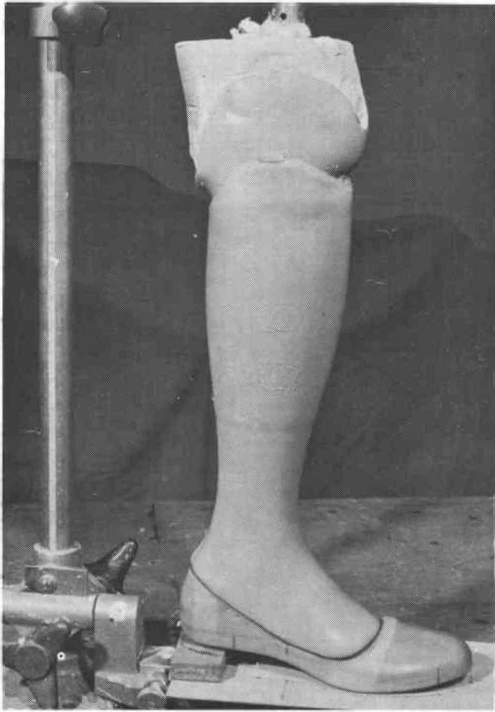


Fig. 3. Calf section tack welded to socket in vertical transfer jig.

evolved from a systematic identification and elimination of errors.

A detailed manual of the manufacturing method is available from the authors (Ballantyne et al, 1983).

Manufacture and fitting problems

Socket brim flexibility

Initially the ultralightweight BK prosthesis was manufactured with a 3mm thick polypropylene socket and a 4.5mm thick polypropylene calf. These dimensions were based on satisfactory static load tests. However, during fittings of the first amputees, the clinic team noted that the excessive flexibility of the medio-lateral brim of the supracondylar socket prevented the completion of an adequate dynamic alignment. All subsequent prostheses were manufactured with a 4.5mm thick polypropylene socket.

Short keel

The keel of a standard SACH foot extends forward to the toe-break. If 4mm is removed from the total surface of the keel to allow for the

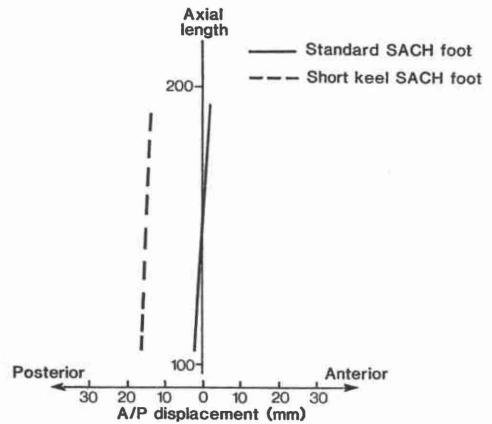


Fig. 4. Socket axis displacement. Standard and short keel SACH foot compared.

draped of the 4.5mm thick polypropylene, the keel no longer extends so far forward. Initially the prostheses for alignment were supplied with an undersize keel on a normal size soleplate. Alignment problems were encountered with the first three prostheses in that the prosthetist had to compensate for the short keel by alignment adjustments.

To confirm these alignment adjustments, the alignment measuring jig was used to monitor the positions accurately, in three dimensions, of reference points placed on the prosthesis. The first three amputees were aligned first with a standard SACH foot and then with a SACH foot with an external short keel. Figure 4 illustrates a typical alignment adjustment necessary to compensate for the short keel. The clinic team considered the external short keel foot unacceptable for a clinical evaluation of an ultralightweight prosthesis.

The Otto Bock external keel IS19 foot has a keel of suitable length and all surfaces of the keel are 3mm undersize except the surface in contact with the soleplate. All subsequent prostheses were aligned with Otto Bock IS19 feet.

Poor socket fit

The next manufacturing problem occurred at delivery of the finished prostheses. Amputees were unable to don the prostheses due to shrinkage of the medio-lateral socket brim dimensions. The slight flexibility of the socket brim at the alignment stage apparently concealed the problem at that point. However,

welding the polypropylene calf section to the socket around the socket brim created a very rigid socket. Medio-lateral socket brim shrinkage was of the order of 3mm.

Using a series of casts and adopting different manufacturing procedures, the socket dimensions were monitored to establish potential causes of the shrinkage problem. Two factors were observed to contribute to medio-lateral socket brim-shrinkage:

- (a) a high vacuum,
- (b) quickly quenching the draped polypropylene in cold water.

The manufacture of all subsequent prostheses was modified by:

1. reducing the applied vacuum from 560mm (22in) Hg to 400mm (15in) Hg,
2. excluding the cold water quench from the manufacturing process,
3. welding the polypropylene calf section to the polypropylene socket at the patellar bar level, rather than around the supracondylar brim.

The socket dimensions of the next six amputees were monitored and found to be consistent throughout the manufacturing process.

Shrinkage of polyurethane foam

Shrinkage of polyurethane foam occurs when this is draped with polypropylene. A test model consisting of two steel discs, 130mm dia and 80mm dia connected with a 270mm length of aluminium tubing and jubilee clips was used to investigate this problem.

The Metrology Department of the University of Strathclyde scribed 10 reference marks on the outer faces of both discs. Ten axial dimensions were recorded.

The model was then clamped in the vertical transfer jig to enable the aluminium tubing to be transferred out. The cavity between the discs was filled with Otto Bock Pedilen 200 foam and the ten axial dimensions were recorded.

Prior to draping, the polypropylene foam adjacent to both discs was undercut to provide a good key between the polypropylene and the discs. The model was draped with 4.5mm thick polypropylene and allowed to cool overnight. The outer faces of the polypropylene were trimmed to expose the ten reference marks and ten axial dimensions were recorded.

The polypropylene was then split along its seam and removed from the model (a visual

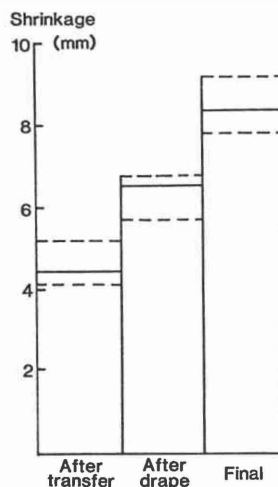


Fig. 5. Shrinkage of test model.

comparison between the polypropylene model and the foam model revealed a polypropylene shrinkage of approximately 2mm). The foam was removed from the model and the two discs were repositioned in the polypropylene grooves. The cut polypropylene edges were then dressed and welded along the axial seam. The final ten axial dimensions were recorded. The results of this investigation are shown in Figure 5. All recorded dimensions were measured accurately by the Metrology Department. The problem of foam shrinkage during transfer out of the alignment unit is now anticipated and an additional amount of foam is used to compensate.

Heating of polypropylene

The temperature and rate of heating of the polypropylene sheet was found to be critical. This problem was investigated by welding thermocouples to the upper and lower surfaces of the polypropylene sheet while other thermocouples were free within the oven to monitor oven air temperature. The rate of heating in a convection type oven was found to be more satisfactory than that of an infra-red oven. An oven temperature of 175°C is recommended with a temperature control of $\pm 3^\circ\text{C}$. The period of time for the polypropylene to be within the oven is dependent upon a number of factors:

- a) the room temperature,
- b) the thickness of polypropylene sheet,
- c) type of polypropylene.

It is recommended that a small sample of similar thickness natural polypropylene is placed in the coolest spot in the oven; when this small sample becomes transparent then the polypropylene sheet is ready for drape. This technique is especially recommended when tan coloured polypropylene sheet is used since there is no observable change in the tan coloured polypropylene when it is ready for drape.

Grade of polypropylene

Difficulties arose due to the lack of consistency of the polypropylene sheets supplied. Once a suitable grade of polypropylene is identified all future sheets ordered must correspond to that grade. In the present study extruded sheet of ICI block copolymers to grade GPE 102 with a tan coloured additive provided a suitable polypropylene.

Soleplate/keel adhesive bond

The bond between the flexible soleplate and the polypropylene keel of the first 18 polypropylene prostheses supplied during the clinical evaluation were found to be loose after a few weeks. This was particularly noticeable in the case of active amputees. The sole of the polypropylene keel was coated with a polypropylene primer and the bond was achieved with standard Evo-Stik contact adhesive.

The flexible soleplate and polypropylene keel of the last six polypropylene prostheses supplied during the clinical evaluation were bonded with a multipurpose hot melt adhesive, Evo-Stik Thermaflo 6820. This polypropylene based adhesive provides excellent adhesion initially with a degree of flexibility. However the combination of cyclic compressive loading together with the flexibility of the adhesive results in extrusion of the adhesive between the surfaces and subsequent breakdown of the bond.

This problem developed during the latter stages of the clinical evaluation and as a result has remained unsolved. The amputees participating in the clinical evaluation were transferred to conventionally manufactured prostheses.

Loss of alignment

Hosmer vertical transfer jig (VFJ-100)

This type of transfer jig is not commonly used

in the U.K. The vertical transfer jig is recommended for manufacture of the ultralightweight BK polypropylene prosthesis because:

- a) foaming of the calf section is easier,
- b) with ankle plate modifications, loss of alignment is minimized.

A comparison of the vertical transfer jig and a horizontal transfer jig was carried out with respect to undesirable movements. Familiarity with the horizontal transfer jig may have minimized discrepancies in its use. In the vertical transfer jig the clamps are further apart, socket mandrel to ankle adaptor, compared with distal socket to ankle adaptor in the case of the horizontal transfer jig. Very large discrepancies can occur with the vertical transfer jig if at any one time more than one clamping screw is released and then tightened.

The following technique is recommended when using the vertical transfer jig:

- a) the socket mandrel must be located parallel to the vertical column,
- b) once the mandrel has been positioned inside the socket on the transfer jig, the transfer jig should only be disturbed for axial movements, i.e. only one clamping screw is released.

Distortion of polyurethane foam

The problem of shrinkage of polyurethane foam was discussed as a manufacturing problem. During alignment checks with the alignment measuring jig (Fig. 1) it was established that loss of alignment occurred.

Six alignment reference marks on the keel, 3 medial and 3 lateral, were monitored at each stage. Four types of polyurethane foam were investigated:

- a) Otto Bock Pedilen 200 foam (Density: 150kg/m³)
- b) Otto Bock Pedilen 700 foam (High Density: 600kg/m³)
- c) Otto Bock Pedilen 200 foam with a steel strengthening tube between the ankle block and the polypropylene socket.
- d) Baydur 6130V foam.

The results of this investigation (Fig. 6) indicate minimum distortion with Pedilen 2000 Foam with the steel tube. The steel tube was introduced to strengthen the foam calf.

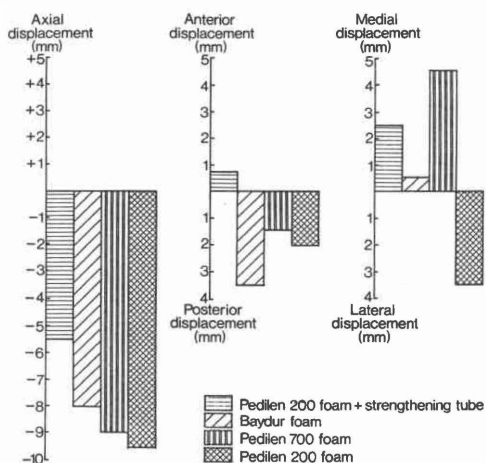


Fig. 6. Loss of alignment due to distortion of polyurethane foam.

Mating of polypropylene calf and socket

Although the polypropylene calf section has been draped over the socket, errors can occur when the calf and socket are relocated together for welding after removal of the polyurethane. A small error, eg one degree, produces approximately a 7mm displacement of the foot relative to the socket.

The following technique is recommended:

1. Reference marks are identified between Polyurethane keel and soleplate of the IS19 Sach Foot prior to alignment.
2. Immediately after alignment, with the mandrel located in the socket and clamped to the vertical transfer jig, the Otto Bock IS19 SACH foot is reattached to the prosthesis. A profile template (Fig. 2) is mounted on the base of the transfer jig by means of a bolt and dowel pin. The prosthesis is lowered onto the template and the profile is accurately traced on to the template with a modified set square.
3. The prosthesis is raised off the template. The soleplate is removed from the keel and the prosthesis is again lowered on to the template. The profile of the keel is likewise traced on to the template. The reference mark on the front of the keel is transferred to the profile template.
4. In order to correctly position the socket in the hollow polypropylene calf section, the socket mandrel is relocated in the vertical transfer jig and the polypropylene calf

section is positioned on the profile template such that the polypropylene keel can be matched to the previous keel profile. The calf section is then tack-welded to the socket.

5. The plantar and posterior seam of the polypropylene calf section are initially tack welded. The plantar and posterior seam are finally welded and the weld areas dressed.
6. With the mandrel relocated in the vertical transfer jig and the soleplate accurately positioned on the profile plate, the prosthesis is lowered on to the soleplate. If the soleplate and the polypropylene keel do not match the tack welds connecting the socket and calf are broken. The calf section is finally welded to the socket with the soleplate and keel matching.
7. After completing weld of the socket and calf section, and attaching the soleplate, any loss of alignment can be checked by locating the mandrel in the vertical transfer jig and noting the position of the soleplate relative to the soleplate profile on the template.

The final alignment of the next three prostheses were checked with the alignment measuring jig to establish the accuracy of this technique. A total of 12 alignment reference marks, 6 keel and 6 soleplate on the medial and lateral sides of the foot were monitored at each stage. Figure 7 compares the alignment of these three prostheses with the average of those obtained from earlier prostheses. It must be noted that the 6 alignment reference marks on the keel will indicate an axial shrinkage of approximately 4mm. This caters for a 4mm thickness of polypropylene on the sole of the keel.

Mating of keel and soleplate

During the investigation of the socket/calf location the mating of the keel and soleplate was also investigated. If the sole of the polypropylene prosthesis is not a perfect match with the soleplate, a plantar or dorsiflexed foot can result. The external keel Otto Bock IS19 Foot, although 3mm undersize on the dorsal part of the keel, is supplied with the sole of the external keel matching the upper surface of the

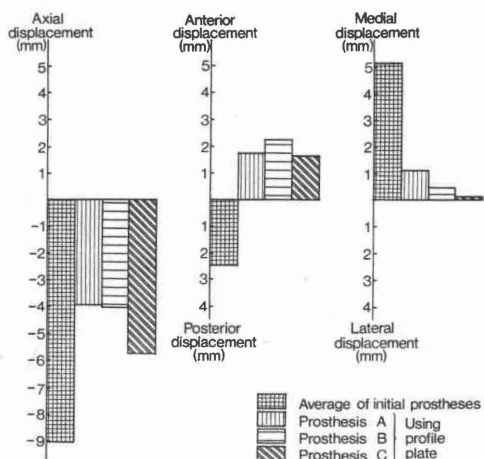


Fig. 7. Improved alignment during manufacture as a result of fabrication modifications.

flexible soleplate. The keel requires to be carefully modified such that when draped with 4.5mm thick polypropylene the sole of the polypropylene matches the upper surface of the flexible soleplate.

The following technique is recommended:

- i) The polyurethane keel is not always located accurately in position on the soleplate on receipt from the manufacturers. Separate the keel and soleplate and then reposition the keel centrally on the soleplate. It may be that once positioned centrally the break points on the keel and soleplate do not coincide. If the keel break point is anterior to the soleplate break point, dress material off the sole of the keel. If the keel break point is posterior to the soleplate break, dress material off the sloping underside of the keel. Once keel and soleplate are mated correctly the two surfaces should be bonded.
- ii) The polyurethane keel should be modified prior to draping by placing a 5mm thick sheet of Pe-Lite between keel and soleplate, marking the excess of foam as shown in Figure 8, and dressing the excess of foam on the dorsal surface of the keel.
- iii) Careful attention must be paid when bonding the polypropylene calf section to the soleplate to ensure that the medial and lateral breakpoints match.

