

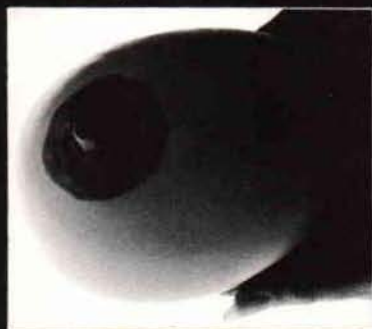
SEPTEMBER 1977

Orthotics and Prosthetics



**Give her
back her
femininity...**

**The totally
natural look
of ThyselF**



After the mastectomy, she still wants to feel and look like a woman. Truform knows that... and offers the ThyselF® 100% silicone breast prosthesis and areola-nipple for that special woman.

The world's foremost bio-engineers of silicones have scientifically designed the ThyselF for maximum comfort and durability. ThyselF is made with a new, non-oily high performance silicone gel encased in a smooth silicone elastomer skin. A base seam assures dimensional stability... most important in a natural, weighted prosthesis. Eight years of clinical testing have shown that a seamed breast prosthesis is less likely to roll away from the chest wall, mold improperly, collapse in the bra cup or lose its shape.

The ThyselF approximates the normal human breast in contour, softness and mobility. It is made

to the same weight and specific gravity as normal breast tissue. A wide range of sizes are available that correspond to actual weights of the human breast.

The ThyselF areola-nipple is worn on the ThyselF form for the perfectly natural look. Like the ThyselF prosthesis, the areola-nipple is 100% silicone and looks, feels, and moves like the skin. This areola-nipple will cling to the silicone breast and can be positioned on the form as desired. Delicately feathered edges defy detection in the sheerest bra. It can be easily trimmed to match the patients own nipple size. Look to Truform for innovations in orthotics and prosthetics.

TRUFORM

Orthotics and Prosthetics

When better products are made,
Truform will make them.



Cincinnati
3974 Rosslyn Drive
Cincinnati, Ohio 45209
513-271-4594
TWX 810-461-2469

Rutherford, N.J.
285 Highland Cross
Rutherford, N.J. 07070
201-438-4132
TWX 710-989-0212

San Francisco
448 Victory Avenue
So. San Francisco, Calif.
94080 415-761-3335
TWX 910-371-7208

In Canada, Contact
Airway Surgical
Appliances Ltd.
Ottawa, Ontario
K1R5T8

© Copyright, 1977 Truform Orthotics and Prosthetics.



Orthotics and Prosthetics

EDITOR

L. Bennett Wilson, Jr.

MANAGING EDITOR

Erin A. Mastro

EDITORIAL BOARD

Irvin L. Muilenburg, C.P.O.

Chairman (1978)

Henry F. Gardner, C.P.O. (1977)

Arthur Guilford, Jr., C.O. (1978)

I. Blair Hanger, C.P. (1976)

Hegfried Paul, C.P.O. (1976)

Robert E. Tooms, M.D. (1977)

William L. McCulloch

Ex Officio

Orthotics and Prosthetics is issued in March, June, September and December. Subscription price, payable in advance, is \$10.00 a year in the U.S. and Canada. Rate elsewhere is \$11.00 a year. Single issues, \$3.00 each. Publication does not constitute official endorsement of opinions presented in articles. The Journal is the official organ of the publisher, The American Orthotic and Prosthetic Association in collaboration with the American Academy of Orthotists and Prosthetists, and serves as the U.S. organ for Interbor. All correspondence should be addressed to: Editor: *Orthotics and Prosthetics*, 1444 N St., N.W., Washington, D.C. 20005. Telephone, Area Code 202, 234-8400.

Orthotics and Prosthetics is indexed by Current Contents/Clinical Practice.

Volume 31, No. 3

September 1977

CONTENTS

EDITORIAL	1
PNEUMATIC SUPRACONDYLAR SUSPENSION FOR KNEE-DISARTICULATION PROSTHESES	3
<i>A. Bar, R. Seliktar, Z. Susack</i>	
VAPC PRESCRIPTION PROCEDURES FOR KNEE ORTHOSES AND KNEE-ANKLE-FOOT ORTHOSES	9
<i>G. Rubin, M. Dixon, M. Danisi</i>	
AN ORTHOSIS FOR A PATIENT WITH A FAILED TOTAL HIP PROSTHESIS	27
<i>T. Jacobson, A. Mason</i>	
THE DESIGN AND PRESCRIPTION OF ABOVE KNEE ORTHOSES	31
<i>E. G. Anderson, J. T. Henshaw</i>	
A HEAT GENERATING SOCKET	41
<i>J. Ficociello, T. Trudell, A. Hebert</i>	
SOME BIOMECHANICAL CONSIDERATIONS IN THE DESIGN OF ANKLE-FOOT ORTHOSES	45
<i>D. N. Condie, C. B. Meadows</i>	
METRICATION	51



ISSN 0030-5928)



COPYRIGHT © 1977 BY THE AMERICAN ORTHOTIC AND PROSTHETIC ASSOCIATION. PRINTED IN THE UNITED STATES OF AMERICA. ALL RIGHTS RESERVED

Index to Advertisers

AAOP 1978 ROUNDUP SEMINAR	IX
ACE ORTHOPEDIC COMPANY	VI
BECKER ORTHOPEDIC APPLIANCE CO.	XVI
IRVING DREW CORPORATION	VI
DUKE UNIVERSITY SEMINAR	VII
FLORIDA BRACE CORP.	V
JOHNSON AND JOHNSON	IV, XII & XIII
KINGSLEY MANUFACTURING CO.	XV
KNIT RITE, INC.	XI
C. U. MOSBY CO.	XVII
O & P NEWSLETTER	XVIII
OTTO BOCK ORTHOPEDIC INDUSTRY, INC.	XXI
PEL SUPPLY CO.	XX
RED CROSS	XIV
SMALLEY AND BATES	X
SUTTON SHOE MACHINERY CO.	VIII
TRUFORM ORTHOTICS AND PROSTHETICS	Inside Front Cover
U.S. MANUFACTURING CO.	XIX
WASHINGTON PROSTHETICS SUPPLY CO.	XVI

Advertisers shown in bold-face type are members of
The American Orthotic & Prosthetic Association

THE AMERICAN ORTHOTIC AND PROSTHETIC ASSOCIATION OFFICERS

President—**Ben B. Moss**
Winter Park, Florida

President-Elect—**Daniel G. Rowe, C.P.O.**
St. Paul, Minnesota
Vice-President—**William M. Brady**
C.P., Kansas City, Missouri

Secretary-Treasurer—**Herman C. Hittenberger,**
C.P.O., San Francisco, California
Immediate-Past President—**Howard R. Thranhardt,**
C.P., Atlanta, Georgia

REGIONAL DIRECTORS

Region I—**Herman E. Buschenfeldt, C.O.**
Stoughton, Massachusetts
Region II—**Kenneth G. Robinson, C.P.**
Whitestone, New York
Region III—**Raymond Francis, C.P.**
Norfolk, Virginia
Region IV—**Charles E. White**
Atlanta, Georgia
Region V—**Jerome E. Skahan, C.P.**
Cincinnati, Ohio
Region VI—**Joseph Smerko, C.P.**
Chicago, Illinois

Region VII—**Ronald W. Cheney, C.P.**
Des Moines, Iowa
Region VIII—**Dennis Cole, C.P.**
Austin, Texas
Region IX—**Rudy Bindi, C.P.O.**
San Francisco, California
Region X—**Walter M. Joslin, C.P.O.**
Albuquerque, New Mexico
Region XI—**Alton W. Christenson, C.P.**
Spokane, Washington

THE AMERICAN ACADEMY OF ORTHOTISTS AND PROSTHETISTS OFFICERS

President—**Ted Thranhardt, C.P.O.**
Orlando, Florida

President-Elect—**Siegfried W. Paul**
C.P.O., Newington, Connecticut
Vice-President—**Michael J. Quigley,**
C.P.O., Downey, California

Secretary-Treasurer—**Stephen H. Kramer, C.P.O.**
Chicago, Illinois
Immediate-Past President—**Joseph M. Cestaro,**
C.P.O., Washington, D.C.

DIRECTORS

Robert F. Hayes, C.P.
W. Springfield, Massachusetts
Eugene Filippis, C.P.O.
Detroit, Michigan

Edward Van Hanswyk, C.O.
Syracuse, New York
J. Donald Coggins, C.P.
Philadelphia, Pennsylvania

NATIONAL OFFICE

William L. McCulloch, Executive Director

Cut it. Mold it. Bend it. Shape it.

No other splint material works so easily.

Wrap around any contour. Lend support to any injured body part. With attractive ORTHOPLAST® Splints, the most versatile splinting material available.

□ A lightweight low-heat thermoplastic featuring maximum ability to be molded.

□ Strong, cohesive, can be made to adhere to itself without glue, simply by heating.

□ Can be riveted, strapped, braced, hinged, bonded, butt-bonded to suit all your splint-engineering needs.

(Can also be reheated and remolded to refit an improving patient whose splint needs have changed.)

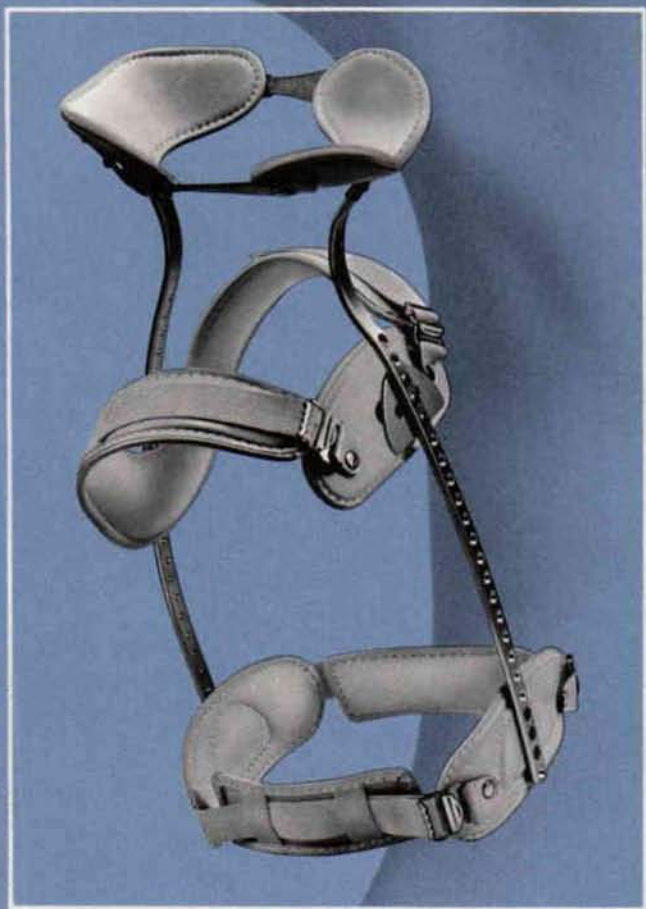
Educational literature, medical reprints, splint patterns and samples may be obtained by writing to Department Johnson & Johnson, New Brunswick, New Jersey 08903.

ORTHOPLAST Splints
TRADEMARK



Johnson & Johnson

*TRADEMARK
© Johnson & Johnson 1971

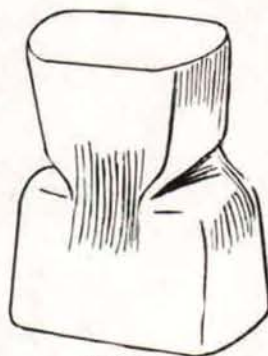


J-21 TWO-POST ORTHOSIS for stabilizing cervical and upper thoracic regions. Spinal orthoses are our only product. They are only available through ethical dispensing orthotists. Because of this we have the motivation and the skill to provide you with the highest quality orthoses possible for maximum acceptance by your doctors and patients. And we back you up with 24-hour delivery of your prescription orders anywhere in the country. Plus, we have a price structure to make our service your most profitable way to fill prescriptions. Florida Brace Corporation, P.O. Box 1299, Winter Park, Florida 32789.

**Florida
Brace
Corporation**

PREFABRICATED MILWAUKEE GIRDLES

- Designed with even 3/16 thickness consistency throughout.
- Made in either medium or low density polyethelene.
- Extra high form for high curve correction.
- Available in seven standard sizes.
- Available in complete assembly from measurements or negative cast.



(Measurement & technique instructions available.)

ace orthopedic company

11913 So. Prairie Ave., Hawthorne, Calif. 90250 • Phone (213) 644-9336, 644-5597

FOR FIT & COMFORT OUR FAMOUS "BRACE SHOE" THE ROVER

- LEATHER SOLE & HEEL
- LONG COUNTER
- EXTRA STRONG STEEL SHANK
- GOODYEAR WELT CONSTRUCTION

Other Patterns Also Available
For Brace Work

Sizes: 5-12 in varying widths,
leather upper.
Colors: Black, White, Beige,
Blue, Green & Taupe Gluv.
Brown Demi-Llama



DREW • DR. HISS
CANTILEVER • DICKERSON

Please Send For Our In Stock Catalog



252 Quarry Road / Lancaster, Ohio 43130

Seminar Program

The American Academy of Orthotists and Prosthetists in conjunction with The Duke University Medical Center's Department of Prosthetics and Orthotics announces an **ADVANCED SEMINAR** in "SPINAL ORTHOSIS" November 11-12, 1977 in the Convention Center of the Holiday Inn-West, Durham, North Carolina.

FRIDAY, NOVEMBER 11, 1977 Convention Center, Holiday Inn-West

- 8:00 **Registration**
- 8:30 **Welcome**
Siegfried W. Paul, C.P.O.
President A.A.O.P.
J. Leonard Goldner, M.D.
- 8:45 **Seminar Objectives**
Bert R. Titus, C.P.O.
- 9:00 **Evolution of Non-operative Treatment of Idiopathic Scoliosis**
Sidney L. Wallace, M.D.
- 9:30 **Coffee**
- 10:00 **Duke Spinal Cord Injury Team**
Donald S. Bright, M.D.
Wesley A. Cook, Jr., M.D.
Patricia Friderichs, R.N.
Morrene L. Kallihan, R.N.
Bert R. Titus, C.P.O.
William E. Harris, C.O.
Percy H. Ray, C.O.
- 12:00 **Lunch**
- 1:00 **Operative and Non-Operative Treatment of the Thoracolumbar Spine**
Frank H. Bassett, III, M.D.
- 1:30 **Rehabilitation After Acute Care**
Frank W. Clippinger, M.D.
- 2:00 **Treatment of Patients with Kyphosis**
Ralph W. Coonrad, M.D.
- 2:30 **Coffee**
- 3:00 **Greenville Spinal Orthosis**
Lawrence W. Brown, M.D.
W. Dewey Friddle, Jr., C.P.O.

- 4:00 **Scoliosis Patients—Management and Treatment**
Frank E. Pollock, M.D.

SATURDAY, NOVEMBER 12, 1977 Convention Center, Holiday Inn-West

- 8:00 **Scoliosis Patients—Management and Treatment**
Sidney L. Wallace, M.D.
Karl Fillauer, C.P.O.
- 9:00 **Scoliosis Patients—Management and Treatment**
Charles F. Heinig, M.D.
Clarence A. Borrows, C.O.
- 10:00 **Coffee**
- 10:30 **Development of Prefabricated Components**
Carlton Fillauer, C.P.O.
- 11:00 **A New Orthotic Concept in Non-Operative Treatment of Idiopathic Scoliosis**
John J. Glancy, C.O.
- 12:00 **Lunch**
- 1:30 **Football at Duke Stadium**
Duke University
vs.
North Carolina State



Tickets: \$8.00 each
If you plan to attend please send check to Bert Titus immediately to reserve a seat.

Continuing Education Credits Impending

REGISTRATION FORM

(Please Print)

LAST NAME FIRST MI
ADDRESS CITY STATE

REGISTRATION INFORMATION & FEES (Check one)

- ☐ \$75.00 Orthotists and Prosthetists*
☐ 75.00 Physicians
☐ 75.00 Physical and Occupational Therapists
☐ 75.00 Allied Health Personnel

*Member AAOP 20% discount

CHECKS MUST ACCOMPANY YOUR REGISTRATION

Make your check payable to:

THE AMERICAN ACADEMY OF ORTHOTISTS & PROSTHETISTS

Mail check to:
Bert R. Titus, C.P.O.
Box 3885
Duke University Medical Center
Durham, North Carolina 27710

Full refunds will be made on requests received at least 10 days prior to the seminar's start. An 80% refund will be made thereafter.

HOTEL RESERVATION FORM

Arrival Date _____
Departure Date _____

LAST NAME FIRST MI
ADDRESS CITY STATE

Please reserve _____ room(s) of the type checked below:

- ☐ Single Room Rate: \$15.50
☐ Double Room Rate: \$22.00

If the rate you selected is exhausted, the next available rate will be assigned. Reservations must be received 2 weeks prior to opening date of convention.

ATTENDING AMERICAN ACADEMY OF ORTHOTISTS AND PROSTHETISTS SEMINAR

Mail this Room Reservation Form, along with your check to:
Holiday Inn-West
3460 Hillsborough Road
Durham, North Carolina 27705

For The Complete Line Of Orthopedic Appliances And Brace Components



BECKER

ORTHOPEDIC APPLIANCE COMPANY

OUR 44th YEAR

Send for Complete Catalog

1776 South Woodward Avenue, Birmingham, Michigan 48011



NEWSLETTER . . . Prosthetics and Orthotics Clinic

A quarterly publication providing the means for interdisciplinary discussion among physicians, therapists, and practitioners. Its eight pages contain important articles, spirited dialogue, and a sense of shared discovery, making it a valuable publication.

Enclosed is my check for \$8.00 for a 1-year subscription to the Prosthetics and Orthotics Clinics Newsletter. (Foreign Subscription Price is \$9.00)

Mail to:

AAOP
1444 N Street, N.W.
Washington, D.C. 20005

Name _____

Address _____

City _____

State _____

Zip _____



PROSTHETIC SOCKS

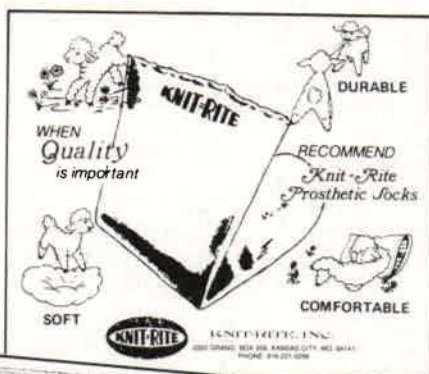
DEPENDABLE, QUALITY SINCE 1923

QUALITY COMES ***FIRST*** AT KNIT-RITE

***Highest Quality Yarns • Carefully
Knitted & Finished***

THEY ARE
COMFORTABLE

AMPUTEE'S
LIKE THEM



LET OUR OVER
50 YEARS
OF EXPERIENCE
BE YOUR ASSURANCE
OF THE **BEST**
IN QUALITY SOCKS.

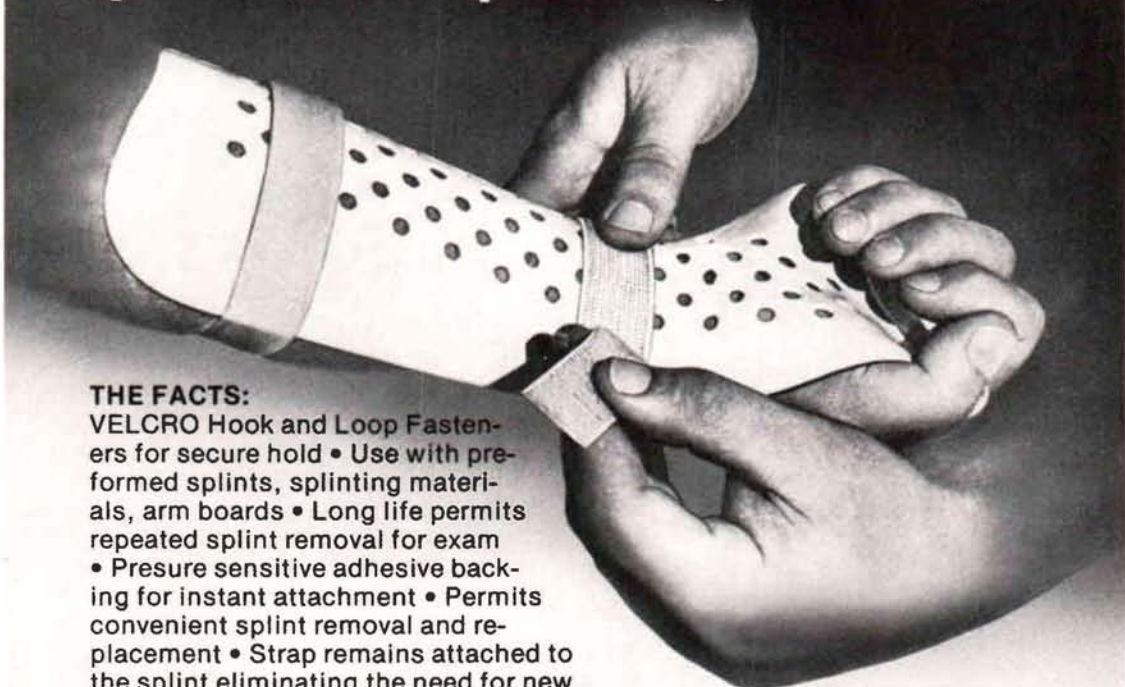
THEY ARE
DURABLE
THROUGH REPEATED
WEARINGS

KNIT-RITE, INC.

2020 GRAND, BOX 208, KANSAS CITY, MO. 64141
PHONE: 816-221-0206
TOLL FREE: 800-821-3094

NEW FROM SMALLEY & BATES

VELCRO® Splint Strap Fasteners. Attach instantly, provide complete adjustability.



THE FACTS:

VELCRO Hook and Loop Fasteners for secure hold • Use with pre-formed splints, splinting materials, arm boards • Long life permits repeated splint removal for exam • Pressure sensitive adhesive backing for instant attachment • Permits convenient splint removal and replacement • Strap remains attached to the splint eliminating the need for new tapes. Contact your supplier today.

IMPORTANT TO REMEMBER: All hook and loop fasteners look much alike. But they don't function that way. For dependability's sake, demand the best — VELCRO BRAND FASTENERS. You can't afford less.

Insist on
VELCRO BRAND



SMALLEY & BATES, INC.