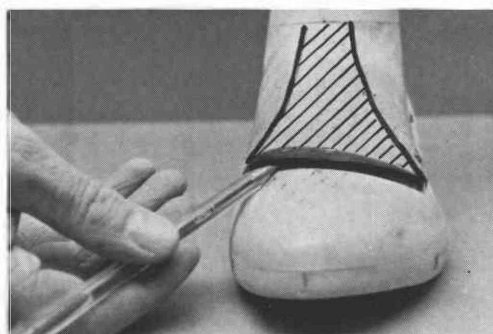


Fig. 8. Modification to polyurethane external keel prior to polypropylene drape.

The correct mating of the keel and soleplate can be monitored by recording the anterior socket brim position relative to the toe of the soleplate immediately after alignment, and again at delivery. If the optimum position of the keel/soleplate is not achieved a plantar or dorsiflexed condition results. Moving the soleplate forward by 2mm relative to the keel introduces dorsiflexion which results in the anterior socket brim moving forward approximately 10mm relative to the soleplate toe. Conversely, moving the soleplate posterior 2mm relative to the keel introduces plantarflexion which results in the anterior socket brim moving posteriorly approximately 10mm relative to the soleplate toe.

Conclusion

The level of interest in ultralightweight prosthesis designs is high but most designs which utilise polypropylene have proved difficult to manufacture to the satisfaction of the prosthetist. However steps can be taken to overcome these problems.

This paper identifies the problems which have led to the revised manufacturing technique.

The results of the clinical evaluation of this ultralightweight BK prosthesis will be published at a later date.

Acknowledgement

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Clinical experience of gait analysis in the management of cerebral palsy*

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Abstract

This paper describes clinical experience of the use of gait analysis in the management of cerebral palsy. Recording procedures are outlined and the advantages of gait analysis in patient assessment are presented.

Introduction

The pathophysiology of cerebral palsy is so complex that a more detailed analysis than that obtainable by standard methods of examination is required for treatment planning.

Gait analysis provides both long lasting documentation of movement disorders and reveals phenomena which are invisible to the eye such as forces, muscle activity and bursts of rapid motion. In studying cerebral palsy, the movements of head, trunk and large body segments as well as those of the feet and hands contain valuable information. Recordings with high spatial resolution such as are obtainable by cinephotography are therefore required; stick figures are sometimes insufficient.

Experience in a busy cerebral palsy clinic has demonstrated that the long term management of these patients is greatly facilitated by gait analysis. This technique has also played a decisive role in improving treatment programmes during the past 15 years.

The instrumentation employed differs little from that of other clinical gait laboratories. It was designed primarily for children and adults with cerebral palsy and other neurogenic disorders with orthopaedic problems and consists of two transparent force platforms

KISTLER model Z 4305 with a natural frequency of 500 Hz; three high speed cameras LOCAM; a six channel electromyography system using radiotelemetry; a digitizing tablet for film evaluation and a connected minicomputer with magnetic discs and a matrix printer.

To date, the gait laboratory has been used to record all ambulatory patients who needed orthopaedic surgery or functional bracing. Considerable benefits have accrued from the follow-up assessment of these patients in the gait laboratory with observation periods up to 12 years. The pre- and postoperative evaluations of patients with hip adductor transfers to the ischial tuberosity (Baumann et al, 1978), distal hamstring lengthening (Baumann et al, 1980) and intertrochanteric femoral osteotomies (Baumann, 1981) have led to an improvement in the treatment programmes by modifying some of the operative procedures and changing the timing of others. They have also provided an improved insight into the benefits and limitations of the three main treatment modalities in cerebral palsy, that is, physiotherapy, orthotics and orthopaedic surgery.

Patients with cerebral palsy suffer from brain damage acquired before, during, or shortly after birth; the basic disorder is non-progressive. Early physiotherapy within the first weeks and months of life may improve some brain functions by stimulating compensatory mechanisms in a still plastic nervous system. Later on, treatment can only help to achieve optimal use of the remaining functions and inhibit the

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*This publication is dedicated to Professor Gerhard Stalder on the occasion of his 60th birthday.

development of secondary deformities. The speed of development of the latter appears to run parallel to the rate of growth. Children with cerebral palsy are born without musculo-skeletal deformity and, ideally, good treatment should fully prevent such deformity.

Gait analysis assists an evaluation of the functional effect of the primary disorders of neuromotor control by the brain such as spasticity, athetosis, ataxia and hypotonicity. In addition, it can demonstrate the practical importance of muscle contractures and secondary bone deformity. The changes in the movement patterns of these patients usually develop slowly over years, as a result the important role of gait analysis in follow-up studies is widely appreciated by clinicians and many authors have published studies in this field.

Clinical application of gait analysis

The clinical application of gait analysis in cerebral palsy has demonstrated important phenomena either caused by natural developments alone or in connection with treatment. Spastic crouch gait, particularly its variant produced by overlengthening of the Achilles tendon, was elucidated by Sutherland and Cooper (1978) who showed that the Achilles tendon lengthening is a particularly hazardous procedure with many contra-indications in spastic cerebral palsy in spite of the fact that it is still the most common operation for this condition (Sutherland 1980). Feldkamp (1979) has carefully described the correlations between the severity of spastic symptoms in cerebral palsy and gait parameters such as step length. Fleiss (1978) has used a force plate not only for evaluation and documentation in children with spastic disorders of movement of cerebral origin, but also for feed-back therapy, in order to improve gait characteristics under voluntary control by the patient.

The author's personal experience is based upon the use of standardized slow motion cinematographic recordings using short exposure times of 1 or 2 ms, an exposure rate of 50 pictures/sec and orthogonally placed cameras moving on rails that can track the patient during locomotion activity. The value of this technique for planning and evaluating natural development and treatment effects in cerebral palsy is beyond doubt (Phelps, 1967). This may

be illustrated by describing a typical case whose management was monitored in this way. A patient with infantile spastic hemiplegia, was treated at the age of 7 years, by Achilles tendon lengthening for equinus foot deformity leading to an excellent result. A severe equino-cavovarus deformity of the foot developed, however, during the growth spurt of puberty. The combination of further operative correction at the level of the foot and leg with intertrochanteric femoral osteotomy for derotation and long term physiotherapy, resulted in an almost normal walking pattern by the age of 17 years. In order to maintain the equilibrium of muscle length around the ankle joint, the patient continues to use a night splint with the ankle joint at right angle. She still shows a small deficit in active knee extension and weak propulsion by her foot on the spastic side.

This is an example of the possible prevalence of secondary effects within the musculo-skeletal system over those of the primary neurological disorder and the importance of optimal orthopaedic management in spite of a persisting neurological deficit.

On the basis of the long term results observed following Achilles tendon lengthening and in some cases of gastrocnemius recession in different gait laboratories, a policy was adopted which has almost completely succeeded in preventing such operations by a combination of physiotherapy and the use of ankle-foot orthoses for positioning at night. In some instances these had to be supplemented by functional ankle-foot-orthoses with a solid ankle made from polypropylene.

Another advantage of gait analysis in cerebral palsy is represented by improved techniques in treating hamstring contractures of patients with spastic diplegia and tetraplegia. Comparison of pre-operative recordings of knee flexion/extension during walking with recordings made at an average interval of 32 months following distal hamstring lengthening, showed satisfactory improvement in knee extension during late swing and early stance phase. Concern remains regarding the regular loss of knee flexion occurring around mid-swing following these operations (Baumann et al, 1980). So far, increased use of so-called fractional lengthening of muscles, instead of tendon-elongation, applying multiple transactions of the aponeurotic tendinous sheets

on and within the muscle appears to provide a better equilibrium between the gain in knee extension while the hip is flexed and the conservation of sufficient contractility of the hamstrings for bending the knee and thus functionally shortening the leg during its forward swing.

In spite of successful operations the preferred policy is to prevent hamstring contractures or treat them with a daily programme of exercises by very slow stretching.

Valuable documents on specific phases of movement are obtainable from stroboscopic photographs, multiple exposures on photographic film, serial drawings of body contours with superimposed force vectors (Sutherland and Cooper, 1978) or by stick figures obtained from computer assisted print-outs of body marker positions. Multiple exposures are informative, easy to obtain and relatively economical when obtained using a series of electronic flash units and a suitable camera. A commercial timer permits recording up to 10 pictures (Fig. 1).

In cerebral palsy, the coordination of force generation by different muscles is disturbed. The measurement of ground reaction forces using force plates must logically reflect the most important functional impairment in locomotion

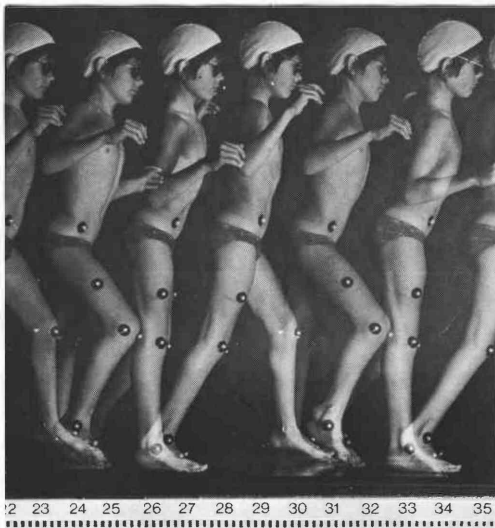


Fig. 1. Multiple exposure photograph showing a typical pattern of gait in a 10 year old boy with cerebral spasticity and moderate hamstring contractures.

produced by this part of the disorder. A prominent feature in force plate recordings from patients with spasticity of cerebral origin is the contrast between high but short peak forces connected with loading of the foot, breaking and supporting, and both low and slowly developing sagittal shear forces during the phase of propulsion in the second half of stance phase (Fig. 2). This can be explained by the natural contraction of many muscles, both flexors and extensors during the period of limb loading (positive supporting reaction), while the rapid, forceful activity of the extensors for propulsion is made less effective by the pathological co-contraction of the flexors in connection with their rapid stretching due to extensor activity.

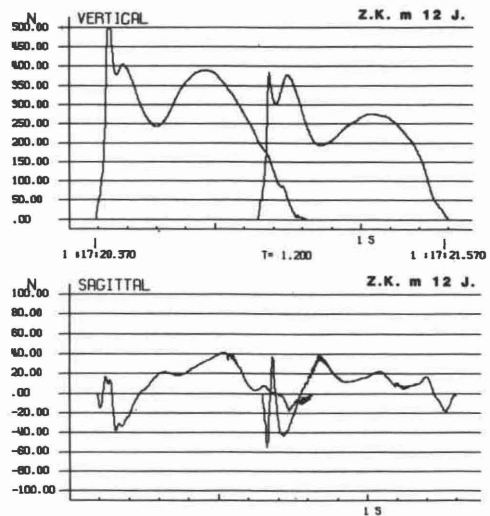


Fig. 2. Typical force platform recordings for left and right foot in spastic diplegia from a boy age 12 years. High initial vertical force peaks, slowly developing propulsive force in the sagittal direction.

The vector of floor reaction forces can be used to calculate approximate moments produced by these forces at the major joints. In addition, force plates may be used to calculate the energy output for walking (Cavagna, 1975). Normally, the vectors of floor reaction forces tend to pass very near the centres of rotation of the major joints. In patients with spasticity, the distance of these force vectors from the joint centres is often markedly increased, leading to much larger passive moments.

Summary

A number of procedures for gait analysis have proved useful for the management of patients with cerebral palsy. They have provided deeper insight into the pathophysiology of locomotion in the presence of spasticity, resulting in better methods of treatment. In addition, both kinematic and kinetic recordings have yielded otherwise unobtainable documents for monitoring the progress of the patients and their walking ability, as well as offering possibilities for the evaluation of the short and long term effects of physiotherapy, orthotics and operative procedures. There are technical inadequacies in gait recording and measuring techniques which still have to be resolved. A high spatial and temporal resolution would increase its value for practical purposes.

Acknowledgements

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The technique of reciprocal walking using the hip guidance orthosis (hgo) with crutches

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Abstract

An orthotic method of providing reciprocal walking for high thoracic levels of paralysis is detailed. The essential features of the hip guidance orthosis are described, as well as the basic muscle requirements for this form of walking (shoulder, arm and hand function plus Latissimus Dorsi). The walking sequence is described at each stage under the three main headings: mechanics, muscle action and hip guidance orthosis reaction—to build a complete picture of the walking process. The importance of considering the input made by the patient in addition to the purely mechanical orthotic contribution is illustrated.

Introduction

Orthotics has, for many people, the aura of being an empirical science. This may be true, not only in that mechanical principles are seldom used in the design of orthoses, but more particularly in that the contribution made by the patient in combining with the orthosis to make a functional system is often ignored. An example of such an empirical system is the provision of body brace and calipers (HKAFO, or traditional "full set") to provide walking function in total paraplegia.

When considering walking in complete paraplegia above L1, the choice lies between swing-through gait and reciprocal (step-by-step) walking. The latter, by reducing the vertical excursion of the centre of mass, can provide a

theoretically more efficient form of walking. The orthoses provided to achieve these forms of gait are long-leg calipers for the lower levels of lesion, generally used in traumatic paraplegic adults, and body brace/calipers, most commonly used in congenitally paraplegic children. The hip guidance orthosis (hgo) (Rose, 1979; Major et al, 1981) is now becoming available and is applicable to both groups of patients (Fig. 1.).

Swing-through gait using long leg calipers has been the subject of biomechanical analysis (Abramson, 1949) in which attention was drawn to orthotic function and user (patient) input. However, this form of gait with unstable hips,

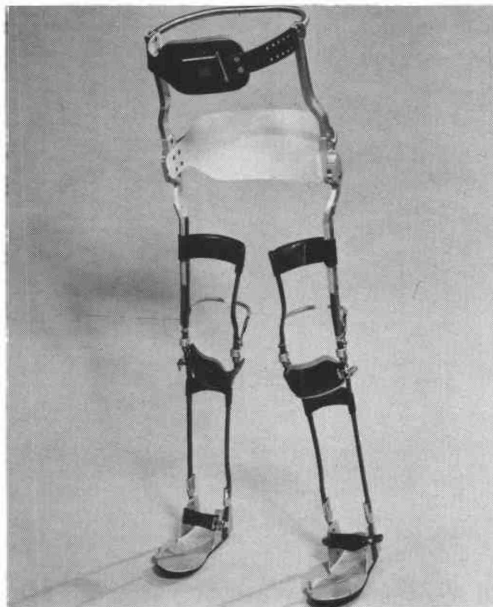


Fig. 1. Hip guidance orthosis.

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tends to require high energy input. Reciprocal gait can be obtained in long-leg calipers but is seldom achieved by patients with lesions above T12, in part due to the energy cost and the slow mode of progression, Body brace/calipers can also be used for reciprocal walking. The hip hinges are used only for sitting and when they are locked for walking the orthosis restricts desirable flexion/extension. The hgo provides stability and control of the hip joints, thus allowing reciprocal walking in complete paraplegia, including high level lesions.

This paper outlines the design and principle of operation of the hgo from both the mechanical and user viewpoint.

Hip guidance orthosis: description

This orthotic system can provide low energy reciprocal ambulation with crutches for both children and adults with spinal cord lesions between T1 and L1 (Fig. 2.).

The essential features of the orthosis are:

- i) A rigid body brace which helps maintain the relative abduction of the legs during the swing phase of the gait cycle.
- ii) A hip joint with a limited flexion/extension range and friction free operation.
- iii) Stabilization of the knees and ankles.
- iv) A shoe plate incorporating rocker sole.
- v) Simple fastening arrangements of the orthosis to ease application and removal.

The addition of crutches and training in the total use of the hgo completes the system.

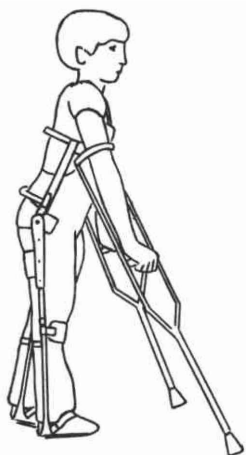


Fig. 2. Hip guidance orthosis can provide low energy reciprocal ambulation for patients with spinal cord lesions between T1 and L1.

The current design uses an aluminium alloy tubular and channel section body brace to provide a rigid lightweight structure. A support point on the chest is provided by a leather chest strap with a seat belt fastening for easy fixation, and on the buttocks by a polypropylene support band attached directly to the bearing housing.

The user's shoe rests on a shoe plate which is provided with a rocker section at heel and toe. The foot and shoe are held in place by a strap with a simple latch fastening enabling the user to retain normal footwear. The shoe plate is fixed to the caliper section, with the appropriate amount of dorsiflexion. The knee is held in extension by a simply latched padded strap reacted by the posterior thigh band and a vertical extension on the rear of the shoe plate. Knee joints are provided, and both these and the hip joints release to allow the user to sit.

The limited flexion/extension range at the hip ensures that step length is controlled. In some cases the physiological extension stop of the hip may operate before the orthotic stop.

Muscles involved in hip guidance orthosis walking

The following provides a brief guide, for those not familiar with anatomy, to the function of the major muscles involved in hgo walking.

Latissimus Dorsi: this large muscle acts when the flexed arm is extended against resistance until the arm reaches the plane of the body; it also acts as a tie between the shoulder and the pelvis on the swing leg side.

Pectoralis Major: acting as a whole, the muscle adducts the humerus; the lower fibres act in conjunction with *Latissimus Dorsi*.

Deltoid: is also capable of acting in parts or as a whole; the rearmost fibres co-operate with the *Latissimus Dorsi*; it acts to steady the shoulder; it acts as an abductor of the shoulder joint.

Trapezius: assists in steadying the scapula and maintains the level and poise of the shoulder.

Triceps: the principal extensor muscle of the elbow.

The mechanics of walking using the hip guidance orthosis with crutches.

In any efficient mode of ambulation there is a constant exchange of energy between the potential and kinetic states. Therefore any discussion of the forces involved must include inertial forces to be complete. The complete

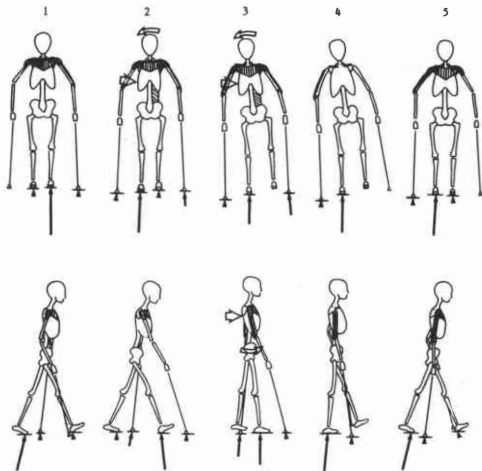


Fig. 3. Hgo walking, stages 1-5 anterior and lateral. Key - \downarrow ground reaction forces. \rightarrow essential hgo reaction forces. \curvearrowright selected rotations. \square active muscles.

sequence for one step of hgo walking is illustrated in Figure 3. In the following description of ambulation using the hgo the cycle will be described from Right Crutch Strike (Fig. 4) but the reader is advised to follow the full cycle and then return to Stage 1, Right Heel Strike, in order to understand fully the nature of these inertial forces.

It should be noted that not all users pass through the phase of gait described by Stage 4 but will go from Stage 3 straight to Stage 5. The user here described is a "Group III" user (see Classification of hgo users), those omitting the Stage 4 being Group II.

Note: In the description of muscle action it is accepted that the muscles of the hand and arm are used throughout, as are the small muscles of the shoulder and Serratus Anterior. Their action is not individually described. The muscle action of moving the crutch forward is also not detailed, the description being confined to the muscles directly involved in producing ground reaction forces. A full analysis of ground reaction forces may be found in the paper by Major et al, (1981).

Inertial forces are only shown where they are essential to an understanding of the mechanics.

In discussing hgo action, it is accepted that stabilization of the lower limb and control of hip adduction are functional at all times. Descriptions are limited to those where reaction forces produced by the device are essential to comprehension of hgo function.

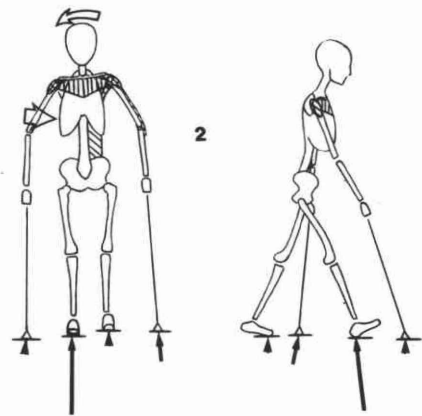


Fig. 4. Hgo walking, stage 2. Right crutch strike, commencement of lateral movement to right.

This work has been confirmed by electromyographic studies of hgo users.

Stage 2. Right Crutch Strike. Lateral movement to right commencing. (Fig. 4)

Mechanics. Most weight is transmitted through the right foot. The right crutch is positioned well forward, providing a small, stabilizing reaction. The left crutch is positioned slightly ahead of the left toe pushing down and back. This starts to tilt the user to the right to clear the left leg. Forward momentum of the trunk gained from the previous step, assisted by the rearward left crutch forces will cause the right hip to move through the "uphill" phase over the right stance foot (Fig. 5).

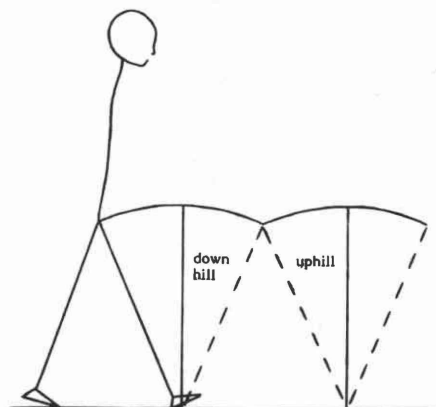


Fig. 5. Crutch force and trunk momentum move the hip "uphill". Potential energy is returned in the "downhill" phase.

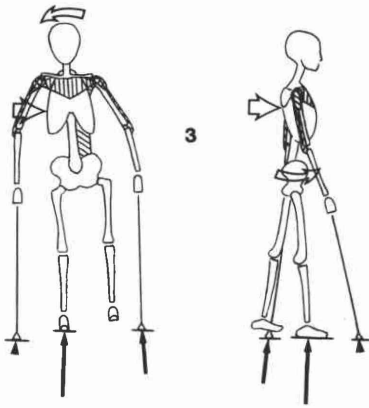


Fig. 6. Hgo walking, stage 3. Early to mid swing of the left foot. Lateral tilt to right; rotation of the trunk in the sagittal plane.

Muscle action. The forces on the left crutch are produced by the left Triceps and shoulder girdle depressors (Serratus Anterior, Pectoralis Minor, lower fibres of Pectoralis Major) with stabilization of the shoulder girdle by the right shoulder girdle depressors and the Deltoids. Extension of the shoulder (rearward crutch force) is produced by Triceps, Pectoralis Major (sternocostal part, until the arm reaches the plane of the body) and the left Latissimus Dorsi, whose action also assists commencement of leg clearance by acting as a tie between the shoulder and pelvis (see Stage 3: muscle action).

Orthotic reaction. An essential feature of the above is that the hgo should provide a reaction force on the right chest wall.

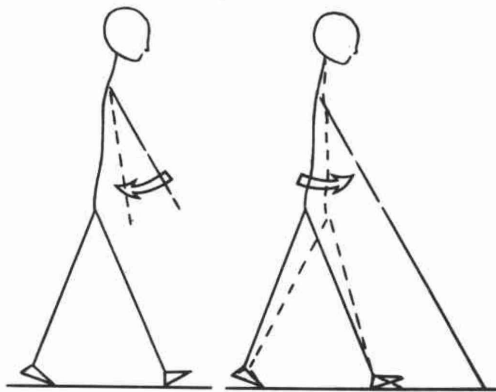


Fig. 7. Left, the normal effect of extending the shoulder is to move the arm relative to the trunk. Right, the introduction of a ground reaction (crutch) stabilizes the arm, thus producing truncal movement.

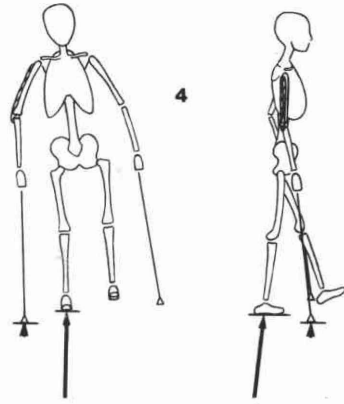


Fig. 8. Hgo walking, stage 4. Peak of right lateral tilt (Group III user only).

Stage 3. Early to mid-swing of left foot. Lateral tilt to right. Rotation of the trunk in the sagittal plane. (Fig. 6).

Mechanics. An increase in vertical forces on the left crutch reduces the load transmitted through the right foot, but the backward force is increased. Since the left arm and crutch are grounded and cannot move backwards relative to the floor, an attempt to extend the shoulder must result in trunk rotation in the sagittal plane, moving the pelvis forward. This in turn will produce extension of the right (stance) hip (Fig. 7). As the body moves up over the right foot the trunk momentum decreases. A twisting moment is produced by the horizontal components of force acting at the right leg and left crutch and this is stabilized by the small force through the right crutch.

Muscle action. The vertical force in the left crutch continues to be produced by the Triceps and shoulder depressors. Latissimus Dorsi provides

- i) forward motion of the pelvis because the arm position is fixed relative to the floor which in turn produces extension of the stance hip by assisting the forward inertial forces of the pelvis.
- ii) Latissimus Dorsi also has an additional function acting as a tie between the crutch supported shoulder and the pelvis. Thus when the hgo user is in mid swing the muscle assists the structure of the hgo in keeping the swing leg clear of the ground and preventing adduction of the hgo structure about the stance hip.

Orthotic reaction. The forward movement of the pelvis relative to the stance foot will carry the hip hinge forward in space, whereas the shoulder girdle makes a relatively small forward movement.

The top rear band ensures that the body brace maintains the correct position relative to the trunk. Reaction forces on the right chest wall will be produced as described in Stage 2 above.

Stage 4. Peak of right lateral tilt (Group III user only). (Fig. 8).

Mechanics. The left crutch force is transferred to the right foot allowing the left crutch to be removed from the ground and moved forward. The right crutch is still providing a small control force. The lateral rocking that has been imposed through the left crutch provides sufficient momentum to carry the centre of gravity towards the right leg support but not past it. In time this motion will be reversed and the body will drop onto the left leg which should have achieved the maximum flexion permitted by the hgo. The forward truncal momentum will have increased due to the "downhill" phase of moving over the stance foot.

Muscle action. There is minimal muscle activity at this point. The left crutch will be moved forward. There is sufficient activity of the right Triceps and shoulder girdle to stabilize the right arm against the small control forces being generated.

Orthotic reaction. The fact that there is very little muscular activity implies that the hgo structure is not reacting muscle force, but is simply resisting adduction and limiting hip flexion.

Stage 5. Left heel strike. (Fig. 9).

Mechanics. Body weight is transmitted through the right foot but transfer to the left foot is about to commence. This will be assisted by the lateral momentum gained by rocking off the right foot. The right crutch is still providing a small control force although this could be increased to assist the rocking if required. At this point the trunk has maximum forward momentum gained from the "downhill" phase.

Muscle action. The only muscle action required is to provide the control force on the right crutch, with increase to assisting force if necessary to rock onto the left foot. This function is fulfilled as before by the right Triceps and shoulder depressors.

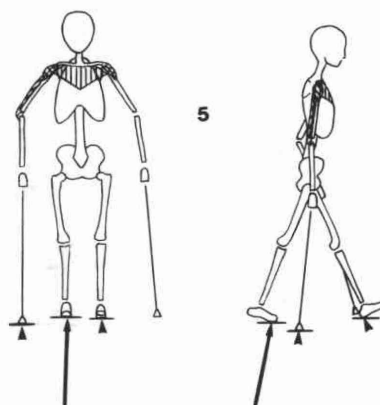


Fig. 9. Hgo walking, stage 5. Left heel strike.

Orthotic reaction. As Stage 4.

The left crutch is then repositioned in front of the left foot ready to begin the sequence for the next step.

Classification of hip guidance orthosis users

The precise mode of hgo walking varies from user to user and may alter with time in an individual user. It is valuable to observe and classify these variations for two reasons:

1. Awareness and understanding of different walking styles is extremely helpful in gaining total understanding of the mechanics of hgo walking.
2. As the user gains familiarity and experience with hgo walking, he may progress from one group to another. Thus classification forms a simple guide to user function and provides a means of monitoring this function.

There are four groups of hgo user:

Group I These are not efficient users of the hgo and demonstrate *inability to perform hgo walking* competently. Their walking is characterised by hesitancy, uncertainty and high energy expenditure. The swing leg may not clear the ground adequately, or the user may swivel on the stance leg. The walking aid may be either *rollator* or *crutches*.

This group of user will need help with their problems and it is worthwhile

1. Checking the fit of the orthosis (following routine mechanical inspection of the hgo)
2. Training the user further to eradicate problems.

Group II In contrast, these users have a rhythmical form of gait with low energy cost. They perform hgo walking as described (see

mechanics of walking using the hgo, but omitting Stage 4). Thus they always maintain at least *three points of contact* with the ground, the flow of walking being right heel strike, right crutch swing and strike, left leg swing and strike, left crutch swing and strike, right leg swing and strike etc. These users will often demonstrate marked truncal movement in the sagittal plane, which increases as they become more vigorous walkers. Speed of walking is not a factor in determining group of user and the walk may be quite slow but will be classified as Group II if the above factors are demonstrated.

Group II walkers may use either *rollator or crutches* (rollator implying at least three point contact) and this group may be usefully subdivided further into those who use rollator (II R) and those whose use crutches (II C).

The majority of hgo users will be Group II.

Group III These are the more experienced users of the hgo who have developed greater confidence and ability. Observation of their walking often reveals a pronounced side-to-side sway as they walk. Close inspection reveals that they include Stage 4 of the described mechanics of hgo walking. Thus at one point during each step they go to *two point contact* only, using the foot and crutch on the *same side* and it is this which is responsible for the pronounced lateral (coronal plane) sway. These users may also demonstrate sagittal plane truncal movement as in Group II but the effect of the lateral movement often masks this. The flow of walking is thus right crutch swing, right heel strike, right crutch strike, left leg swing, left crutch swing, left heel strike, left crutch strike, etc. (i.e. the crutch on the same side strikes after the foot).

It is obvious, therefore, that to perform this mode of walking the walking aid must be *crutches* to achieve two point contact. Because these users are more proficient, they will usually walk more quickly, and over a greater variety of surfaces than Group II.