88 Park Avenue, Nutley, NJ 07110 • 201/661-5155

EXCLUSIVE DISTRIBUTORS OF VELCRO PRODUCTS FOR HEALTH CARE

A CHALLENGE

The professions of prosthetics and orthotics have constantly improved since the days of the armorer and the blacksmith. The credit for this constant development must go to the prosthetic/orthotic educational programs, which have not only increased our professional knowledge and skills, but have improved our communications skills as well.

Today's highly successful practitioners, as a group, are more expert in patient management than they are in fabrication techniques. They have a thorough clinical knowledge of anatomy, physiology, kinesiology, and biomechanics. They deal competently with engineering concepts.

These practitioners have learned through years of experience, as well as through formal and informal educational programs, such as short term courses and presentations at our national and regional scientific sessions.

Most people learn by trial and error — if they survive long enough. However, the learning process can be shortened through formal education, which will be required of budding practitioners as of 1980.

We have discussed at length the benefits of formal education at the baccalaureate level in prosthetics and orthotics. We have beaten, skinned, and dried that mule. It is time for us to stop talking and start doing.

We must get on with the task of finding something to pull our wagon down the road of continually improved devices and better service for the handicapped citizens of this nation. We should all support the existing educational programs and encourage other medical schools to begin baccalaureate degree programs in prosthetics and orthotics.

Bernard Simons



PNEUMATIC SUPRACONDYLAR SUSPENSION FOR KNEE- DISARTICULATION PROSTHESES

A. Bar, B.Sc.¹

R. Seliktar, Ph.D.²

Z. Susack, M.D.³

There is considerable controversy over through-knee amputations due to the technical complexity of the prosthetic fitting. The biomechanical advantages, however, resulting from knee disarticulation in provision of an end, or load-bearing, stump overrule all other considerations. We therefore believe that knee disarticulation should be preferred over above-knee amputations whenever this is possible (2).

The two major sources of problems in through-knee (T.K.) amputations are the lack of space below the stump for installation of a conventional or controlled knee mechanism and the broad femoral condyles which impose severe socket design limitations. The shape of the stump requires the use of either a leather corset type of socket or a hard socket with a flexible or open area at the supra-condylar region, so as to enable passage of the wide bony end of the stump (femoral condyle). The leather socket is disappearing gradually from prosthetics practice due to its disadvantages of too much flexibility of the socket as a whole, and tightness resulting from use of laces, which causes muscle atrophy. The hard (fibre reinforced plastic) socket is gaining popularity but the procedure for fabrication involves various casting stages including a flexible silicone

rubber window with a hard flap for tightening, and therefore is rather complex and requires special skills. Due to the flexibility of this arrangement and inaccuracy in the production process, significant "piston" action may occur during gait.

The use of surgical techniques by which the width of the condyles is reduced is contradictory to the end-bearing concept. Reduction of the load-bearing area increases the interface pressures to a point that it is not comfortable for the patient to support himself on the end of the stump.

This paper describes a technique that uses inflatable pneumatic bags fitted inside the socket at the supracondylar region to provide a practical means of suspension.

Method

In the first prototype, the conventional technique for plastic socket fabrication was employed. A plaster cast of the stump was produced. "Pe-Lite" was used for an inner lining of the hard socket and two shaped rubber bags were designed to engulf the narrow supracondylar neck of the "Pe-Lite" socket. The outer hard socket, therefore, obtained a more cylindrical shape and allowed free passage of the femoral condyles when the bags were deflated. The two bags (Fig. 1)

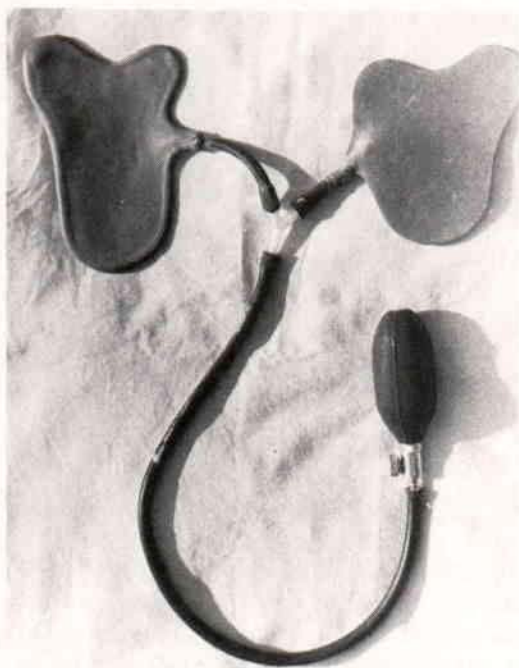


Fig. 1. The pneumatic rubber bags and the bulb.

were fitted between the socket and the liner, one on the medial side and one on the lateral side as illustrated in Figure 2. The bags were connected via a three-way manifold and a rubber tube fitted with a manually operated valve to a pneumatic bulb (hand pump). The bulb, valve, and tubes were taken from a standard blood pressure cuff (5).

The amputee inserts his stump into the socket and after finding the correct position inflates the bags. The Pe-Lite liner is compressed against the stump and the condyles are locked into place. The liner assists in spreading the pressure of the bags over a larger area of the stump (4). The pressure in the bags can be adjusted by the amputee and once the desired pressure has been reached, the valve can be locked and the bulb removed. To remove the prosthesis, the amputee opens the valve to let the bags deflate.

The advantages of the proposed technique are the following:

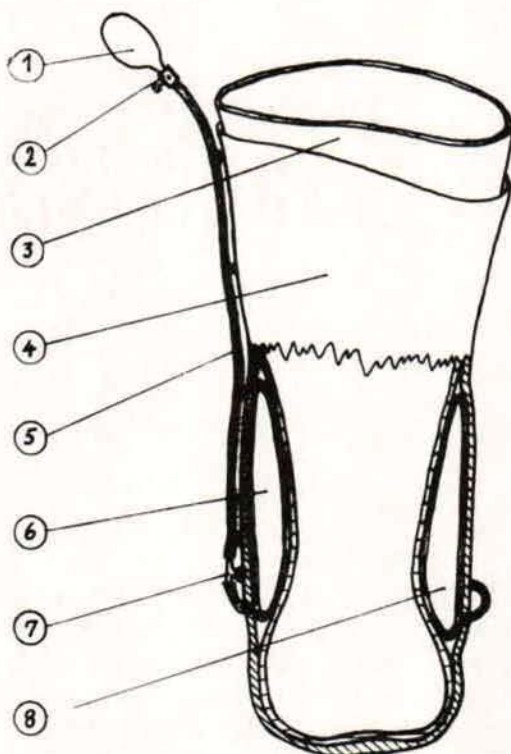


Fig. 2. Schematic drawing of the socket during use. Parts: 1. The bulb (hand pump), 2. Valve, 3. Hard-fiber-reinforced plastic socket, 4. Rubber tube, 5. Lateral bag, 6. Mainfold, 7. Medical bag, 8. Inner (Pe-Lite) lining.

1. Good grip of the socket over the stump and thus reduced "piston" action.

2. Easy and quick assembly of the prosthesis.

3. A good fit and large range of adjustability to variations in the stump volume due to climatic changes, weight variation, and edema.

4. Even pressure distribution in the vicinity of the bags and, therefore, elimination of stress concentration on the soft tissue and reduction of the risks of developing pressure sores.

5. Ability to reduce pressures on the stump during prolonged sitting by deflating the bags temporarily, without the necessity to undress to remove the leg.

Evaluation of the Concept

A preliminary study was conducted to evaluate the concept with special emphasis on the "piston" action phenomenon. At this stage only one patient had been fitted with an "OHC" knee-disarticulation prosthesis⁴ (four-bar knee joint with a Dynaplex hydraulic unit) (3) employing the proposed suspension technique. The patient was a 38-year-old war veteran, who had used a prosthesis for 2½ years, and was a current user of the "OHC" prosthesis.

A comparative study between the performance with the conventionally fitted socket and the experimental socket was carried out with respect to three points:

1. Relative displacement between the stump and the socket during gait.
2. Convenience especially in donning and removing the prosthesis.

3. Adequacy of fitting.

The relative movement between the stump and socket was measured by taking X-rays (1) of two simulated gait positions (Figs. 3-6):

1. When the prosthesis was bearing all of the weight of the patient.
2. When the prosthesis was suspended on the stump and the other leg was bearing all of the weight of the patient.

Although this approach disregards the effects of inertia and the dynamics of the walking cycle, it can provide significant information on the "piston" action. The X-rays also provided information in relation to the geometrical match between the socket and the stump. Figures 3 and 4 illustrate the locking action which the bags apply to the femoral condyles. By comparing these results to the ones in Figures 5 and 6 which illustrate the same positions with the conventionally fitted prosthesis, it is evident that the relative



Fig. 3. X-ray of the new socket with both legs bearing weight.



Fig. 4. X-ray of the new socket when the prosthesis is not bearing weight.



Fig. 5. X-ray of the conventional socket with both legs bearing weight.

movement is far less with the pneumatic suspension.

The displacement which was measured from the X-rays was 42mm with the conventionally fitted technique and only 23mm with the pneumatic bags. The patient's subjective opinion was that during movement there was far less "piston action" than with his previously fitted prosthesis. This, in his opinion, improved his gait performance.

The patient was also filmed by a television system and video-tape-recorder with slow motion facilities, and the ground forces ap-

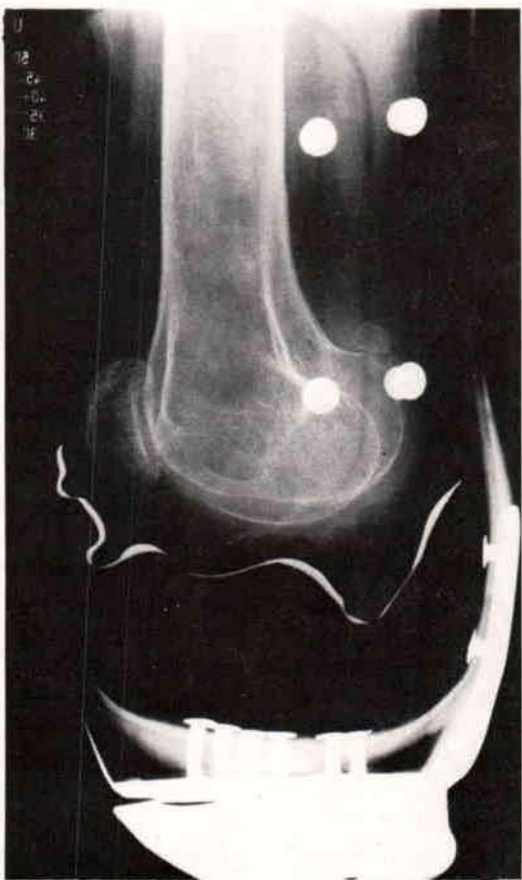
plied by both his feet during gait were recorded by two "Kistler" force plates. The T.V. and force records will not be discussed here since they require further exploration.

Conclusions

From the limited evaluation of the concept, it was evident that the suspension of the prosthesis was improved considerably by use of the pneumatic system. As a consequence the kinematic features of gait were improved. The pressure distribution on the stump was assessed subjectively by the patient and he commented on a more uniform distribution with this arrangement.

It is recognized that the analysis is rather

Fig. 6. X-ray of the conventional socket when the prosthesis is not bearing weight.



limited at this stage but a further study with a larger group of patients is now being planned.

Acknowledgement

The study was conducted at the Department of Bio-Medical Engineering in the Technion-Israel Institute of Technology and the Biomechanics Unit of the Loewenstein Rehabilitation Hospital. The prosthetic facilities were provided by "Gapim" Ltd. and the bags were manufactured by "Franz Levi" Ltd.

Literature Cited

1. Byers J.L., *X-Rays: a "fitting tool" for the prosthetist*, Orthotics and Prosthetics, 28:4, Dec. 1974, pp. 55-57.

2. Harris E.E., *The through-knee amputation prosthesis*, Prosthetic and Orthotic Practice, Edward Arnold (Publishers) 1970.

3. Lyquist E., *The OHC knee disarticulation prosthesis*, Orthotics and Prosthetics, 30:2, June 1976, pp. 27-28.

4. Murphy Eugene F., *Transferring load to flesh*, Part 1. concepts, Bull. Pros. Research, Fall, 1971, BPR 10-16, Veterans Administration (U.S.)

5. Staats T., *Inflatable wedge suspension system*, Orthotics and Prosthetics, 27:1, March 1973, pp. 34-37.

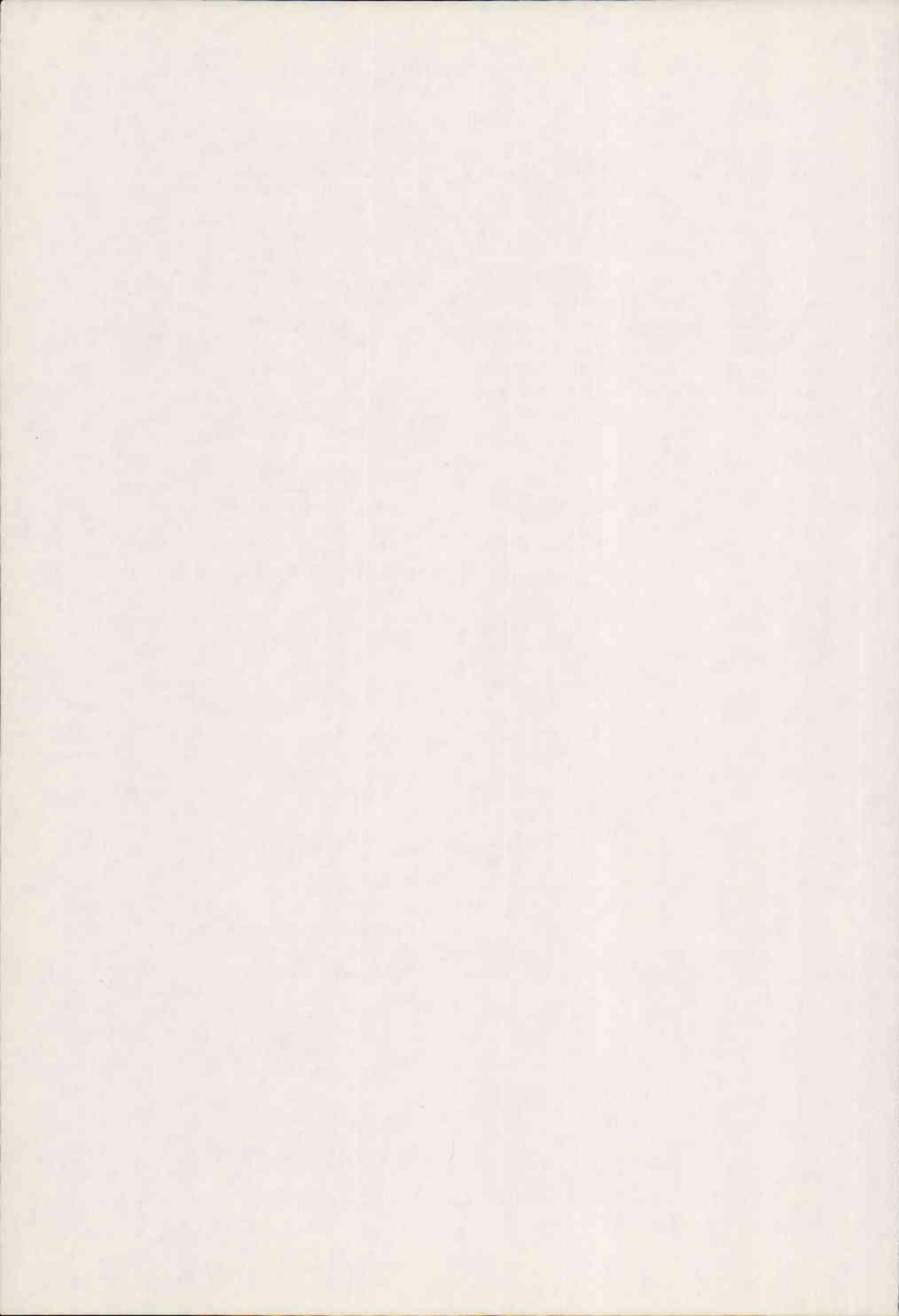
Footnotes

1 Biomechanics Unit, Loewenstein Rehabilitation Hospital, Raanana, also Post Graduate student at the Bio-Medical Engineering Department, Technion Israel Institute of Technology.

2 Department of Bio-Medical Engineering, Technion-Israel Institute of Technology and the Biomechanical Unit, Loewenstein Rehabilitation Hospital, Raanana.

3 Loewenstein Rehabilitation Hospital, Raanana.

4 U.S. Manufacturing Co., 623 South Central Avenue, Glendale, Calif. 91209



VAPC PRESCRIPTION PROCEDURES FOR KNEE ORTHOSES AND KNEE-ANKLE-FOOT ORTHOSES

by Gustav Rubin, M.D., FACS¹
Malcolm Dixon, B.S., M.A., RPT²
Michael Danisi, C.O.³

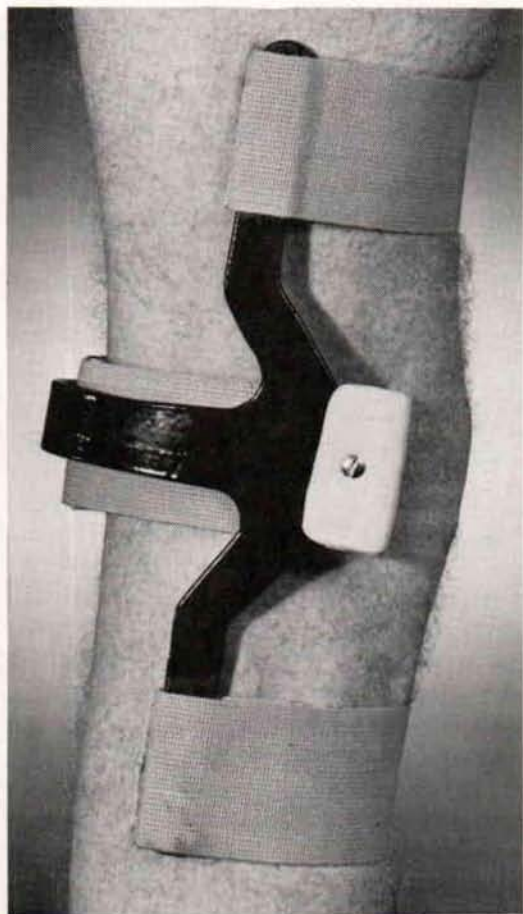


Fig. 1. Lateral view of the "Swedish Knee Cage."

It is the purpose of this paper to present the VAPC Clinic Team's approach to the prescription of knee orthoses (KO's) and knee-ankle-foot orthoses (KAFO's).

To conform to recently accepted procedure the use of eponyms has been avoided wherever possible. Because the total elimination of eponyms from orthotic literature is still in transition, the parenthetical inclusion, such as the term, "Swedish Knee Cage" (Fig. 1), will be noted in the KO-KAFO chart (Fig. 2). This is, as indicated, a metal "rigid three-point pressure KO" (1) and should be distinguished from a plastic contoured "rigid three-point pressure KO" such as the IRM SK KO (2) shown in Fig. 3.

In the accompanying KO-KAFO chart the authors have placed emphasis upon the knee. As Viel has indicated the "key problem remains knee stability" (14). AFO and shoe component charts (Figs. 4 & 5) have been included, which, with the KAFO chart, aid in the representation of a total KAFO orthotic system.

Evaluation Procedure

The development of an orthotic prescription proceeds through several stages:

1. Patient's History

VAPC PRESCRIPTION PROCEDURES FOR KO'S AND KAFO'S (ADULT) *

ETIOLOGY	PATHOLOGY	MODIFYING FACTORS	DESIRED KNEE CONTROLS	Rx (KNEE) *	ELABORATION**
Upper Motor Neuron Defect (Spastic) (Unilateral considered here. See section I, below, for bilateral)	1. Brain trauma (CVA, etc.) 2. Spinal cord trauma 3. CNS Disease (Tumor, M.S., etc.) (Also applicable to section I, below)	1. With M-L stability, but hyperextension (posterior cruciate and poster. capsule laxity) — Mild Hyperext (5° to 15°) — Severe Hyperext (15° or more) 2. With AP instability — Knee collapse in flexion 3. With M-L Ligament Laxity — M-L instability	Stop hyperextension if painful or if maximum limit (allow sufficient for stability) Prevent excessive hyperextension Prevent flexion instability Resist medio-lateral joint stress.	Rigid three-point Pressure Orthosis (Swedish knee cage) Offset knee joints*** or knee lock Knee stabilizing AFO; Spiral KO Polypropylene KO or double bar KAFO, with knee lock joints Same as above Spiral or hinged elastic knee support Polypropylene KO Polypropylene KO, Double Bar KAFO	1. Cane if needed 2. Varus-valgus knee strap or extension knee cap as indicated, with double bar KAFO.
Lower Motor Neuron Defect (Flaccid)	1. Poliomyelitis 2. Guillain-Barre Disease 3. Peripheral Nerve Trauma 4. Peripheral Nerve Disease (Diabetic, alcoholic, uremic polyneuritis, etc.) 5. Other	Same as Above	Same as Above	Same as Above	Same as Above
Disruptive Injury to Knee Ligaments	1. Medial collateral 2. Lateral collateral 3. Cruciate (Anterior) 4. Cruciate (Posterior) 5. All of above	Mild Laxity Mod. Laxity Severe Laxity Mod. or Severe Laxity Instability in all directions	Resist medio-lateral joint stress As Above Resist A-P Joint Stress Stop hyperextension Lock Medio-Lateral and AP Joint Stress	Hinged elastic KO; Spiral KO Polypropylene KO; Double Bar KAFO; Double anterior loop KO (Lencx Hall) As Above Offset knee joints Knee lock	1. Cane if needed 2. Varus-valgus strap as indicated Knee lock if necessary Surgical intervention, or rigid knee shell if clinically indicated
Injury to Muscles Muscle Disease (Dystrophy)	Impairment of function of muscles controlling the knee	1. Extent of muscle weakness 2. Presence of contractures	Prevent AP instability for Progressive correction of contractures	Mild — Spiral KO; cane; knee stabilizing AFO Mod — Polypropylene KO; Double Bar KAFO (with offset joints or knee lock) Severe — Same as Above Double Bar KAFO with Dial Knee Lock	1. Offset joints may be used if there is at least 5° of hyperextension 2. Extension or varus-valgus knee caps if indicated 3. Knee flexion stop + extension aid
Articular Impairment of Hip Joint	1. Osteoarthritis 2. Post-traumatic arthritis 3. Atrophic arthritis 4. Post-infectious arthritis 5. Other	Degree of pain experienced	Knee joint must be locked to efficiently transmit forces from the floor, to the orthosis, and to the pelvis, and thereby partially unweight the hip.	1. Cane if mild pain 2. If pain mod. or severe: ischial ring or quad socket KAFO with locked knee and locked (or limited motion) ankle. If necessary, add cane or crutches.	See below
Osseous Inadequacy of the Femur	1. Fracture (a) Recent (b) Delayed Union (c) Non-union 2. Metastatic Cancer 3. Paget's Disease 4. Other	Degree of unweighting necessary will be based on extent of involvement and potential or actual structural weakness of the femur, or pain 1. Minimal 2. Moderate 3. Extensive	As above	Cane Ischial ring or quad socket KAFO and cane As above but crutches instead of cane	Quad socket orthosis**** less efficient for unweighting at head-neck level of femur than ischial ring***** and more efficient at mid-shaft level or below.
Painful Articular Impairment of Knee Joint (or if Ligament Laxity is present see C above)	1. Osteoarthritis 2. Post-traumatic arthritis 3. Atrophic arthritis 4. Post-infectious arthritis 5. Other	1. Mild stress pain — ML 2. Mod. pain on stress — AP and/or ML 3. Severe pain on stress 4. Mod. or severe pain on weight bearing	Resist ML joint stress Resist ML and/or AP joint stress As Above As above plus stop knee motion As above plus stop knee motion	Hinged or spiral KO, and/or cane Spiral KO and/or cane Polypropylene KO; Double anterior loop KO Double Bar KAFO Above with knee lock plus cane Quad socket or ischial ring KAFO	If varus or valgus deformity add corrective pads or straps If pain is mild to moderate then a gluteal weight-bearing corset may be used.
Painless Articular Impairment of Knee Joint	Asensory arthritis (As Charcot's Disease)	Instability	Lock knee motion Diminish vertical impact trauma	Quad socket or ischial ring KAFO with knee lock	Pull straps as necessary Cane
Paraplegia or functional clinical equivalent	1. Functional Muscle Power absent from abdominals and below 2. Abdominal Power Muscle retained, but muscle power absent below level of abdominals 3. Pelvic control and hip flexors retained. More distal muscle power absent	Non-ambulator. Stand only in orthoses. Exercise function possible in orthoses. Occasionally a strongly motivated patient will achieve limited ambulation. Community ambulation possible.	Lock knee motion	1. Polypropylene KAFO's with metal knee side bars and joints, and knee locks 2. Double bar KAFO's with knee locks 3. Ambulatory aid with above orthoses, i.e. crutches, walker, etc. (Wheelchair also needed)	1. Must be highly motivated 2. Must constantly work to develop remaining trunk and upper limb muscles 3. Functional level attained related to level of injury, but if (1) and (2) are present, a T5 may achieve exercise function.