Group IV Comparatively few users will be classified into this group. These users demonstrate an assurance not shown in the previous groups. The main feature of this mode is the *apparently random use of crutches*. The crutches may be advanced simultaneously or at random intervals. These users have reached a very refined form of hgo walking, where their awareness and familiarity with walking enables them to inject forces to their own particular needs, and to use inertial forces to greater advantage. The first couple of steps in a walking sequence usually conforms to the previously described pattern, and once in progress the more random mode takes over. Obviously this mode of walking is only achieved with *crutches*.

This group of users generally demonstrates an economy of truncal movement, which, although present, is reduced in comparison to Groups II and III.

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Measurement of skin perfusion pressure by photoelectric technique— an aid to amputation level selection in arteriosclerotic disease

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Abstract

During a period of 14 months 60 amputations, 41 below-knee and 19 above-knee, were performed on 54 patients with gangrene of the lower limb. Wound healing was evaluated in 59 amputations. A newly introduced standardized photoelectric technique for measurement of the local skin perfusion pressure (SPP) was used preoperatively, the result of which served as a guide to the selection of the proper amputation level. An overall healing rate of 90 per cent was found. Sixty-eight per cent of the amputations were performed below-knee. The healing rates for individual SPP levels were identical to those obtained with the isotope washout technique. The standardized photoelectric technique is simple and rapid and gives only negligible discomfort to the patient allowing repeated measurements at different levels on the leg.

Introduction

The isotope washout technique for determination of the skin perfusion pressure (SPP) (Holstein et al, 1977) has proved a reliable method of predicting the chance of wound healing following below-knee (BK) and above-knee (AK) amputations (Holstein et al, 1979 a, b; Støckel et al, 1981). It is, however, time consuming and often painful to the patients. The photoelectric technique (Gyntelberg et al, 1974; Nielsen et al, 1973) which is rapid and non-invasive and gives negligible discomfort to the patients has recently, in a double blind study (Støckel and Brøchner-Mortensen, 1981), been shown to give results identical to those of the isotope washout technique and with the same precision.

This paper presents the clinical results of BK and AK amputations performed after introduction of the photoelectric technique as a routine method for preoperative assessment of proper amputation level.

Patients and methods

Patients

During a period of 14 months (1.7.1980 – 31.8.1981) 60 amputations of the lower limb were performed on 54 patients (30 males and 24 females) with gangrene and/or severe ischaemic pain. Selection of amputation level was guided by preoperative determination of the local SPP. There were 41 BK and 19 AK amputations. Pertinent clinical data on the patients appear in Table 1. Nine of the 19 patients with diabetes mellitus were treated with insulin. Duration of diabetes was more than ten years in nine patients and less than two years in three patients. Of the 44 patients a major amputation had previously been performed in 15 cases (fourteen contralaterally; one homolaterally) and in four cases bilateral or contralateral reconstructive peripheral arterial surgery (from seven months to ten years before the current amputation) had been performed.

Table 1. Distribution of diabetes mellitus, age and level of amputation in 60 BK and AK amputations.

	No. of cases	Median age years	BK/AK ratio
Diabetes mellitus	19	78 (44-88)	18/1
Without diabetes mellitus	41	73 (49-93)	23/18

Skin perfusion pressure

In all cases but two the SPP was determined by the photoelectric method as the minimal

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external pressure required to prevent skin reddening after blanching of the skin. The technique has been described in detail (Støckel and Brøchner-Mortensen, 1981). The technical equipment consisted of a photodetector* placed against the skin and connected to a plethysmograph*. External counter pressure, applied by means of a blood pressure cuff, was suddenly raised to suprasystolic level and then reduced to a constant, slow speed. When inflow of blood in the capillaries of the skin starts, the tracing changes direction and SPP is read as the counter pressure at this point. Because of difficulties interpreting tracings from low pressure extremities the newly introduced standardized reading technique was used in all cases. By this technique the *systolic* blood pressure measured indirectly by strain-gauge technique at the same level of the leg guides the reading of the photoelectric tracing. Results of the photoelectric recording are given as the mean value of two determinations. Measurements were performed at two different levels of the leg; the anterolateral side of the calf 10 cm distal to the knee joint and the anterolateral side of the thigh 10 cm proximal to the upper margin of the patella.

In one patient the standardized photoelectric method could not be used due to incompressibility of the crural arteries. The patient had bilateral BK amputations, and in both cases the SPP was determined preoperatively by the isotope washout technique (Holstein et al, 1977).

Surgery

The median time interval between the SPP measurement and the operation was four days (one to nineteen days.) At calf level, amputation with a long posterior and a short anterior flap was used; simple myoplasty was used in all the AK cases. Postoperatively the wounds were loosely covered with Tube-gauze^R. Sutures were removed after 22 days (12 to 42 days).

Primary healing was defined as complete healing of the wound at the end of the sixth postoperative week. *Healing by second intention* was defined as healing from the seventh to the end of the twelfth postoperative week possibly after minor surgical revision. Cases where reamputation was necessary were called *failures*.

Statistics

Fisher's exact test was used.

Results

Mortality

Four patients died during hospitalization from four to 34 days after the amputation. Sutures had been removed and the wounds were completely healed in three of the patients. One patient with a BK amputation developed gas gangrene and died four days after the operation. This patient is excluded from the material.

Wound healing in 40 below-knee amputations.

Figure 1 shows the relationship between the preoperative SPP and wound healing in the 40 cases where a BK amputation was performed. One failure in each of the SPP groups 21–30 mm Hg and 31–40 mm Hg was due to infection and haematoma in connection with necrosis. Three failures in the group 41–50 mm Hg were due to necrosis in one case and infection and haematoma in connection with necrosis in two cases. One failure in the SPP group 51–60 mm Hg was due to necrosis. There was no significant difference between diabetics and non-diabetics ($P = 1.00$) with respect to relative number of failures in the SPP interval 31–60 mm Hg.

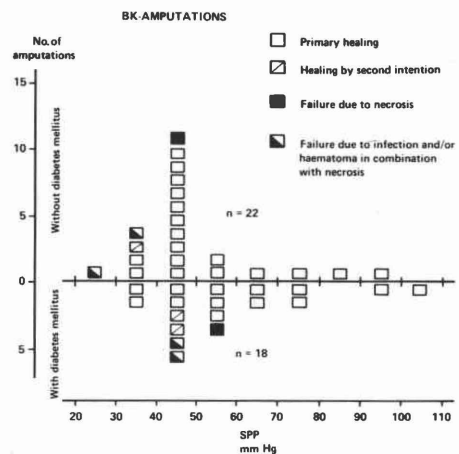


Fig. 1. Healing and wound complications in 40 BK amputations in relation to the preoperative local skin perfusion pressure.

Wound healing in 19 above-knee amputations (AK).

Figure 2 shows the relationship between the preoperative SPP and wound healing in the 19 cases where an AK amputation was performed. All amputations healed primarily or by second intention.

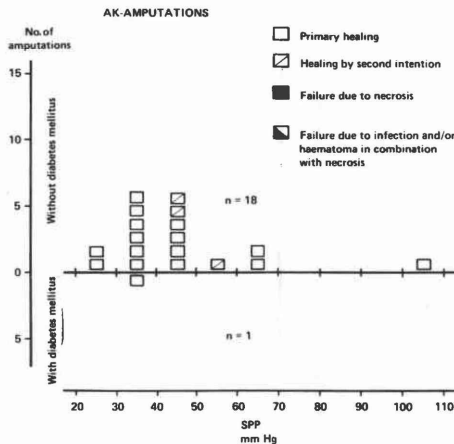


Fig. 2. Healing and wound complications in 19 AK amputations in relation to the preoperative local skin perfusion pressure.

Discussion

The benefit of using a reliable objective method for the prediction of proper amputation level is shown by a reduction of the number of reamputations and/or by an increase of the BK/AK ratio compared to the results obtained when selection of amputation level is based on clinical judgement alone (Moore, 1973; Christensen, 1976; Kostuik et al, 1976).

Holstein et al, (1979 a, b) showed that there is a strong positive correlation between the SPP and the chance of wound healing following BK and AK amputations. The recent finding (Støckel and Brøchner-Mortensen, 1981) that the standardized photoelectric technique gives results identical to those of the isotope washout technique and that the reproducibility of the two methods was equal suggested that the healing rate in a clinical study of BK and AK amputations would be of comparable size in the individual SPP groups. This comparison is given in Table 2 showing no significant difference between the two methods in any of the SPP groups studied. From an ethical point of view comparison of clinical results following amputations with SPP below 20 mm Hg is not possible as the chance of healing at these low pressures is minimal (Holstein et al, 1979 a, b). At borderline SPP values, especially, clinical factors such as the surgical technique, the postoperative treatment and the general condition of the patient can influence the chance of wound healing. As previously described by

others (Termansen 1977) a significantly higher BK/AK ratio was found in the diabetic group compared to non-diabetics ($P = 0.019$) indicating that patients with diabetes as a group are better candidates for BK amputations than non-diabetics.

Table 2. The observed healing chances (BK amputations) given as per cent when the local SPP is measured preoperatively by the isotope washout technique and the photoelectric technique. Number of cases are indicated in brackets.

	Skin perfusion pressure (mm Hg)	
	31-40	> 40
Isotope washout technique (Holstein et al, 1979 b)	82% (11)	93% (29)
Photoelectric technique (Present study)	83% (6)	88% (33)
P-value	1.00	0.85

The results of the present study indicate that the standardized photoelectric technique can replace the cumbersome isotope washout technique as a routine method for selection of proper amputation level. The method is simple and rapid and gives only negligible discomfort to the patient; repeated measurements at different levels of the leg are therefore possible. The standardized photoelectric technique is usable in most patients including patients with oedema and diabetes mellitus. The isotope washout technique will, however, still be the method of choice in those rare cases where a systolic blood pressure cannot be obtained or in cases where it is not possible to get a technically satisfactory photoelectric tracing because of extremely thin skin at the measure point. In the present study it was thus necessary to use the isotope washout technique in 2 cases (same patient) corresponding to 3 per cent of all investigations.

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Functional capabilities of lower limb amputees

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Abstract

Five hundred lower limb amputees were evaluated by personal interview at the Artificial Limb Centre, Pune, India. Information thus obtained on activities of daily living and functional capabilities with their prostheses was analysed. The analysis showed that 55% of the amputees were totally independent, 40% had to use a crutch or cane and only 5% were solely dependent on a wheelchair for ambulation. Further, it was also confirmed that as age increased, functional independence decreased, and that below-knee amputees were more independent than above-knee and bilateral amputees. When compared with reports of other workers from the developed countries, the results were equally good, and in some functions, were even better.

Introduction

The aims of the survey were to obtain information directly from the patients on activities generally considered essential for daily living, vocational activities, living arrangements and changes therein. An attempt was made to ascertain the relationship of age and amputation level to the eventual outcome. Information regarding the above capabilities was recorded as supplied by the amputees themselves.

Materials and methods

A questionnaire was prepared and 500 lower limb amputees who had come to the centre in 1980/81 for repair/replacement of their prostheses were interviewed individually and their answers to the questionnaire recorded.

In the interest of simplicity, the level of amputation was divided into three categories—

- 1 Below-knee including partial foot, Syme and below-knee amputations.
- 2 Above-knee including knee disarticulation, above-knee and hip disarticulation amputations.
- 3 Bilateral including combinations of the above.

Primary evaluation consisted of relating the level of functional achievement to the site of amputation. Secondary factors considered were aetiology, age and sex. Relevant data were analysed.

Patient sample

Of the 500 patients interviewed, 298 (60%) were soldiers and 202 (40%) civilians. There were 474 (95%) males and 26 (5%) females. The ages of the patients at the time of amputation ranged from 2 to 65 years (Fig. 1.), and the oldest was now 92 years of age. The majority,

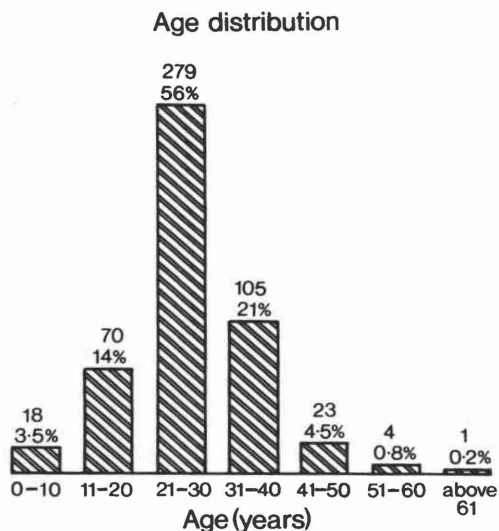


Fig. 1. Age at time of amputation.

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279 (56%), were between 21 and 30 years of age. The marital status of the amputees as found in this series is reflected in Table I. The majority of the patients (60%) married after becoming amputees.

Table 1. Marital status

	At time of amputation		After amputation	
	Married	Unmarried of marriageable age	Married	Unmarried
Male	296	160	104	56 (35%)
Female	9	17	2	15 (88%)
Total	305	177	106	71
%age	63	37	60	40

Duration of disability

The length of time since the amputations varied from 1 to 30 years as shown in Figure 2. There were 61 patients (12%) of over 30 years duration, of whom 60 were World War II veterans and one was a First World War casualty.

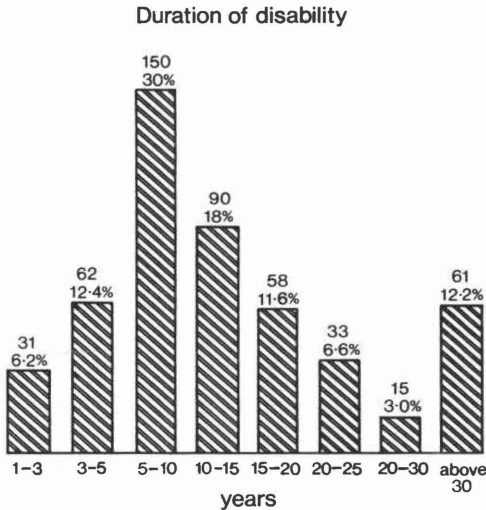


Fig. 2. Time since amputation.

Cause of disability

The majority of cases, 408 (82%), were due to trauma, 86 (17%) due to disease and 6 (1%) congenital. The aetiology for traumatic amputation is depicted in Figure 3. Among amputees who lost their limbs due to disease, 48 cases (56%) were due to Thromboangiitis

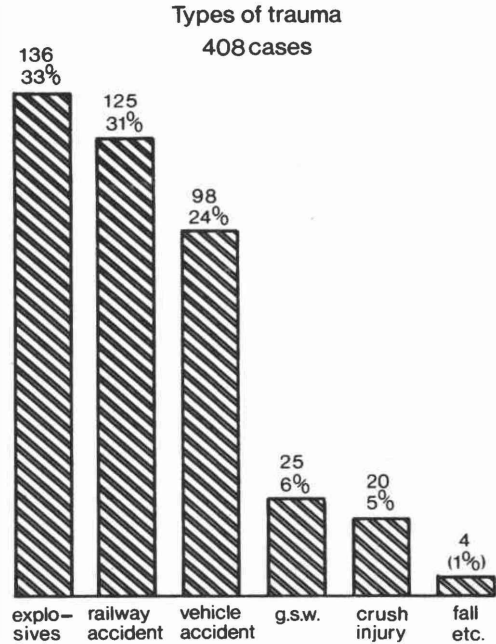


Fig. 3. Types of trauma.

obliterans, 18 cases (21%) due to gangrene, 4 (5%) due to diabetes, 6 (7%) due to sarcoma and 10 (12%) due to others.

Type of amputation

There were 308 (61.5%) below-knee, 124 (25%) above-knee and 68 (13.5%) bilateral amputees.

Results

Activities of daily living

There is an extreme paucity of information in the literature relating to activities of daily living (ADL) among amputees.

Dressing

(Including donning and doffing prostheses). All our patients could dress and don their prostheses without any external help, but some took more time than others.

Bathing

Of the total group, 80% could sit on the floor and bathe in the normal manner, 4% took a standing shower and 16% sat on a stool; both latter groups used wall, grab-bars or hand-rails to assist them. Of the bilateral amputees, 25 (37%) sat on the floor and 43 (63%) sat on a stool.

Getting in and out of chairs

Support was not required by 241 (48%) of patients but 238 needed arms on low chairs, while 21 (4%) required arms on all types of chairs. Of the below-knee amputees, 67% did not require any support, while in above-knee about 67% amputees did need support.

Use of aids for ambulation

Table 2 shows that 267 cases (53%) used no assistive devices, 204 cases (41%) used one cane and the remaining 29 cases (6%) used 2 canes or crutches and wheelchairs. Out of 60 bilateral amputees, 12 used wheelchairs exclusively.

Many more patients between 31 and 60 years used one or more assistive devices compared to those younger than 30 years. When both age and level of amputation are considered, 54% of below-knee under 30 years and 10% of below-knee above 30 years did not need assistive devices. In the above-knee group, 31% of those 30 years of age and under, and 7% of those above 30 years did not need assistive devices. In bilateral amputees, 25% of those under 30 years and 4% of those above 30 years did not need assistive devices.

Table 2. Amputation level and use of assistive devices

	Below-knee	Above-knee	Bi-lateral	Total	%age
None	199	48	20	267	53.4
One cane	107	72	25	204	40.8
Two canes	1	1	11	13	2.6
One crutch	1	2	—	3	0.6
Two crutches	—	1	—	1	0.2
Wheelchair	—	—	12	12	2.4
Total	308	124	68	500	

Daily distance walked

Twelve per cent of the total patient population felt that they walked as much as non-amputees. Most of the patients (84%) walked outdoors daily for approximately 1-2 km, 1.5% walked only in the house, and 2.5% (among bilateral cases) did no walking at all.

Use of stairs

Patients were asked their ability to ascend (Fig. 4.) and descend (Fig. 5.) stairs. Only 27% of the group did not need help, while 3% (all bilateral) could not manage stairs at all. Those needing hand rails or other assistance totalled 70%. Of the total group, 16% descended stairs

step over step, while 81% preferred one step at a time. Thirteen bilateral cases could not use stairs either way.

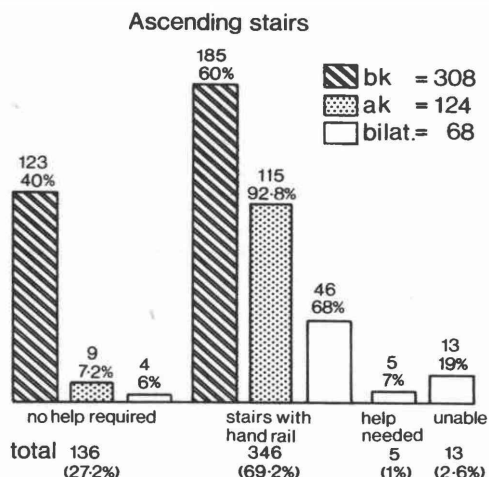


Fig. 4. Stair climbing ability.

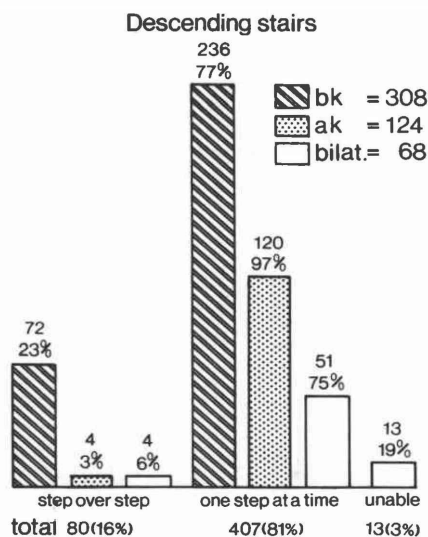


Fig. 5. Stair descending ability.

Use of ramps

Most patients (92.8%) had no trouble using ramps (Fig. 6.), while 4.6% needed help and 2.6% could not manage ramps at all with their prosthesis but could use them with a wheelchair.

Getting up from the floor

Getting up from the floor, a fairly simple task,

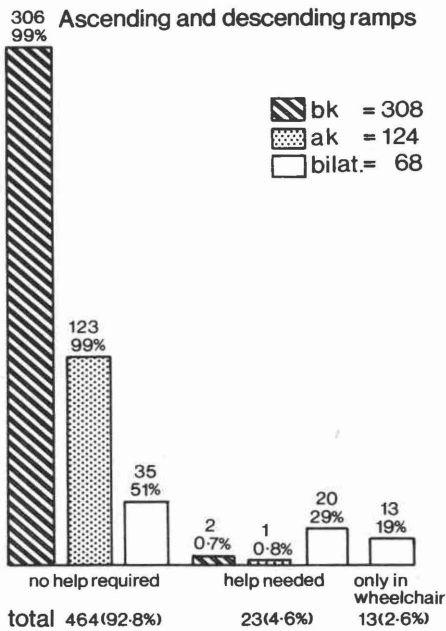


Fig. 6. Use of ramps.

can be difficult for the individual who lacks proprioception and push off. Thus, 8% of below-knee, 14% of above-knee, and 41% of bilateral amputees needed help, while 30 patients in all, including 15 (22%) bilateral amputees, could not get up from the floor.

Transportation

The ability to drive and use public transport is an important part of today's life style. The majority of patients, 417 (83%) had no previous driving experience. Only 6% could drive a vehicle.

Two hundred and forty patients (48%) could ride a bicycle while 250 (50%) stopped cycling after amputation and 10 (2%) did not know how to cycle even prior to amputation (Fig. 7).

Concerning the use of public transport, 485 (97%) cases could use taxis, buses and trains; and 15 (3%) could use some forms of public transportation but not all.

Employment

Of all the patients 12% stayed in the same job while 47% had to change occupation; only 3.5% were unable to work and another 4% were able to work but were unemployed.

Living arrangements

The ability to return to and maintain a normal

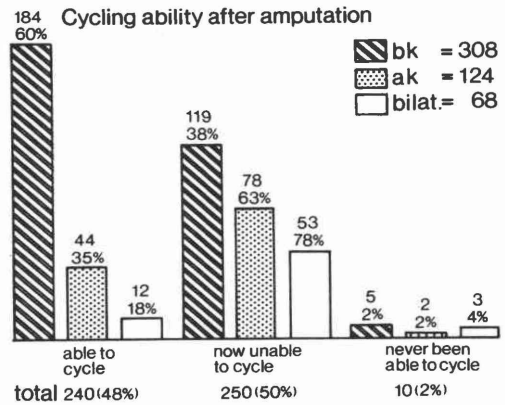


Fig. 7. Cycling ability after amputation.

home life is an important aspect of total rehabilitation. The patients were asked three questions (1) Where do you now live? (2) Did you have to change your living arrangements? (3) Did you make modifications in your home?

Ten (2%) lived alone, 177 (35%) lived with their own families and 313 (63%) lived with several families.

Most patients 479 (96%), had not changed their living arrangements. The 21 (4%) who had changed because of amputation, included 9 (3%) below-knee, 2 (2%) above-knee and 10 (15%) bilateral amputees. Two patients had ramps installed in place of steps. Some converted the Indian type latrine to Western commode. Others put a small platform or chair in the bathroom. Some had a railing attached to the adjoining wall.

Sexual relationships

Seventy four per cent of the amputees stated that they had not experienced any change in their sexual relationships since amputation; 18% were unmarried. The 8% who said that they were affected, included 16 below-knee, 15 above-knee, and 10 bilateral amputees.

Other effects of amputation

Of the 500 amputees, 438 (87%) could not walk as before, 299 (60%) could not walk long distances, 319 (64%) could not climb, 286 (57%) could not do heavy lifting, 427 (85%) could not play outdoor games and 394 (79%) could not kneel/squat.

Classification of functional level achieved

To summarize the information given in this section, the patients were classified into five

simple categories (Table 3).

- Class I — Totally independent.
 Class II — Independent with one cane or crutches.
 Class III — Independent in home ambulating with prosthesis, but need wheelchair for outdoor activities.
 Class IV — Independently ambulant with crutches, but not wearing a prosthesis.
 Class V — Non-ambulatory except in wheelchair.

Table 3. Functional outcome of amputation

	Below-knee	Above-knee	Bi-lateral	Total
Class I	216 (70%)	45 (36%)	20 (30%)	281 (55%)
Class II	90 (29%)	79 (64%)	29 (42%)	198 (40%)
Class III	2 (1%)	—	7 (10%)	9 (2%)
Class IV	—	—	—	—
Class V	—	—	12 (18%)	12 (3%)
Total	308	124	68	500

Functional outcome was compared to level of amputation and age at time of amputation. Data were analysed revealing the following.

Age had a definite effect on the functional outcome of the patient; as age increased, functional independence decreased.

There was also a significant relationship between the level of amputation and functional outcome. The below-knee amputee was more independent than the above-knee and the bilateral amputee.

There was a significant age and level of amputation interaction indicating that relative to the below-knee amputee, the above-knee amputee's functional independence decreased more rapidly with age. The functional decline of the bilateral amputee in comparison to the below-knee amputee was even more rapid.

Discussion

This study was carried out to document some of the characteristics of the amputee and to compare the results with those of other authors who have done similar studies.

The patient sample was compared with those

of other investigators. A sex distribution of 95% males and 5% females in this series differs from that reported by Glattly (1964) and Kegel et al, (1978) which was 77% males and 23% females. An earlier survey done in this centre of 14,400 civilian new patients (Narang and Jape, 1982) showed 88% males and 12% females. The lower incidence of female patients in this study is probably due to the socio-economic structure of a male dominant society. Women also usually stay at home and are thus less exposed to the hazards of trauma.

This study also shows a greater trend towards below-knee amputations. Of this sample 62% had a below-knee amputation as compared to 56% in the Kay and Newman study, 39% in the Glattly study and 65% in the Kegel et al study.

Glattly did not mention bilateral amputee status, but Kegel et al showed it as 15% and Kerstein et al, (1974) as 23%. In this study it was 14% of the total number.

The mean age of 25 years at the time of surgery for this sample was much lower than that of other investigators (Kegel et al — 45 years, Kerstein et al — 57 years, Stern (1976) — 65 years, Silverstein and Kadish (1973) — 66 years, and Bugel and Carlson (1961) — 65 years). The explanation for the difference is that the main cause of amputation in this series is trauma (82%) in a younger age group and not diseases of old age such as arteriosclerosis (Table 4).

Table 4. Reason for amputation.

	Disease	Trauma	Tumour	Congenital
Present study 1979-1980 lower extremity	16%	82%	1%	1%
Kegel et al 1964-1976 lower extremity	49%	35%	8%	7%
Glattly 1961-1963 upper and lower extremity	58%	33%	5%	4%
Kay and Newman 1973-1974 upper and lower extremity	70%	22%	5%	3%
Kerstein et al 1961-1971 lower extremity	85%	7%	3%	5%
Davies et al 1965-1967 upper and lower extremity	37%	50%	4%	8%

Amputations occur mostly among younger people exposed to work hazards and also due to the ignorance and lack of observations of safety measures in India.

None of the patients had problems in donning their prostheses, being young individuals. Bathing presented problems to only 20% amputees (Table 5), while Kegel reported 55%. Indians usually bathe in a squatting position on the floor. Some of the above-knee and a large number of bilateral amputees required a stool, or showered and used grab bars.

Table 5. Comparison with other studies.

	Present study	Kegel et al	Kerstein et al
Dressing problem	None	13%	
Bathing difficulty	20%	55%	
Help required getting in and out of chairs	52%	60%	
Ambulation device required	47%	44%	
Bilateral amputee— independent ambulation with or without cane	68%	25%	40%
Bilateral amputee— wheelchair user	18%	40%	54%
Unable to use public transport	3%	2%	
Employment			
Same occupation	13%	22%	
Changed occupation	50%	4%	
Unable to work	35%	8%	
Change of home	1.5%	13%	
Change in sex life			
Below-knee	5%	8%	Whole
Above-knee	12%	22%	group
Bilateral	15%	35%	15%

Of the bilateral amputees evaluated, 68% were independently ambulant with or without cane and 18% used wheelchairs. These figures may be compared with those reported by Kegel et al— 25% and 40%, and Kerstein et al— 40% and 54% respectively. The higher incidence of functional capability in bilateral amputees in this study is because the majority of the patients were younger.

Cycling is the commonest and cheapest mode of transport in India and evaluation showed that of the 98% who could ride a bicycle before amputation, 50% gave up riding, but 60% below-knee, 37% above-knee and 19% bilateral amputees could still ride.

Public transport could be used without much difficulty by 97% of patients. Only 3%, who were all bilateral amputees, experienced difficulty in getting into the bus because of steps, short halts, etc.

Only a small percentage (12%) returned to the same occupation, 47% had to change their professions after amputation. Since 60% of the amputees covered in this study are soldiers, it follows from the nature of their previous work that a majority of them have to change their occupation. Among the civilians, people engaged in physical labour have to seek alternate jobs. This explains the difference in this regard between this study and that of Kegel et al where only 4% changed their jobs and that of Kerstein et al where only 15% changed their jobs.

Those previously engaged in physical labour are unable to find work after amputation because they have a low educational level. They lose their jobs due to physical inability and find difficulty in getting other jobs because of intellectual inability.

The ability of the amputee to return to and maintain a normal home life is extremely important. In this study, most of the amputees did not have to change their homes. This is more due to circumstances than choice. Most Indians live in overcrowded homes. Finding suitable accommodation after amputation is well nigh impossible. Most of them who are used to living in crowded, inconvenient homes with inadequate sanitary facilities continue to do so after amputation because of financial difficulties in finding new homes and scarcity of alternative housing.

It was observed that 85% of amputees could no longer take part in outdoor games.

Patients whose sexual relationships were adversely affected because of amputation were 5% below-knee, 12% above-knee and 15% bilateral, whereas in the Kegel et al study it was 8% below-knee, 22% above-knee and 35% bilateral, and in Kerstein et al it was 15% all together. The reasons are as follows. First of all, the amputees in this series were much younger. The other reason is that 61% of these amputees who were of a marriageable age, were already married. Of those who were not married before amputation, 60% married later.

Contrary to the assumption that loss of limbs may cause a psychological barrier to normal sexual behaviour, it was found that none of our amputees experienced such a barrier. On the contrary, most of them confessed to a heightened sexuality. Another thing is that women generally being passive and submissive in India, rejection by wives is rare.

The patients whose sex life is adversely affected are those who could not get married. They have few outlets since sexual permissiveness is still more or less a taboo.

An examination was made of the impression that below-knee amputees do better than above-knee amputees who in turn do better than bilateral amputees. Results confirm that below-knee amputees definitely do need less help than above-knee and above-knee less than bilateral amputees. In total functional outcome 70%

below-knee, 36% above-knee and 30% bilateral were found in Class I.

The patients identified the following needs in their suggestions for improvement. Only 153 offered suggestions.

- (a) A few wanted a more cosmetic looking foot.
- (b) A few wished for a more durable foot.
- (c) A few complained of the heavy weight of prosthesis.
- (d) Some wanted a manual on the maintenance of prostheses.
- (e) Some suggested ventilation holes and others water proofing of the artificial limb.
- (f) The majority complained of frequent breaking of locking joints and wished these to be more durable.

FUNCTIONAL CAPABILITIES SURVEY AMPUTEES

Interview Schedule

Name: Disability No.