* Rx of HKAFO'S not included here

* See AFO and Shoe Component Charts for Additional Elements of the Prescription.
 ** If Sensation is impaired, Polypropylene Orthoses should be lined with plastazote.
 *** Functional knee joints
 **** If the patient has good quadriceps muscle power, the quad socket orthosis can function well with either offset knee joints or knee locks.
 ***** If the patient can tolerate ischial weight bearing.
 ***** Hemiphasiac knee arthritis is a specific indication for single lateral bar quad socket orthosis to prevent trauma to the opposite limb.

Fig. 2. Prescription Procedures for Knee Orthoses and Knee-Ankle-Foot Orthoses for Adults

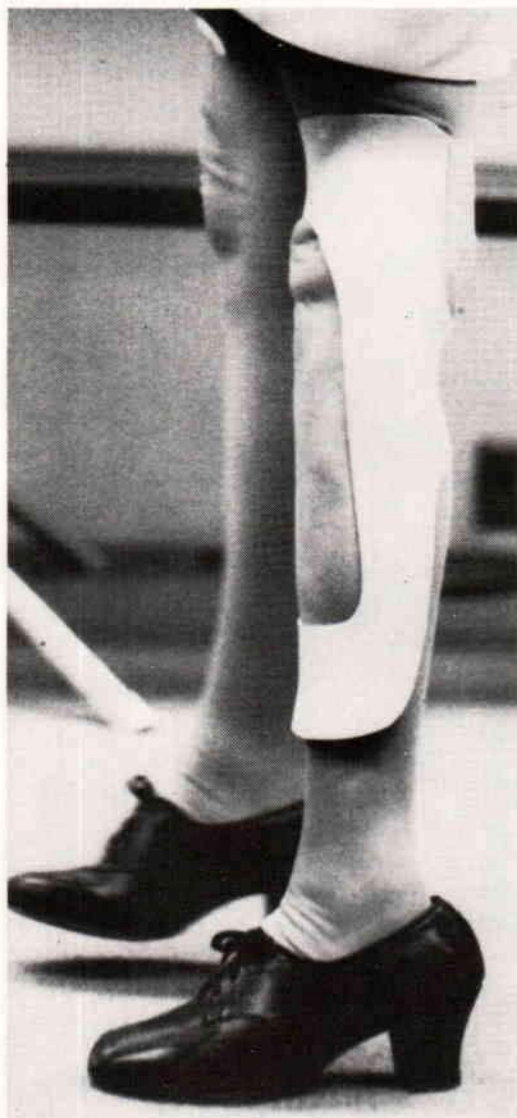


Fig. 3. The SK Knee Orthosis developed at the Institute for Rehabilitation Medicine

2. Physical Demands of Patient's Vocational and Recreational Pursuits
3. Physical Status
4. Gait Characteristics
5. Determination of Functional Requirements of Components
6. Selection of Components
7. Discussion with the Patient to Obtain His Acceptance of the Prescription
8. Prescription of the Orthosis

History

Information should be elicited about the character of the terrain where the patient will walk and, when indicated, frequency and duration of clonic episodes, conditions within the home environment (stairs, etc.), age, general health and past experience with orthoses.

Physical Demands of the Patient's Vocational and Recreational Pursuits

These factors will directly influence selection of components. An example of this consideration is given later. Most patients present unique problems which can be evaluated only on an individual basis.

Physical Status

When clinically indicated, a referral to an internist for an examination including cardio-pulmonary evaluation should be made, especially when a great amount of effort will be required, as with bilateral KAFO's. Neuro-musculo-skeletal evaluation including the conditions of joints and their supporting structures should be given particular attention by the Clinic Team. Other consultants should be called upon for opinions where necessary, as, for example, dermatologists.

Gait Characteristics

The patient who can ambulate or stand should be required to do so, even if assistance or parallel bars are needed. The problems that are manifested, in association with the findings of the first three stages, will lead the Clinic Team directly to the next stage, determination of the functional requirements of the orthoses.

Determination of the Functional Requirements of the Components Needed

The format developed by McCollough (1) is very useful. He suggests the use of the following symbols "to indicate desired control of designated function":

PRESCRIPTION PROCEDURES FOR AFO'S				
ETIOLOGY	PATHOLOGY	MODIFYING FACTORS	DESIRED CONTROL	PRESCRIPTION
1. LOWER MOTOR NEURON DEFECT (PERONEAL N.)	FLACCID PIS EQUINUS	STABLE*	Assist dorsiflexion of foot at ankle	SHOE CLASP (VAPC) AFO
		UNSTABLE*	Assist dorsiflexion and resist varus-valgus	POLYETHYLENE (TEUFEL)
		MOD.	Assist dorsiflexion and resist varus-valgus	POLYPROPYLENE
2. LOWER MOTOR NEURON DEFECT (SCIATIC N.)	FLACCID PIS EQUINUS (WITH CALF MUSCLE CONTRACTURE**)	STABLE*	Assist dorsiflexion of foot at ankle	SHOE CLASP
		UNSTABLE*	Assist dorsiflexion and resist varus-valgus	POLYETHYLENE
		MOD.	Assist dorsiflexion and resist varus-valgus	POLYPROPYLENE
3. UPPER MOTOR NEURON DEFECT	FLACCID PIS EQUINO-CALCANEUS (WITHOUT CALF MUSCLE CONTRACTURE)	STABILITY NOT A FACTOR SINCE CHOICE IS LIMITED TO STABLE ORTHOSES	Resist dorsiflexion and resist plantar flexion	SPIRAL ORTHOSIS (TRM), BUT IF BILATERAL INVOLVEMENT, THEN - POLYETHYLENE OR POLYPROPYLENE FABRICATED TO RESIST DORSIFLEXION AND PLANTAR-FLEXION
		MILD***	Assist dorsiflexion	SHOE CLASP PIS
		MOD.***	Assist dorsiflexion and resist plantar flexion	POLYETHYLENE; IF NOT ADEQUATE, THEN - POLYPROPYLENE
4. ANY OF THE ABOVE	SPASTIC PIS EQUINUS	SEVERE***	Stop dorsiflexion and plantar flexion (If foot deforms in brace)	POLYPROPYLENE - IF NOT ADEQUATE, THEN - DOUBLE BAR (SHOE ATTACHMENT) AFO
		ANY OF THE ABOVE	Allow limited subtalar motion	SINGLE BAR (ROTATION) ORTHOSIS (VAPC) FOR FLACCID OR SINGLE BAR (NO ROTATION) FOR SPASTIC
		Any of the above controls PLUS	Hold subtalar motion	DOUBLE BAR AFO IF SUBJECT IS OVERWEIGHT OR VERY ACTIVE
5. PAINFUL DESTRUCTIVE DISEASE OF ANKLE	ARTHRITIS (POST-TRAUMATIC, INFECTION, INFLAMMATORY, ETC.)	ANY OF THE ABOVE	Stop plantar-flexion, dorsiflexion, varus and valgus	POLYPROPYLENE ORTHOSIS MODIFIED TO RESTRICT DORSIFLEXION AND PLANTAR FLEXION
		ANY OF THE ABOVE	Partially unweight the leg, ankle, or foot	PTB WEIGHT-BEARING AFO
		ANY OF THE ABOVE	Hold subtalar motion	DOUBLE BAR AFO IF SUBJECT IS OVERWEIGHT OR VERY ACTIVE
6. a) STRUCTURAL INADEQUACY DISTAL TO THE KNEE b) PAIN DISTAL TO KNEE, ON WEIGHT BEARING	a) NON-UNION OR DELAYED UNION OF TIBIA: CHANCOFF'S DISEASE OF ANKLE/FOOT, ETC. b) DESTRUCTIVE DISEASE OF ANKLE, ETC.	TISSUE BENEATH THE ORTHOSIS MUST BE CAPABLE OF WITHSTANDING THE PRESSURES OF PARTIAL UNWEIGHTING; FOR EXAMPLE, SENSATION MUST BE INTACT	Partially unweight the leg, ankle, or foot	PTB WEIGHT-BEARING AFO
		ANY OF THE ABOVE	Hold subtalar motion	DOUBLE BAR AFO IF SUBJECT IS OVERWEIGHT OR VERY ACTIVE
		ANY OF THE ABOVE	Allow limited subtalar motion	SINGLE BAR (ROTATION) ORTHOSIS (VAPC) FOR FLACCID OR SINGLE BAR (NO ROTATION) FOR SPASTIC

* Stability is: a. evaluated during trial of a stock brace (VAPC shoe clasp, Teufel, Polypropylene) on the patient by the Clinic Team, or, b. can be assumed by the nature of the terrain the subject may walk upon (fields, golf courses, etc.).

*** During the clinic team evaluation of orthoses, the degree of spasticity is related to the "triggering" of spastic equinus (or equino-varus) by the stock brace. The patient is placed in the brace and the foot is moved into the brace. For example, if the stock brace triggers the foot into spastic equinus, one must try the stock Teufel. The stock Polypropylene. If the foot deforms within the Polypropylene, the stock Polypropylene is required. Very severe spasticity cannot be controlled by a brace.

** Many patients with sciatic nerve injuries develop calf contractures sufficient to stabilize the ankle at about 90°, in the weight bearing position. These patients need only a correction for the flaccid pes equinus.

**** Most such patients will tolerate a properly fitted shoe insert brace, or a shoe clasp. Those who develop areas of irritation should be changed to external bracing with individualized shoe modifications, if indicated.

Fig. 4. Prescription Procedures for Ankle-Foot Orthoses

LOWER LIMB SYSTEM

THE ANKLE-LEG COMPONENT		THE FOOT COMPONENT*
Type	AFO Designation	Shoe Modifications
Dorsiflexion Assist AFO	1- Shoe Clasp 2- Polypropylene Posterior Leaf Spring 3- Ortholene Posterior Leaf Spring 4- Conventional	1- Hard counter; Blucher shoe* 2- Depth shoe** with thin inlay 3- Depth shoe** with thick inlay 4- Solid stirrup or caliper stirrup foot-plate and a very strong shank; Blucher shoe*
Dorsiflexion Assist plus spring-loaded varus control	Posterior Leaf Spring Orthosis with spring-loaded varus correction	Posterior caliper stirrup footplate with Blucher shoe* and outflare heel
AFO with plantarflexion stop***	1- Polypropylene 2- Conventional Double Bar 3- Single Bar	1- Depth shoe with thin inlay 2- Solid stirrup or caliper stirrup foot-plate; strong shank; Blucher shoe* 3- Solid stirrup or caliper stirrup foot-plate; strong shank; Blucher shoe*
AFO with dorsiflexion stop	Conventional Double Bar	Solid stirrup or caliper stirrup foot-plate; rocker bar; long steel spring; Blucher shoe**
AFO with limited motion ankle	1- Conventional Double Bar 2- PTB Orthosis	1- Solid stirrup or caliper stirrup foot-plate; SACH heel; rocker bar long steel spring; Blucher shoe* 2- Solid stirrup; SACH heel; rocker bar; long steel spring; Blucher shoe*

Fig. 5. Shoe Components for Lower-Limb Orthoses

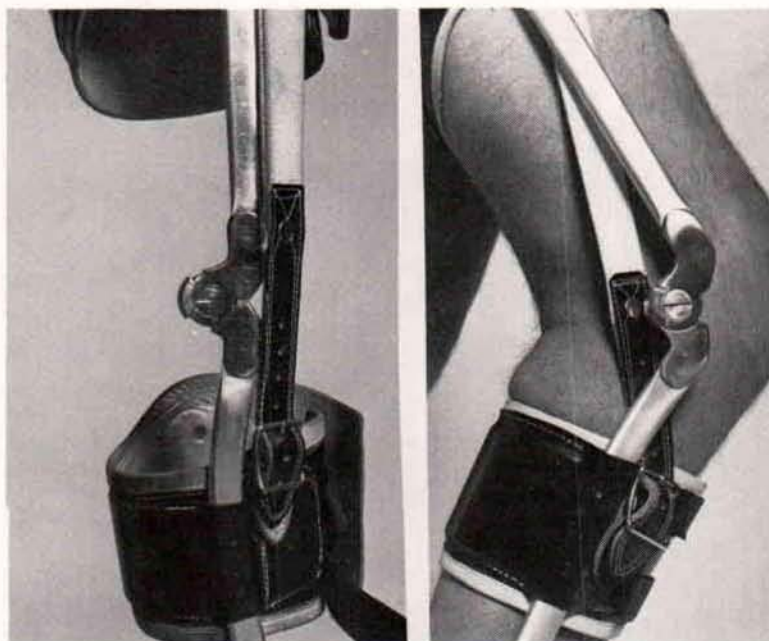


Fig. 6. Knee Orthosis with Offset Knee Joints

F = FREE — Free motion.

A = ASSIST — Application of an external force for the purpose of increasing the range, velocity, or force of a motion.

R = RESIST — Application of an external force for the purpose of decreasing the velocity or force of a motion.

S = STOP — Inclusion of a static unit to deter an undesired motion in one direction.

v = Variable — A unit that can be adjusted without making a structural change.

H = HOLD — Elimination of all motion in prescribed plane (verify position).

L = LOCK — Device includes an optional lock.

The authors use in a clinical trial a stock shoe clasp or a stock polypropylene AFO to aid in evaluation of the anticipated response to AFO's. This is particularly helpful to determine if spring loading will precipitate clonus when mild to moderate spasm exists.

Selection of the Most Desirable Components For the Individual Patients

This decision will take into account not

only the function of the components but also the weight, cosmesis, and sturdiness of the materials. A 118-lb. city-dwelling female will usually require a different prescription for the same condition than would a 250-lb. male farm worker. For the farm worker, in contrast to the city dweller, it would usually be advisable to sacrifice cosmesis for strength and durability of components. As indicated above, the AFO components (Fig. 4) and the shoe components (Fig. 5) have been charted separately and those charts should be used in conjunction with the KAFO chart to arrive at a prescription.

Discussion With the Patient

The prescription developed by the Clinic Team should be discussed with the patient to obtain his cooperation. When possible, a device similar to that planned for him should be shown to the patient. He may refuse to accept change and prefer to continue with an orthosis of a type to which he is accustomed rather than a more modern orthosis. Prescription over the patient's objection will almost invariably lead to rejection.

Prescription

When all of the factors discussed above have been considered thoroughly the prescription will usually "fall into place."

KO's and KAFO's

The following orthoses are discussed briefly in the order in which they are referred to in Figure 2.

Rigid Three-Point Pressure KO (Figs. 1)

There are several variants of this KO. The simplest is of metal and fabric, the metal rigid three-point pressure KO (Fig. 1). Examples of plastic "rigid three-point pressure KO's" have been demonstrated by Lehneis (1) (the IRM SK KO), (Fig. 3) and by Nitschke (the PTS KO) (1). The metal device is available commercially and the latter two require custom fabrication. The area of clinical application of these orthoses is described in the chart. Their principal function is to limit knee hyperextension by virtue of the three-point pressure design. The medio-lateral support that is provided by rigid orthoses of this type is only present in the hyperextended position. As soon as knee flexion occurs the effectiveness of the M-L support is lost.

KO With Offset Knee Joints or Knee Locks (Figs. 6 and 7)

These may be used to stop or lock the knee to control hyperextension. If the knee hyperextension is between 5 deg. and 15 deg. the offset knee joints may be satisfactory and a trial with offset joints should be made since knee motion will be retained. If these joints are not adequate, i.e., if the knee is in slight flexion, or in excessive hyperextension, it will be necessary to use knee locks. For the offset knee joints to function properly and prevent knee collapse in flexion several prerequisites must exist, 1) the knee must hyperextend at least 5 deg., 2) there should be no hip flexion contracture, 3) there should be no ankle dorsiflexion deformity, and 4) there

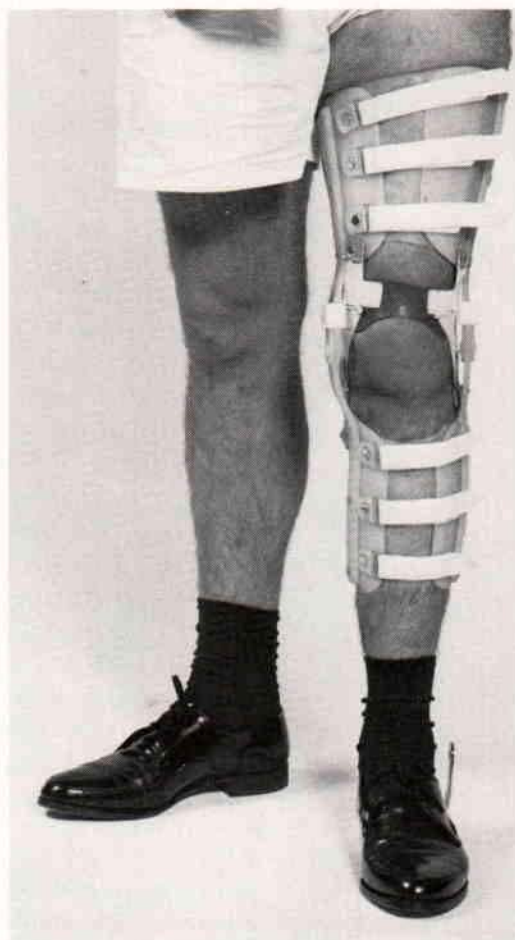


Fig. 7. Knee Orthosis With Knee Joint Lock
should be adequate power from the gluteus maximus and the soleus.

Knee Stabilizing AFO (Fig. 8)

This design is designated an AFO because no component of the orthosis crosses the knee joint; nevertheless, its principal action is on the knee joint (9), and it, therefore, is included here. It may be used if, in addition to the need for knee stabilization, there is a concomitant requirement for an ankle orthosis. The ankle orthosis should incorporate a dorsiflexion stop adjusted in plantarflexion to produce a knee extension force. There must also be an absence of hip flexion contracture as well as retention of fair hip extensor power (7). The authors pre-



Fig. 8. Ankle Foot Orthosis Designed to Provide Stabilization About the Knee

fer to use this orthosis when quadriceps power is rated not less than "poor" and with an intact opposite lower limb. When the indications for its use are present, this orthosis allows the patient to retain an important freedom, knee motion. It is useful when mild or moderate knee flexion instability is present.

The Spiral KO (Fig. 9)

The Spiral KO is an elastic fabric KO reinforced with flexible stays. It is useful only for mild instability and functions primarily as a "reminder" type of orthosis, i.e., as the patient ambulates the restraints introduced "remind" him to bring his knee to full extension on weight-bearing, and thereby stabilize the knee. Its presence also "reminds" the patient to favor the knee when it is used for mild medio-lateral instability. The stays add only minimal resistance to knee instability.

Polypropylene KO (Fig. 10)

This orthosis (2) includes the unique fea-

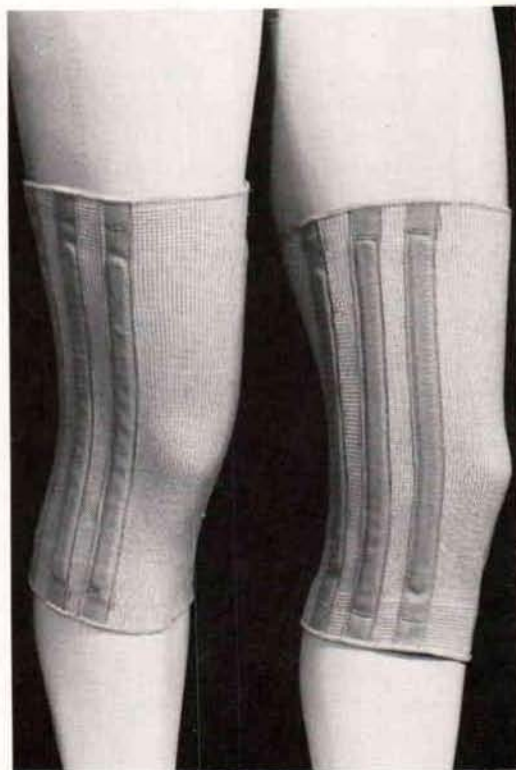


Fig. 9. A Knee Orthosis made of elastic fabric, known as the Spiral KO

Fig. 11. Single bar knee-ankle-foot orthosis developed at the VAPC.