Age: Sex: M/S State:

Income: Source of payment:

Education:

Do you receive pension benefits? Yes/No

Any other benefit/compensation/None.

How long ago was your arm/leg amputated?

Which arm/leg? Rt/Lt/both

If arm, were you right-handed or left-handed before amputation?

Level of amputation:

Phantom feeling

- (a) No phantom feeling
- (b) Can feel just part of missing limb
- (c) Can feel entire missing limb
- (d) Phantom is same length as opposite limb
- (e) If leg, phantom is used when walking
- (f) If arm, there is movement in fingers of phantom
- (g) Missing part is painful and requires medicine
- (h) Missing part is painful but requires no medicine
- (j) Other

Condition of stump

- (a) Scar along front/bottom/back of stump
- (b) Any other surgical scar on amputated limb?
Yes/No

If Yes, reason:

- (c) Does the amputation scar adhere to bone? Yes/No
- (d) Does fluid ever drain from anywhere on the limb?
Yes/No
- (e) Do you have any areas that are tender to touch?
Yes/No
- (f) Is your stump painless/uncomfortable/painful?
- (g) Any other condition:

Condition of unamputated limb

- (a) Normal
- (b) Does not allow me to be very active
- (c) Some cramping, but no problems
- (d) Open sores present
- (e) Painful all the time
- (f) Other:

Social adjustment

Do you live alone/with your nuclear family/in a joint family?

How have your family/friends responded to you as an amputee?

Do you feel that people are more reluctant to accept you socially since your amputation? Yes/No/Do not know

Do you feel handicapped or deprived from leading a normal life? Yes/No

If Yes, how:

Has your amputation affected your sexual activities, either physically or emotionally? Yes/No

Do you feel there is a change in your personality as a result of amputation? Yes/No
Do you find the appearance of your prosthesis a social embarrassment? Yes/No. Comments:

Prosthetic history

How long have you had a prosthesis?
Do you still wear your prosthesis? Yes/No
How many prosthesis have you had since your amputation?
Have you ever had a prosthesis from somewhere else? Yes/No
Have you made any modifications to your own prosthesis? Yes/No
If Yes, how?
How many hours per day do you wear your prosthesis?
(a) Do not wear at all
(b) 0-2 hours
(c) 2-4 hours
(d) 4-6 hours
(e) All day
(f) If arm, specify hand/hook

Putting on and removing prosthesis

(a) Can do completely alone
(b) Need some help
(c) Other
How long does your prosthesis last before you need a new one?
Is your prosthesis comfortable when you wear it? Yes/No
Comment:
Do you feel that the prosthesis is as much a part of you, as your other limb? Yes/No
How?
How long did you go for training after you got your first prosthesis?
(a) No training
(b) Less than two weeks
(c) 2-4 weeks
(d) 1-2 months
(e) 2-4 months
(a) Longer than 4 months
Length of time between surgery and completion of prosthetic training:
(a) No training
(b) One month
(c) Two months
(d) Four months
(e) More

FOR LEG AMPUTEES ONLY

Description of prosthesis

How do you keep your prosthesis on?
(a) Do not wear
(b) Cuff suspension
(c) Waist belt
(d) Leather corset
(e) Pelvic band
(f) Cuff suspension with waist belt
(g) Shoulder harness
(h) Muscle contraction (for BK)

(j) Total suction
(k) Any other
How many stump socks do you wear?
(a) Do not wear prosthesis
(b) One 3 ply
(c) Two 3 ply
(d) More
(e) None

Use of prosthesis

How do you get in and out of chairs?
(a) Do not need chair arms
(b) Need arms on low, sunken chairs
(c) Need to use arms on all chairs
(d) Other
Do you have a wheelchair? Yes/No
If yes, for which activities?

Mobility

(a) Use no crutches, canes etc
(b) Use one cane
(c) Use two canes
(d) Use one crutch
(e) Use two crutches
(f) Use walker
(g) Do not walk at all
(h) Use wheelchair
(j) Other

Outdoor Indoor

How do you manage kerbs?
(a) Without help
(b) Need help
(c) Cannot manage at all
(d) Other

Going down stairs

(a) Step over step
(b) One step at a time
(c) Other

Ramps

(a) Do not need help
(b) Need help
(c) Can only go up ramp
(d) Cannot go up or down ramp
(e) Other

Getting up from the floor

(a) Do not need help
(b) Need help
(c) Other

Dressing

(a) Can dress and undress completely alone
(b) Need help in getting dressed and undressed
(c) Other

Bathing

(a) Sit on floor
(b) Take standing shower
(c) Other

Amount of walking

(a) As much as anyone
(b) Walk in house + 6 Km.
(c) Walk in house + 5 Km.

- (d) Walk in house + 4 Km.
- (e) Walk in house + 3 Km.
- (f) Walk in house + 2 Km.
- (g) Walk in house + 1 Km.
- (h) Walk in house + ½ Km.
- (j) Walk only in house
- (k) Do not walk

Driving/motor cycle riding/cycling

Public transportation

- (a) Can use taxi
- (b) Can use bus
- (c) Can use airplane
- (d) Can use train
- (e) Can use all above
- (f) Other

Extra activities

- (a) Swimming
- (b) Running
- (c) Track games
- (d) Basketball
- (e) Football
- (f) Other

Work situation

- (a) Retired and stay at home
- (b) Part time work
- (c) Full time work
- (d) Able to work, but unemployed
- (e) Unable to work for reasons other than amputation
- (f) Unable to work because of amputation
- (g) Doing different type of work because of amputation
- (h) Child, do not work yet
- (j) Other

Type of work

- (a) Do not work
- (b) Sedentary (sit most of the day)
- (c) Stand most of the day
- (d) Heavy lifting involved
- (e) Great deal of walking involved
- (f) Other

Any other medical complication since amputation, how long?

- (a) Blindness
- (b) Stroke
- (c) Heart attack
- (d) Diabetes
- (e) Other

What do you do now that you are an amputee that you could not do before?

What could you do before that you cannot do now because of amputation?

Have you had to change your living place because of amputation? Yes/No

Have you had any modification done to your home because of amputation? Yes/No

If yes, what?

Do you have any suggestions to improve either the function or appearance of your prosthesis? Yes/No
If Yes, what?

Remarks:

Place:

Date:

Name of person taking interview

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Technical note

A method for socket duplication using Silcoset R 105

N. J. YOUNG

Princess Margaret Rose Orthopaedic Hospital, Edinburgh.

Abstract

A technique for duplicating an existing comfortable socket has been in use for two years. The method, using *Silcoset R105, provides the prosthetist with a re-usable positive mould thus enabling the manufacture of two prostheses of comparable fit.

Introduction

Amputees have often expressed a desire to be provided with two prostheses of similar characteristics. The main factors contributing to this state are socket fit and alignment. Although it may prove impossible in the clinical situation to align two prostheses identically, it should be possible to provide identical sockets. The following technique has been used on patellar-tendon-bearing (PTB), above-knee (AK) quadrilateral and Syme sockets, but could be adaptable for other types of limb.

Method

The socket to be duplicated must be internally clean and dry. Silcoset will separate freely from most plastics, but porous materials such as cordovan may require a very thin coating of a separating agent. Any proprietary domestic wax or silicone based polish should prove suitable for the purpose, it can be removed after duplication by wiping over with a solvent such as acetone. This may however affect the colour of the material in question.

Before attempting to duplicate sockets, it may therefore be a worthwhile exercise to evaluate the separating abilities of the agents and solvents in use on samples of the materials employed at that centre. The socket is cast in situ and a wrap

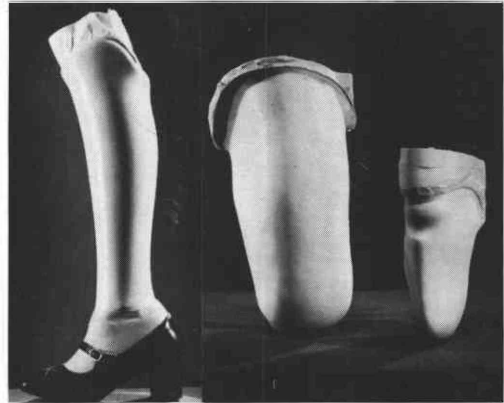


Fig. 1. Left, PTB prosthesis with masking tape around socket brim. Right, Silcoset moulds of quadrilateral AK and PTB sockets.

of masking tape a few centimetres high around the brim of the socket will aid stability when the cured Silcoset is removed (Fig. 1, left).

The amount of Silcoset required in each case can only be determined by experience, but most PTB sockets will require 2-3 layers giving around 900 g total weight.

To ensure that the first layer freely covers as large an area as possible, grade 2 silicone fluid (10% by volume) manufactured by Charles F. Thackray may be added to reduce the viscosity. This mixture should only be used as a primary coating as the rigidity of the mould is reduced if subsequent applications are applied. The manufacturers of Silcoset supply a rapid curing agent which when used as the catalyst (0.5% by volume) should allow 3-5 minutes working time. The Silcoset is distributed around the socket walls by rotating the prosthesis until the material sets. This process is repeated, allowing an interval of around 10 minutes between applications until

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a suitable thickness of mould is obtained. This is normally 0.5–1.0 cm but will depend on the dimensions of the socket in question. It has been found that additional bulk around the brim will aid dimensional stability when the mould is poured.

The cured Silcoset mould may be separated and removed about 15 minutes after the final layer has set. Should difficulty arise in removal, some silicone fluid applied to the hands will enable them to be slipped between the mould and socket interface. Once the distal surfaces have been separated and the vacuum broken, the mould can be pulled out by its base.

The duplicate mould (Fig. 1, right) is poured in the usual fashion with plaster of Paris. The antero-posterior and medio-lateral dimensions of the socket brim should be checked with those of the mould before the plaster has set, if any variation is found the mould can be distorted manually to the correct size while setting is in progress. While discrepancies of this nature are

rare, they can occur if the Silcoset walls are particularly thin or the proximal circumference larger than usual. An alternative technique when pouring is to immerse the mould in water to brim level to help equalize the outward pressure of the plaster. Lamination can now be carried out over the duplicate mould in the usual manner, the plaster removed and the Silcoset freed from the new socket and stored for future use. Large duplicates may be poured in two stages. While the mould is supported proximally, plaster is poured to around mid level and allowed to set. This then provides a stable key for the remainder to be filled. Damage to a mould such as tearing may be repaired using Silastic R medical adhesive type A.

Acknowledgements

We are grateful to Mr. M. Devlin for producing the illustrations and Mrs. C. Barclay for typing the script.

Technical note

RTV silicone insoles

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Abstract

A cheap and fast method of providing long term accommodating insoles is described. Room temperature vulcanizing (RTV) silicone rubber is used, with suitable coverings, to provide pain relief and support for feet and ankles. The combination of physical properties of the finished item provides a useful balance between support and flexibility which results in these insoles being readily accepted by the patients.

Introduction

This technical note describes a technique which may be of use to people wishing to make a cheap but effective accommodating insole. It has been used in Derby UK for the alleviation of pain due to a valgus heel, for the accommodation of flat feet, and to provide support for dropped metatarsal heads. The technique is easily learnt and is quick, providing a cheap and long lasting insole.

Method

A cast of the foot is obtained by preparing a pad of putty, about two inches thick, large enough to provide a full footprint. The putty is slightly warmed so that it flows into the contours of the foot evenly. A fine layer of plaster of Paris is sprinkled on the top surface of the putty. The same powder is applied to the sole of the patient's foot and the patient is then requested to place the foot on the pad and apply weight normally to the foot whilst standing. The foot is then carefully removed and the resulting impression filled with a slurry of Kafir-D. Once the mould has set it can be removed from the putty which can be rolled up, kept on one side, and used on another occasion. As the linseed oil

in the putty oxidizes it can be replaced by anhydrous lanolin which enables the useful life of the putty to be extended to about a year. The mould is examined and any small defects corrected; if any modifications are required, i.e. to support a particular dropped metatarsal head, they can be done at this stage. The cast is now ready for the insole to be moulded on top. Room temperature vulcanizing (RTV) silicone rubber is used (Silcoset 153)* and this is spread over the

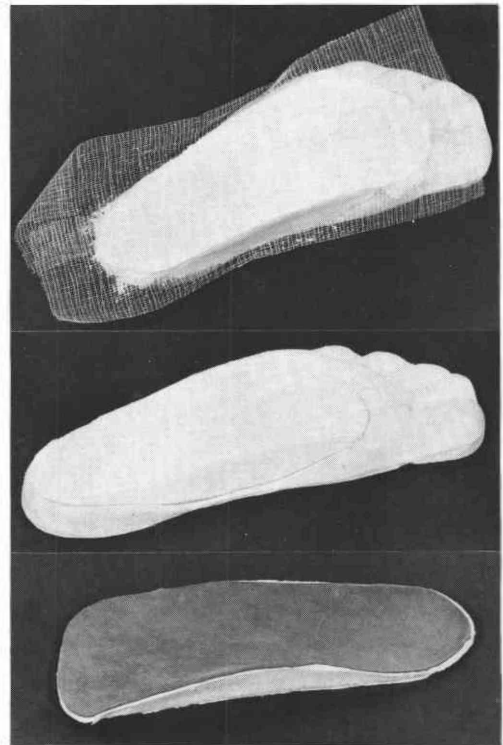


Fig. 1. Top, the untrimmed RTV insole in place on the cast of the foot showing the coarse weave cotton scrim used to provide a smooth base. Centre, the uncovered insole trimmed to approximate size. Bottom, the finished insole ready to fit to the patient.

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surface of the cast using flexible metal spatulas and built up to provide a flat sole. A coarse weave cotton scrim is used to provide a smooth surface on the bottom of the insole (Fig. 1, top). The insole then has to be left for at least 24 hours to enable the vulcanizing reaction to complete. If necessary this can be speeded up by putting the cast insole into an oven at a low temperature i.e. 40–50°C. After the 24 hour period a check must be made that all the silicone in the thicker regions such as the instep have vulcanized. Sometimes there can be a pocket of unvulcanized rubber inside these thicker regions. The insole can now be trimmed with an ordinary pair of scissors to the approximate size (Fig. 1, centre) and coverings attached. These coverings cannot be glued on with any conventional adhesive, and it was found that Silcoset 105 (a liquid RTV silicone) could be painted on to both the insole and the covering and the two pressed together to cure. The

Silcoset cures by the addition of a catalytic hardener. The rate of cure can be adjusted to suit the situation but a few minutes is usually sufficient. The base of the insole is usually covered with a chamois leather or similar and the top with a thin smooth leather or leather substitute (Fig. 1, bottom).

Fitting to the patient is simple, requiring only a few minutes with the aid of a pair of scissors. These insoles last for some considerable time, it is only the covering material which wears out and this can be easily replaced. The resulting insole is flexible enough to move with the foot during walking but is sufficiently resilient to provide support where required. The total cost of materials amounts to £3–£4 and the time required to make this, discounting the time taken for the RTV silicone to vulcanize, is about one hour. The insole can be easily transferred to different footwear so only one need be made in most circumstances.

Technical note

An angular alignment protractor for use in the alignment of below-knee prostheses

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Abstract

A device is described which is capable of accurately measuring angular alignment changes made during the alignment stages of the production of a below-knee prosthesis.

Introduction

The term "alignment" is defined as the position and orientation of the socket relative to the foot. This alignment is considered to be important, if not critical, for the optimum performance of the amputee.

In below-knee prosthetics, during static and dynamic alignment sessions, an adjustable shank unit is used to make alignment changes. One of the most commonly used adjustable shank units is the "Berkeley jig". It is capable of precise linear adjustments, that is antero-posterior and medio-lateral displacements using the scale on the unit itself. Antero-posterior and medio-lateral angular adjustments can be made, but unfortunately cannot be quantified.