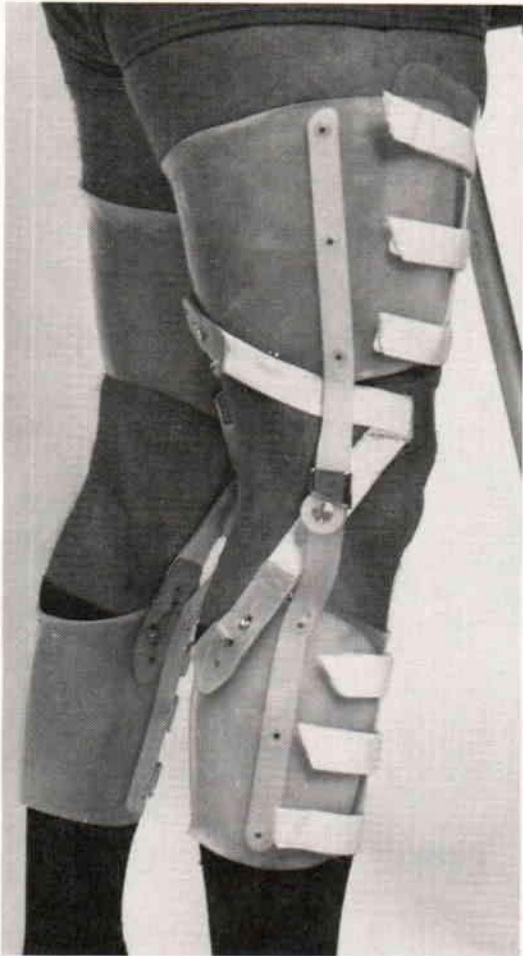


Fig. 10. A polypropylene knee-orthosis developed at the VAPC. This model has a knee lock.

ture of suprapatellar-cuff suspension in the manner of the cuff suspension of the PTB prosthesis. It can be fabricated with drop locks at the knee for moderate or severe flexion instability. When used to resist medio-lateral ligament laxity, a knee lock is unnecessary except in extreme cases.

Double-Bar or Single-Bar KAFO (Fig. 11)

Traditionally this is the term used to describe a KAFO fabricated with either aluminum or steel medial and/or lateral bars, with or without (as specifically indicated) an ankle joint, and with either a solid stirrup or a split stirrup. Offset knee joints or knee locks may be used. Variants may employ all

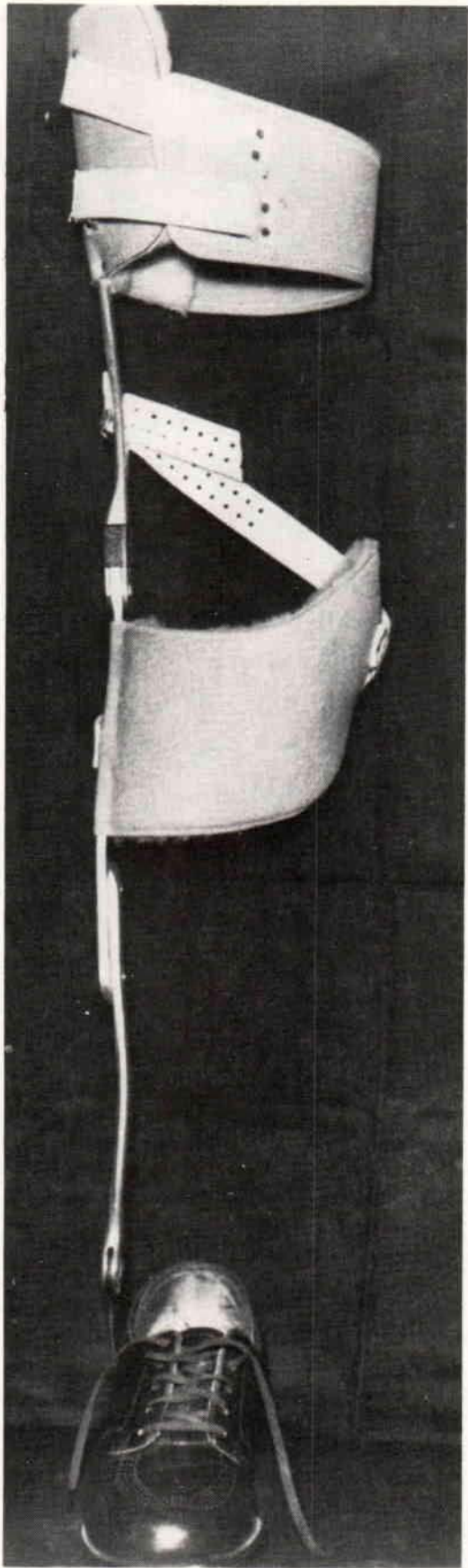




Fig. 12. An all polypropylene knee orthosis is shown in the left and center photographs. A conventional metal knee-ankle-foot orthosis is shown in the photograph on the right.

polypropylene (Fig. 12), polypropylene and polyethylene (Fig. 13), pneumatic knee joint locks (Fig. 14), or a KAFO of polypropylene plus a shoe clasp (Fig. 15).

Hinged Elastic KO (Fig. 16)

The hinged elastic KO is slightly more effective for resistance to medio-lateral knee ligament laxity than is the spiral KO, and is used if the complaints are mild. The improved resistance to M-L displacement and the addition of limited A-P displacement resistance are achieved with hinged medial and lateral metal struts and knee locks. These provide resistance restraints rather than true locking because of the elasticity of the cuffs.

Double Anterior Loop KO (Lenox Hill Derotation Orthosis) (Fig. 17)

The double anterior loop KO is essentially a metal KO fabricated to provide resistance to medio-lateral displacement and limited resistance to anteroposterior placement due to ligament laxity. A stop to A-P displacement is added when knee locks are employed. Suspension is achieved by the use of circular latex-rubber straps, a disadvantage when circulatory or edema problems are present.

Plastic "Shell" KO (Fig. 18)

The plastic "shell" KO is a custom made, contoured solid knee orthosis providing



Fig. 13. A polyethylene KAFO with metal joints. knee immobilization. The figure shows the minimum length of this device that was adequate in the illustrated instance. To achieve maximum efficiency the orthosis should reach as far as possible proximally and distally and yet allow hip and ankle motion. Suspension is achieved by contouring the orthosis over the suprapatellar area and above the flare of the femoral condyles.

Ischial Ring KAFO (Fig. 19)

This double bar KAFO utilizes a knee lock and limited-motion or locked ankle joints to

achieve direct weight transmission from the ischial tuberosity to the floor. If weight-bearing is accomplished efficiently on the ischial seat, the hip joint can be at least partially protected against vertical impact trauma. The difficulty with this orthosis is that many patients will not tolerate the required extent of localized pressure on the ischial tuberosity and will release the anterior strap of the orthosis to allow the ischial tuberosity to slip forward and down (4).

Double-Bar KAFO With Dial Knee (Fig. 20)

The Dial Knee is employed to achieve gradual correction of a knee flexion contracture which is still amenable to correction and not rigidly fixed. The dial permits the knee to be locked into increasingly greater degrees of extension.

Double-Bar KAFO With Knee Flexion Stop And Extension Aid (Fig. 6)

This orthosis is useful for unilateral knee flexion instability, in the presence of poor or absent quadriceps function and an intact opposite extremity. A flexion stop at no more than 60 deg. will give the patient an opportunity to recover from sudden knee flexion collapse, and the extension aid, plus gravity, will then help him restore stability by bringing the leg to extension against the stop of offset knee joints (Fig. 6) (13).

The Quadrilateral Socket KAFO (Fig. 21)

This design provides ischial, gluteal, and proximal thigh-bearing; i.e., the socket, as it encompasses the thigh, provides supportive features. The upward forces on the hip joint are therefore greater than in the case of a properly worn ischial ring orthosis, and toleration by the patient is also greater. This orthosis is useful for partially unweighting the femur just below the hip, and useful to a more limited degree for unweighting the hip joint itself (7).

As indicated in Section G of Figure 2, under the column labeled "Elaboration," when a lesser degree of unweighting is required



Fig. 14. The ORTHO-WALK pneumatic orthoses

than would be provided with the quadrilateral socket KAFO, a gluteal corset KAFO may be employed. When the patient has good control of extensor power at the knee, offset knee joints can be used. Otherwise the orthosis should be fabricated with knee locks. The orthosis illustrated in Figure 22 was fabricated for a patient who could not wear the PTB orthosis because of peripheral neuritis and absence of sensation in the PTB cuff support area. This device is quite similar to the immediate precursor of the VAPC PTB orthosis (8).

Bilateral Double-Bar KAFO's For the Paraplegic (Fig. 23)

In KAFO's for the paraplegic patient, the knees must be locked in the neutral position, ankles must be dorsiflexed about 10 deg., and the patient must lean his pelvis forward and his trunk backward to allow the patient to balance with the center of gravity over the

mid-foot, as illustrated by the Scott-Craig orthosis (5, 11). Because of the retention of proprioception the poliomyelitis patient knows where his lower limbs are but the spinal cord patient must learn to sense position, and, as a result "polio patients accomplish greater levels of ambulation than spinal cord injured patients with the same motor deficit" (3).

Single Lateral-Bar Quadrilateral Socket KAFO (Fig. 24)

The single-lateral bar quadrilateral socket KAFO is not only useful for the patient with hemophiliac knee arthritis (6) as recorded on the chart, but, when not used with a quadrilateral socket, lightweight patients who need bilateral orthoses will frequently find single lateral-bar KAFO's more comfortable. The impact of medial bars against

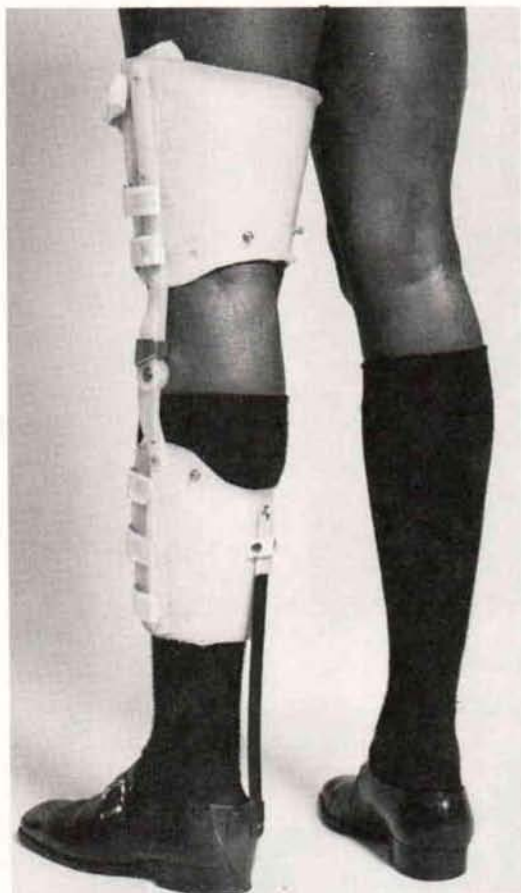


Fig. 15. A polypropylene knee orthosis combined with the VAPC shoe clasp type of ankle-foot orthosis to provide a knee-ankle-foot orthosis.



each other is obviated. In the specific instance of the patient with hemophilia, the elimination of the medial bar removes a potential source of contusion of the opposite limb.