The angular alignment protractor

A protractor is described (Fig. 1) which is light, simple to attach, easy to use and capable of accurately measuring angular alignment changes. The design is based on a three-dimensional ankle goniometer devised by Lamoreux (1983). It consists of self aligning, parallelogram linkages originally designed for measuring finger joint motions (Long, 1970). The linkages were then adapted for two-dimensional knee and ankle goniometry (Lamoreux, 1971).

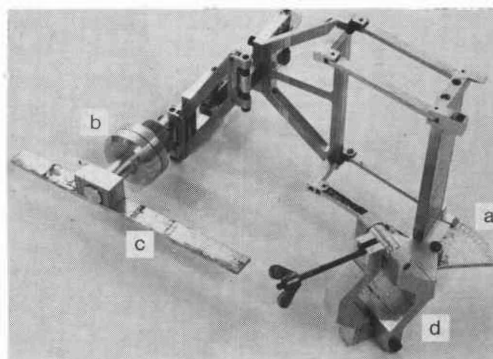


Fig. 1. The angular alignment protractor— a) antero-posterior scale; b) medio-lateral scale; c) fastening strip; d) clamp.

The antero-posterior scale (Fig. 1a) is marked off in 3° increments and can be read to an accuracy of $\pm 1^\circ$. The medio-lateral scale (Fig. 1b) is marked off in 6° increments and can be read to an accuracy of $\pm 2^\circ$.

To make a precise angular alignment change, the flat metal strip at the top of the protractor (Fig. 1c) is fitted into a preformed polyester gutter on the socket. The clamp (Fig. 1d) is fixed onto the pylon tube of the prosthesis. Once the protractor is attached (Fig. 2) the alignment adjustment is made and checked off on the relevant scale and the protractor is then removed. The clamp and lower linkage must be turned round for use with an opposite sided prosthesis. By modifying the pylon tube clamp the protractor may be used with modular systems.

The protractor is simple and quick to use, enabling the user to align a prosthesis, make several alignment changes and still return to the

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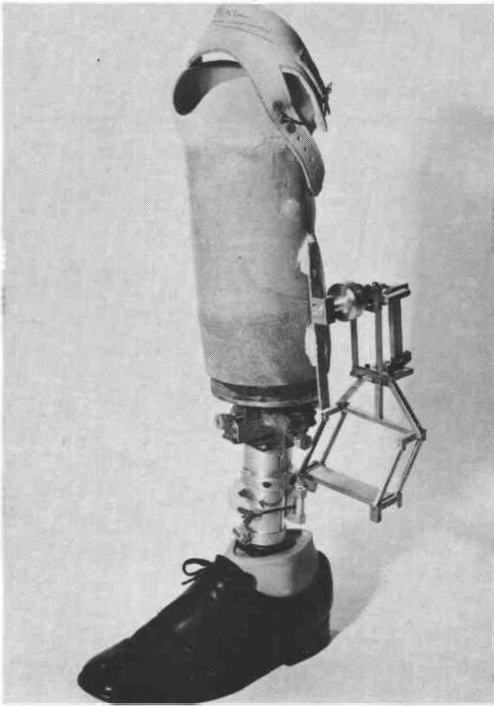


Fig. 2. The protractor fitted to a BK prosthesis.

same alignment (Saleh, 1981). Its use is advocated for making or recording precise angular alignment changes. It may be useful in the training of prosthetists, routine clinical work and research.

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Review

Choosing the best wheelchair cushion. P. Jay. Royal Association for Disability and Rehabilitation (RADAR), 25 Mortimer Street, London, W1N 8AB. 203p, £4.00.

A suitable cushion is an essential aid for many people who use wheelchairs. This book is a guide to help those who are involved in the provision of wheelchairs and cushions in the selection of a cushion which will satisfy the user's needs.

The first section describes the function of the cushion and it is suggested that it should provide a safe, comfortable, stable seat, which provides the user with a platform from which they may operate. The emphasis of much current information and research on wheelchair cushions is on safety and prevention of pressure sores and other tissue trauma in patients at particular risk. The author recognises the importance of tissue trauma prevention but makes it clear that many of the patients who use wheelchairs are not at particular risk of developing pressure sores, and other functions of the wheelchair cushions may, for these patients, be of more importance.

A wheelchair cushion is not a substitute for a well adjusted wheelchair and the author devotes considerable length to the correct adjustment of the wheelchair for the patient using it, and points out the importance of eliminating sag in sling seats before the cushion is provided. This is also followed by a section which describes the relationship between the cushion and the wheelchair.

There is also a long account on the causation and prevention of pressure sores. This includes a discussion of the use of pressure gauges to assess how well the wheelchair cushions are actually protecting the tissues. It is not easy to use such pressure gauges, and some useful information can be obtained by simple techniques, such as palpating the seated area through the cushion, which the author might usefully have mentioned.

There follows the most useful section of the book, which is a long account of sheepskins, wheelchair cushions and bases. There is an extensive catalogue of devices which are currently available, including their sizes and weights and general descriptions. Most valuable is an account of their particular advantages or

disadvantages, which are so important when one comes to select a cushion for a particular patient.

The book ends with a summary of those factors which should be considered in selecting the most appropriate cushion for the patient's needs, and how one actually obtains a wheelchair cushion.

This book, I think, achieves its aim of helping those who are involved in the provision of wheelchair cushions. It also provoked considerable thought. There are two areas in which it is clear, from reading this book, that more information is urgently needed. Although the author suggests that for many wheelchair users, pressure sore prevention may be of rather secondary importance, it is this aspect of wheelchair function which receives by far the largest amount of attention. Such factors as posture control are dealt with extremely briefly. This may well reflect the direction of current interest and research, and there seems to be little useful information on the control and maintenance of satisfactory posture in adult patients, particularly the elderly.

The second thought which arises from reading the book is how long do wheelchair cushions last? Those of us who provide wheelchair cushions, particularly foam ones, are all too well aware that wheelchair cushions last for a relatively short time and need to be replaced. The author does comment at several points on the importance of how long a cushion lasts, which is clearly an important consideration in deciding whether a wheelchair cushion is expensive or not. It is also extremely important in maintaining the function of the cushion, and the author suggests that the user or provider of the cushion should regularly examine it, to see whether it is degenerating or breaking down. This is an important regular procedure but, unfortunately, many cushions are unsatisfactory before they reach this end point.

The author is to be congratulated for producing a useful and thought provoking publication, which should be read by all who provide wheelchairs or cushions.

Dr. J. C. Barbanel,
Bioengineering Unit,
University of Strathclyde,
Glasgow.

Calendar of events

New York University Medical School

Course No. 7431

The Icelandic-Swedish-New York University (ISNY) Flexible Socket System.

Additional sections offered:

7431 D 16-18 May, 1984

7431 E 23-25 May, 1984

7431 F 30 May-1 June, 1984

7431 G 6-8 June, 1984

7431 H 13-15 June, 1984

7431 I 20-22 June, 1984

7431 J 27-29 June, 1984

Information: New York University Medical Center, Prosthetics and Orthotics, 317 East 34th Street, New York, NY 10016 USA.

10-11 June, 1984

CPA Pre-Congress Course: Sports Medicine in the 80's Ottawa, Ontario.

Information: Rhonda Nishio, Physiotherapy Dept, Royal Ottawa Rehabilitation Centre, 505 Smyth Road, Ottawa, Ontario K1H 8MT, Canada.

10-12 June, 1984

2nd Canadian Congress of Rehabilitation "Sharing Expectations in Rehabilitation", Vancouver, British Columbia.

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

11-15 June, 1984

Interpretation of Gait Analysis Data Course, San Diego, CA.

Information: Children's Hospital and Health Center, 8001 Frost Street, San Diego, CA 92123, USA.

12 June, 1984

CPA Pre-Congress Course: Locomotion—Myth vs New Findings Related to Evaluation & Training, Ottawa Ontario.

Information: Jennifer Nymark, Physiotherapy Dept, Royal Ottawa Regional Rehabilitation Centre, 505 Smyth Road, Ottawa, Ontario K1H 8MT, Canada.

12 June, 1984

CPA Pre-Congress Course: Biomechanical Analysis of the Shoulder Girdle Complex Ottawa, Ontario.

Information: Frida Apostolopoulos, Scientific Chairman, 1984 CPA Congress, Physiotherapy Dept, Ottawa, Avic Hospital, 1053 Carling Ave, Ottawa, Ontario K1V 4E9, Canada.

12 June-4 July, 1984

The 7th World Wheelchair Games, Champaign, IL.

Information: Prof. Timothy Nugent, Rehabilitation Education Centre, 1207 South Oak Street, Champaign, IL 61820, USA.

16-28 June, 1984

1984 International Games for the Disabled, Nassau County, New York.

Information: Mr. Michael Mushett, Director, 1984 International Games for Disabled, c/o Special Populations Unit Eisenhower Park, East Meadow, New York 11554, USA.

17-22 June, 1984

The Second International Conference on Rehabilitation Engineering combined with the 7th Annual Conference on Rehabilitation Engineering.

Information: Conference Services, National Research Council of Canada, Ottawa, Ontario K1A 0R6, Canada.

17-24 June, 1984

19th International Congress of Physical Therapy Barcelona, Spain.

Information: Secretaria del Congreso Gran Via de les Corts, Catalanes, 548.1 1^a, Barcelona-11, Espana.

19-22 June, 1984

Sixth International Conference, Analysis and Optimization of systems.

Information: Service Des Relations Exterieures Domaine De Voluceau-Rocquencourt, B.P. 105-78153 Le Chesnay CEDEX, France.

22-27 June, 1984

Annual Meeting of the National Association of Rehabilitation Facilities, Orlando, FL.

Information: National Association of Rehabilitation Facilities PO Box 17675, Washington, DC 20041, USA.

24-29 June, 1984

Spinal Disorders 1984.

Information: Prof. Alf Nachemson, Dept. of Orthopaedic Surgery I. Sahlgren Hospital, S-41345 Gothenburg, Sweden.

25-29 June, 1984

Congress '84, International Federation of Orthopaedic Manipulative Therapists, Vancouver, British Columbia.

Information: IFOMT 84—Scientific, 1704-1200 Alberni Street, Vancouver, BC V6E 1A6, Canada.

16-25 July, 1984

Postgraduate Course in Paediatric Orthopaedics, Singapore, Malaysia. National University of Singapore 0316, Malaysia.

23-26 July, 1984

The 10th Annual Meeting of the American Orthopaedic Society for Sports Medicine, Anaheim, California.

Information: Douglas W. Jackson, M.D., Program Chairman, c/o Thomas Nelson Associates, 70 West Hubbard Street, Suite 202, Chicago, IL 60610, USA.

18-23 August, 1984

Annual Meeting of the National Rehabilitation Association, Atlanta, GA.

Information: Judy Harris, National Rehabilitation Association, 633 South Washington, Alexandria, VA.

29-31 August, 1984

Bi-annual Conference on Human Locomotion, Manitoba, Canada.

Information: CSB Human Locomotion III, Department of Mechanical Engineering, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada.

3-7 September, 1984

The Eighth International Symposium on External Control of Human Extremities, Dubrovnik, Yugoslavia.

Information: Dr. Dejan Popovic, Yugolsav Committee for ETAN, PO Box 356, 11001 Belgrade, Yugoslavia.

12-14 September, 1984

The Fourth Annual Advanced Course in Lower Extremity Prosthetics.

Information: Lawrence W. Friedmann, M.D., Chairman, Department of Physical Medicine and Rehabilitation, Nassau County Medical Center 2201 Hempstead Turnpike, East Meadow, NY.

17-19 September, 1984

37th Annual Conference on Engineering in Medicine and Biology, Los Angeles, California.

Information: Patricia I. Horner, 4405 East-West Hwy, Ste 402, Bethesda, MD 20814.

17-21 September, 1984

Scoliosis Research Society Annual Meeting, Orlando, FL.

Information: SRS, 444 N. Michigan Avenue, Chicago, IL 60611.

24-26 September, 1984

Current Management of Children's Orthopaedic Problems, Grand Rapids, MI.

Information: AAOS, 444 N. Michigan Avenue, Chicago, IL 60611.

27-28 September, 1984

Surface Topography and Spinal deformity, Oxford, England.

Information: Mr. J. D. Harris, Oxford Orthopaedic Engineering Centre, Nuffield Orthopaedic Centre, Headington, Oxford OX3 7LD.

30 September-5 October, 1984

16th Congress of the International Society for Orthopaedic Surgery and Traumatology (SICOT) London, England.

Information: Conference Services Ltd, 3 Bute Street, London SW7 3EY, England.

16-19 October, 1984

11th International Conference of Social Gerontology, Rome, 1984.

Information: International Centre of Social Gerontology, 91 rue Jouffroy-75017 Paris, France.

24-28 October, 1984

American Academy of Cerebral Palsy and Developmental Medicine Annual Meeting. Washington, DC.

Information: AACPD, PO Box 11083, Richmond, VA 23230, USA.

24-28 October, 1984

American Academy of Neurological and Orthopaedic Surgeons Las Vegas, NV.

Information: 2320 Rancho Drive, Suite 108, Las Vegas, NV 89102, USA.

2-4 November, 1984

The 21st Australian Sports Medicine Federation National Conference, Perth, Australia.

Information: Mr. David Roberts, Director, 21st ASMF Conference, Post Office Box 109, Pennant Hills NSW 2120, Australia.

4-7 November, 1984

First Asia-Pacific Regional Convention, Adelaide, Australia.
Information: DPI Regional Convention, GPO Box 909, Adelaide 5001. Australia.

14-17 November, 1984

Spinal Deformities—current issues and answers Kiawah, SC.
Information: AAOS, 444 N. Michigan Avenue, Chicago, IL 60611, USA.

18-23 November, 1984

2nd International Symposium on Design for Disabled Persons, Tel. Aviv, Israel.
Information: PO Box 29784, Tel. Aviv 61297, Israel.

1985

'REHA-Aids for the Handicapped, 3rd International Fair and Forum', Düsseldorf, postponed from 1984.

Information: NOWEA, Düsseldorf Messegesellschaft mbH. Postfach 320203 Stockumer Kirchstrabe 61 4000 Dusseldorf 30, Germany.

1985

International Workshop on Technical Aids to be held in association with the Congress of International Federation for Medical and Biological Engineering, Helsinki, Finland.

Information: International Federation of Medical and Biological Engineering, c/o National Research Council, Ottawa, Ontario K1A 0R8, Canada.

24-29 January, 1985

American Academy of Orthopaedic Surgeons Annual Meeting Las Vegas, NV.
Information: AAOS, 444 N. Michigan Avenue, Chicago, IL 60611, USA.

7-12 July, 1985

14th International Conference on Medical and Biological Engineering and 7th International Conference on Medical Physics, Helsinki, Finland.

Information: Finnish Society for Medical Physics and Medical Engineering, PO Box 27 33 231, Tampere 23, Finland.

September or October, 1985

5th World Congress of the International Rehabilitation Medicine Association, Sydney, Australia.
Information: Prof. G. G. Burniston, Australian Association of Physical Rehabilitation Medicine, Prince Henry Hospital, Little Bay, 2036 Australia.

1986**25 February, 1986**

American Academy of Orthopaedic Surgeons Annual Meeting New Orleans, L.A.
Information: AAOS, 444 N. Michigan Avenue, Chicago, IL 60611, USA.

23-26 June, 1986

American Orthopaedic Association Annual Meeting Hot Springs, Va.
Information: AAOS, 444 N. Michigan Avenue, Chicago, IL 60611, USA.

29 June-5 July 1986

ISPO 5th World Congress, Copenhagen.
Information: ISPO Secretariat, Borgervaengt 5,2100 Copenhagen ø Denmark.

September, 1986

Scoliosis Research Society Annual Meeting, Bermuda, West Indies.
Information: SRS, 444 N. Michigan Avenue, Chicago, IL 60611, USA.

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Preliminary Announcement

International Conference and Advanced Course on AMPUTATION SURGERY AND LOWER LIMB PROSTHETICS Dundee, 1985

Sec. General — Dr. Ian M. Troup

A Conference is to be held in the University of Dundee from 1st July, 1985 to 5th July, 1985 inclusive.

The scientific programme will include epidemiology, causal conditions, levels and limiting factors, level assessment in peripheral vascular disease, pre-operative care, post-operative care and stump environment. All levels of lower limb amputation will be considered and will include surgery, biomechanics, socket design, components and prosthetic prescription. Where surgical, medical or orthotic options are feasible, they will be discussed; for example, the role of excision and internal prosthetics in pelvic tumors and the special problems of the partial foot amputation will be examined in detail.

All principal subject areas will be introduced by at least one international authority and in each instance principal discussants will be identified.

Bonar Hall, University of Dundee will accommodate the scientific proceedings and West Park Hall Hostel will provide residential accommodation.

An appropriate social programme will be arranged and will include official receptions, a conference dinner and a half-day trip.

The number of participants will be strictly limited to 150.

Further details on request: Secretariat,
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September 12, 13, 14, 1984

LECTURES

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SPEAKERS

Prof. Dr. Rene, Baumgartner, Chief of Orthopedics, Orthopedic University Clinic, Zurich, Switzerland.

Pierre Botta, C.P., Chief Prosthetist, Orthopedic University Clinic, Zurich, Switzerland.

Yasoma B. Challenor, M.D., Dir., Dept. of Rehabilitation Medicine, Blythedale Children's Hospital Valhalla, NY.

Lawrence W. Friedmann, M.D., Chairman, Dept., of Physical Med. & Rehab., Nassau County Medical Center; Prof. of Rehabilitation Medicine, SUNY @ Stony Brook. Bernice Kegal, R.P.T., Chief Physical Therapist, Prosthetics Research Study, Seattle, Washington.

Sybil Kohl, M. S. W., Senior Social Worker, Institute for Rehabilitation & Research, Baylor University, Houston, Texas.

Elizabeth Kolin, Ph.D., Psychologist, Dept. of Physical Medicine & Rehabilitation, Nassau County Medical Center, East Meadow, NY.

Al Muilenberg, President, Muilenberg

Prosthetics, Inc.; Consultant Prosthetist, Institute for Rehab. & Research, Houston, Texas.

Joyce Ott, R.P.T., Physical Therapy Department, Dept. of PM&R, Nassau County Medical Center.

Allen Russek, M.D., Assistant to Chairman, Department of Physical Medicine & Rehabilitation, Nassau County Medical Center, East Meadow NY.

Daniel Shapiro, M.D. Assistant to Chairman, Department of Physical Medicine & Rehabilitation, Nassau County Medical Center, East Meadow, NY.

Patrick Watson, TV Producer, Author; Board of Directors, School of Prosthetics & Orthotics, Quebec, Canada.

Hugh G. Watts, M.D., Director of Orthopedics, Childrens Hospital of Philadelphia, Pennsylvania.

Ron Whyte, Playwright.

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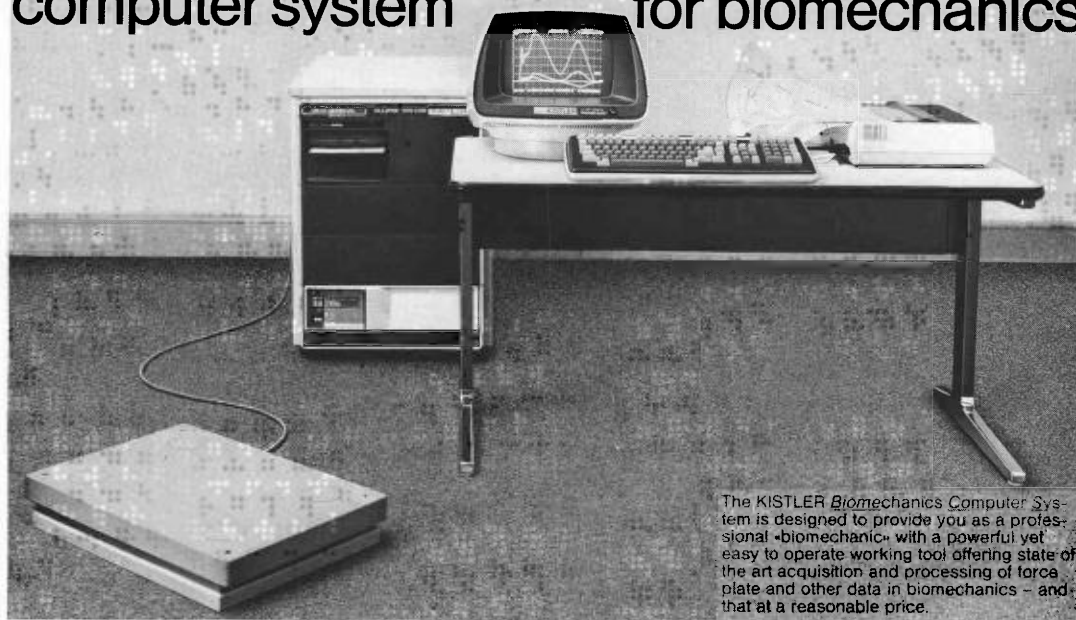
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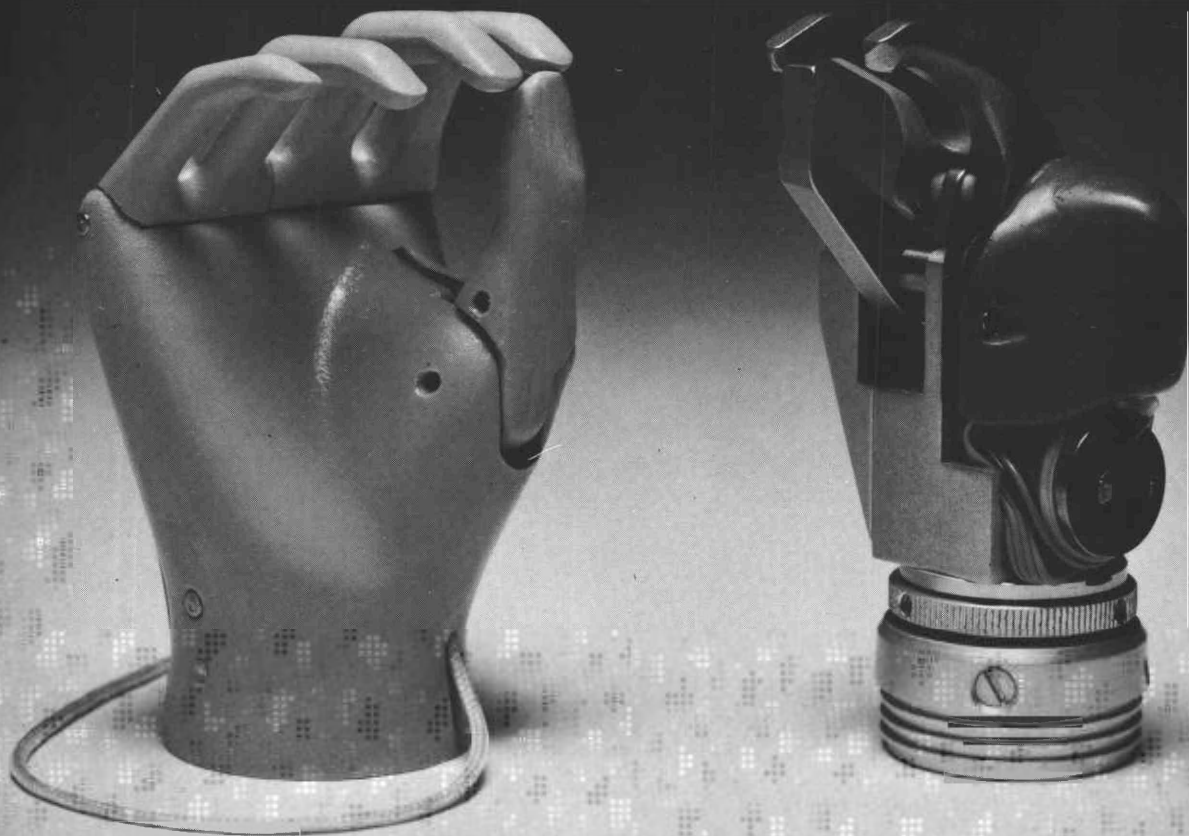
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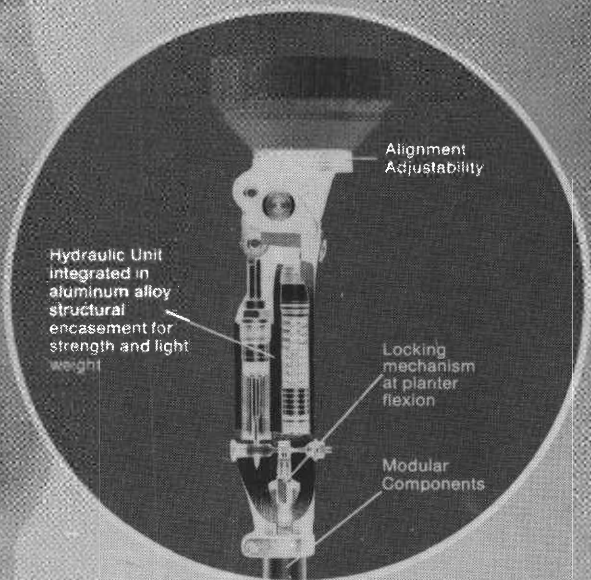
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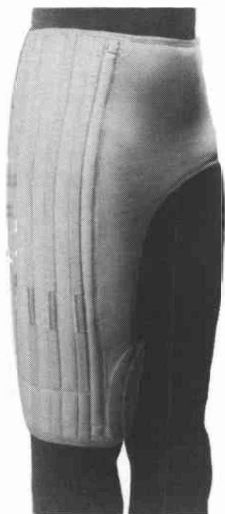
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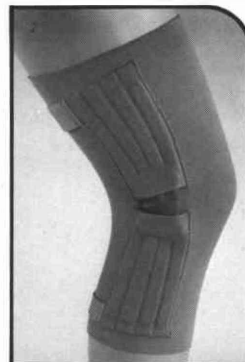
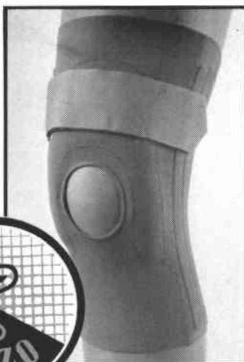
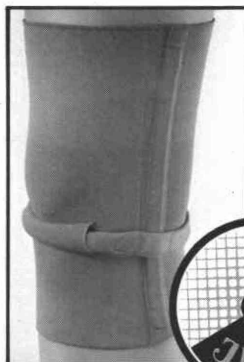
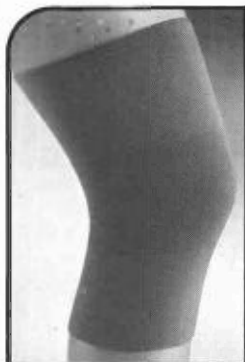
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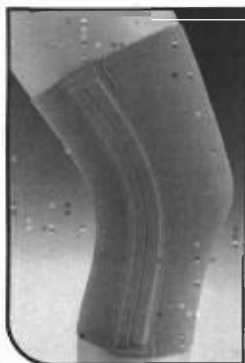


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Information for Contributors

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

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Reference to an article in a journal

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

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

Reference to a contribution in a book

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

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

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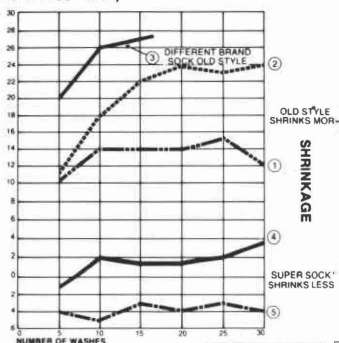
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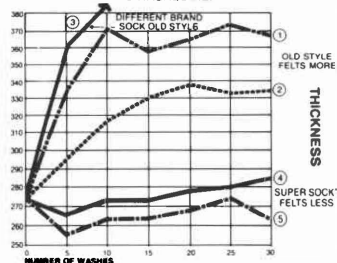
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82% of the field test group preferred the Super (wool) Sock; 12% preferred the Old Style wool sock; 6% preferred the Orlon/Lycra sock (also machine washable).

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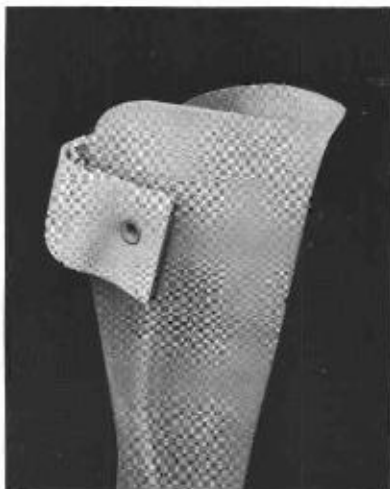


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TWX: #9107710513 / CABLE CODE: KNIT-RITE

'An Exciting New Company Over 60 Years Old'



A clear comparison.

Note the clarity of the orthosis on the right when compared to the orthosis on the left.

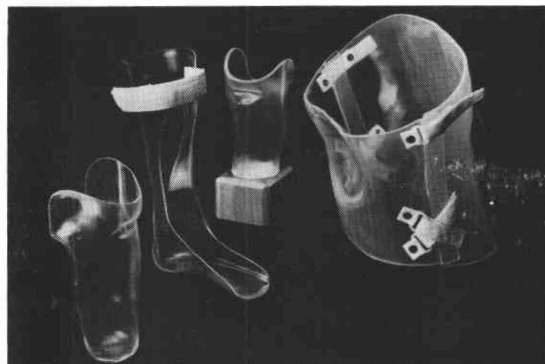
The orthosis on the right is constructed from Thermo-Vac Clear Plastic, a new thermoplastic polymer that's an excellent material for the fabrication of a wide variety orthotic and prosthetic devices.

Thermo-Vac allows you to see through your orthotic or prosthetic device to detect pressure areas and intimacy of fit. Skin blanching around bony prominences and skeletal deformities are easily detected. And after visually determining the extent of contact support the Thermo-Vac material may be reformed with the application of heat.

For quick, easy ordering use the following product numbers:

Thermo-Vac Sheets

2' X 2' X .0625 — T14-203-0100
 2' X 2' X .125 — T14-203-0200
 2' X 2' X .1875 — T14-203-0300
 2' X 2' X .250 — T14-203-0400
 2' X 4' X .0625 — T14-202-0100
 2' X 4' X .125 — T14-202-0200
 2' X 4' X .1875 — T14-202-0300
 2' X 4' X .250 — T14-202-0400
 4' X 4' X .0625 — T14-201-0100
 4' X 4' X .125 — T14-201-0200



The advantages of Thermo-Vac are clear. You fabricate a device that's without pressure areas or large deviations from the skeletal form while your patients receive an orthotic or prosthetic device they can live with - comfortable and functional.

4' X 4' X .1875 — T14-201-0300
 4' X 4' X .250 — T14-201-0400

Thermo-Vac Rod Stock

3/16" Diameter Rod Stock — T15-400-0000

USME™

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