In the case of the hemophiliac knee with a quadrilateral socket KAFO, it may be found worthwhile to hinge the socket laterally rather than medially, to avoid the possibility of inadvertent contusion against the scrotum as the patient swings the socket open, a problem which we have encountered.

Summary

An attempt has been made to outline in a concise form our Clinic Team's basic approach to lower-limb orthosis prescription. The word "basic" should be empha-

Fig. 17. The Lenox Hill Derotation Orthosis

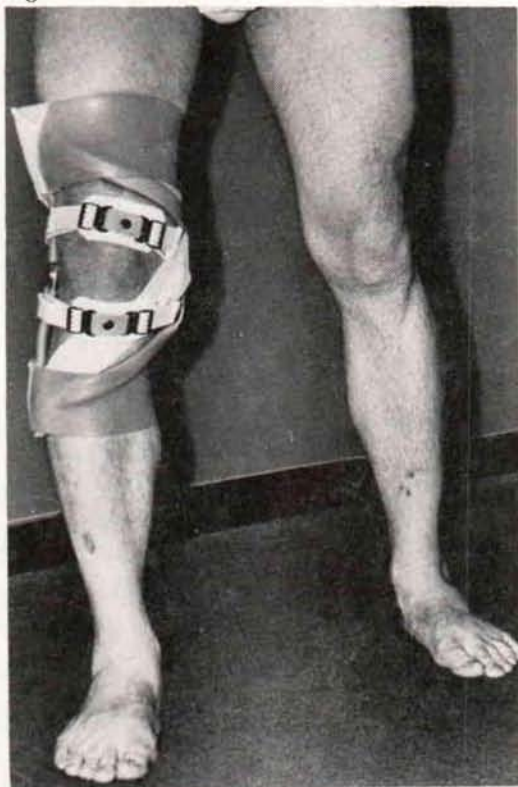


Fig. 16. A hinged elastic knee orthosis



Fig. 18. A plastic shell knee orthosis for complete immobilization of the knee joint.

sized since the Clinic Team does not limit itself to the devices described here, but have used, at various times, other devices as they are reported. These have not been discussed since an encyclopedic approach has not been attempted. It has been our purpose to present our point of view, and, therefore, the charts included illustrate the foundation upon which we build. They are intended to have one function only—that of teaching tools. The authors do not presume to instruct certified orthotists or physicians with long experience in prescription procedures.

Bibliography

- 1 Committee on Prosthetics Research and Development, *Seventh Workshop panel on lower-extremity orthotics*, Orth. and Pros., March, 1971, pp. 1-31.
- 2 Dixon, M., and R. Palumbo, *Polypropylene knee orthosis with suprapatellar latex strap*, Orth. and Pros. 29:3, pp. 29-31, September, 1975.
- 3 Hussey, Robert W. and E. Shannon Stauffer, *Spinal cord injury: requirements for ambulation*, Arch. of Phys. Med., 54: pp. 544-547, Dec. 1973.
- 4 Lehmann, J. F. and G. G. Warren, *Ischial and patel-*



Fig. 19. Conventional double-bar knee-ankle-foot orthosis with knee lock.

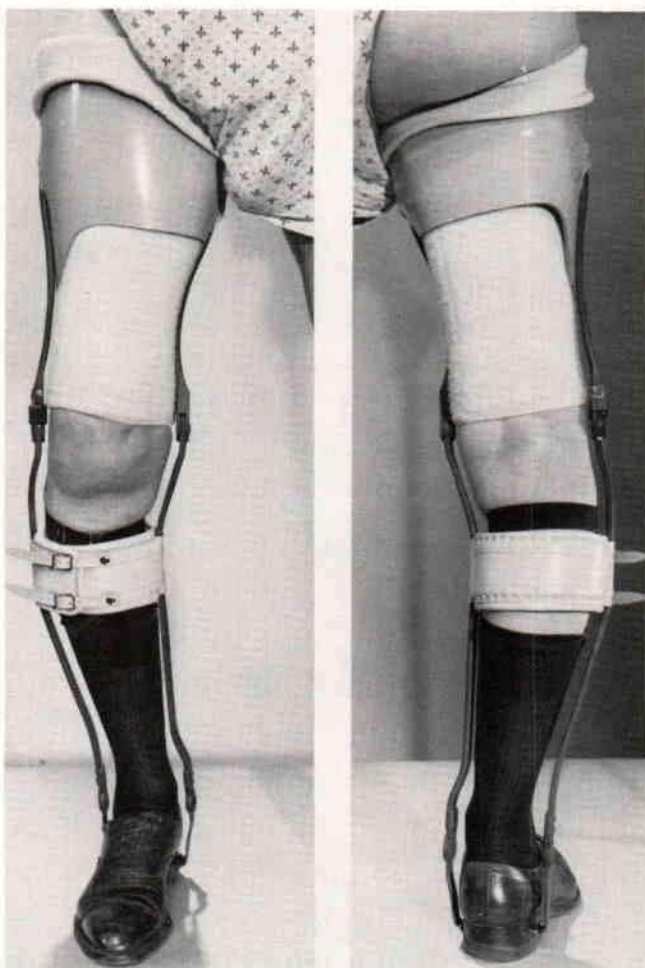


Fig. 21. Anterior and posterior views of a KAFO with a quadrilateral cuff.



Fig. 20. The Dial Knee Unit disassembled.

Fig. 22. Lateral view of a KAFO with a gluteal corset.

lar-tendon weight-bearing braces: function, design, adjustment, and training, *Bull. of Pros. Res.*, 10-19, pp. 6-19, Spring, 1973.

5 Lehmann, J. F., C. G. Warren, D. Hertling, M. McGee, B. C. Simons, and A. Dralle, "Craig-Scott orthosis: biomechanical and functional evaluation," *Arch. Phys. Med. Rehab.*, 57: pp. 438-442, September 1976.

6 McCollough, Newton C. III: *Comprehensive management of musculo-skeletal disorders in hemophilia*, CPRD, National Academy of Sciences, Washington, D.C., 1973, pp. 90-91.

7 Perry, Jacqueline and Helen Hislop, *Principles of lower extremity bracing*, American Physical Therapy Association, 1740 Broadway, New York, New York.

8 Rubin, Gustav and Malcolm Dixon, *The modern ankle-foot orthoses*, *Bull. of Pros. Res.*, 10-19, pp. 20-41, Spring, 1973.

9 Rubin, Gustav, and Michael Danisi: *A knee-stabilizing ankle-foot orthosis*, *Orth. and Pros.*, 29-3: pp. 11-14, September, 1975.

10 Rubin, G., D. Bonarrigo, M. Danisi, and M. Dixon, *The shoe as a component of the orthosis*, *Orth. and Pros.* 30:2, pp. 13-25, June, 1976.

11 Scott, Bruce A., *Engineering principles and fabrication techniques for the Scott-Craig long leg brace for paraplegics*, *Orth. and Pros.* pp. 14-17, December, 1971.

12 Staros, A. and Maurice LeBlanc, *Orthotic components and systems*, *Atlas of Orthotics*, American Academy of Orthopedic Surgeons, C. V. Mosby Company, 1975.

13 VA Prosthetics Center Staff *Improvement and innovation: some case studies in orthotics*, *Orth. and Pros. Appl. J.*, pp. 283-297, Sept., 1963.

14 Viel, Eric, *Critique of lower extremity bracing*, *Orth. and Pros.*, pp. 28-33, September 1968.

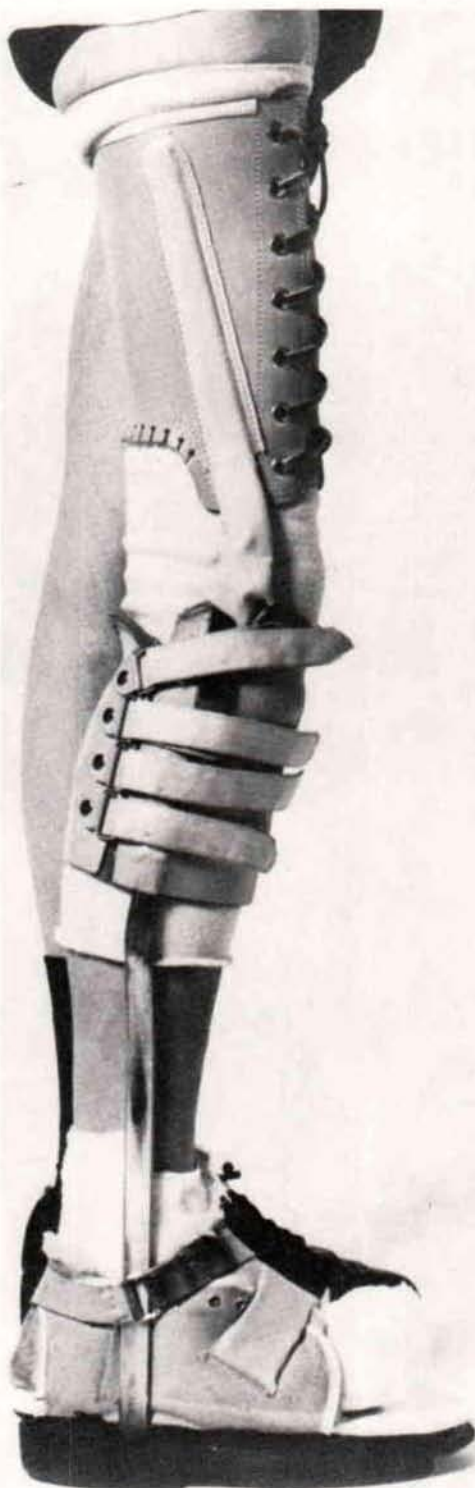




Fig. 23. Double bar KAFO's for a paraplegic patient.

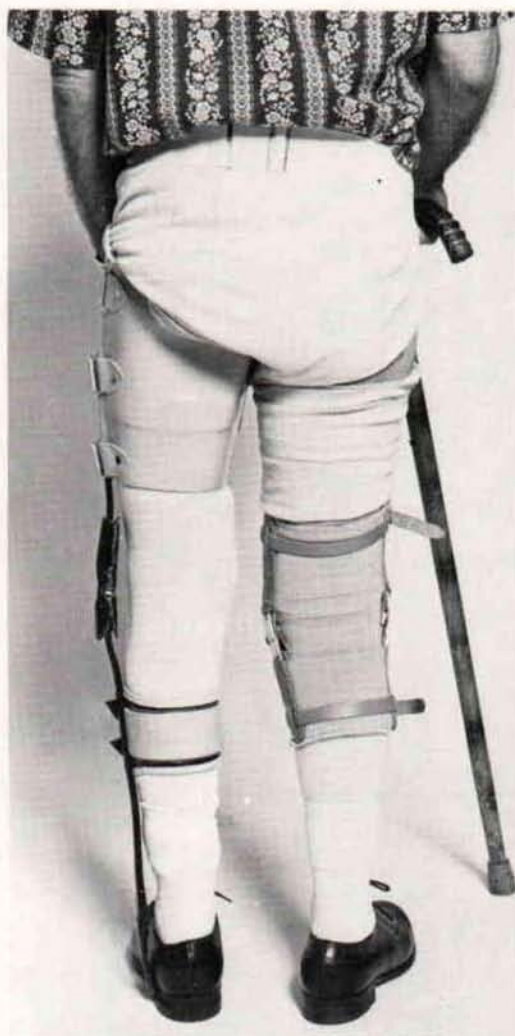


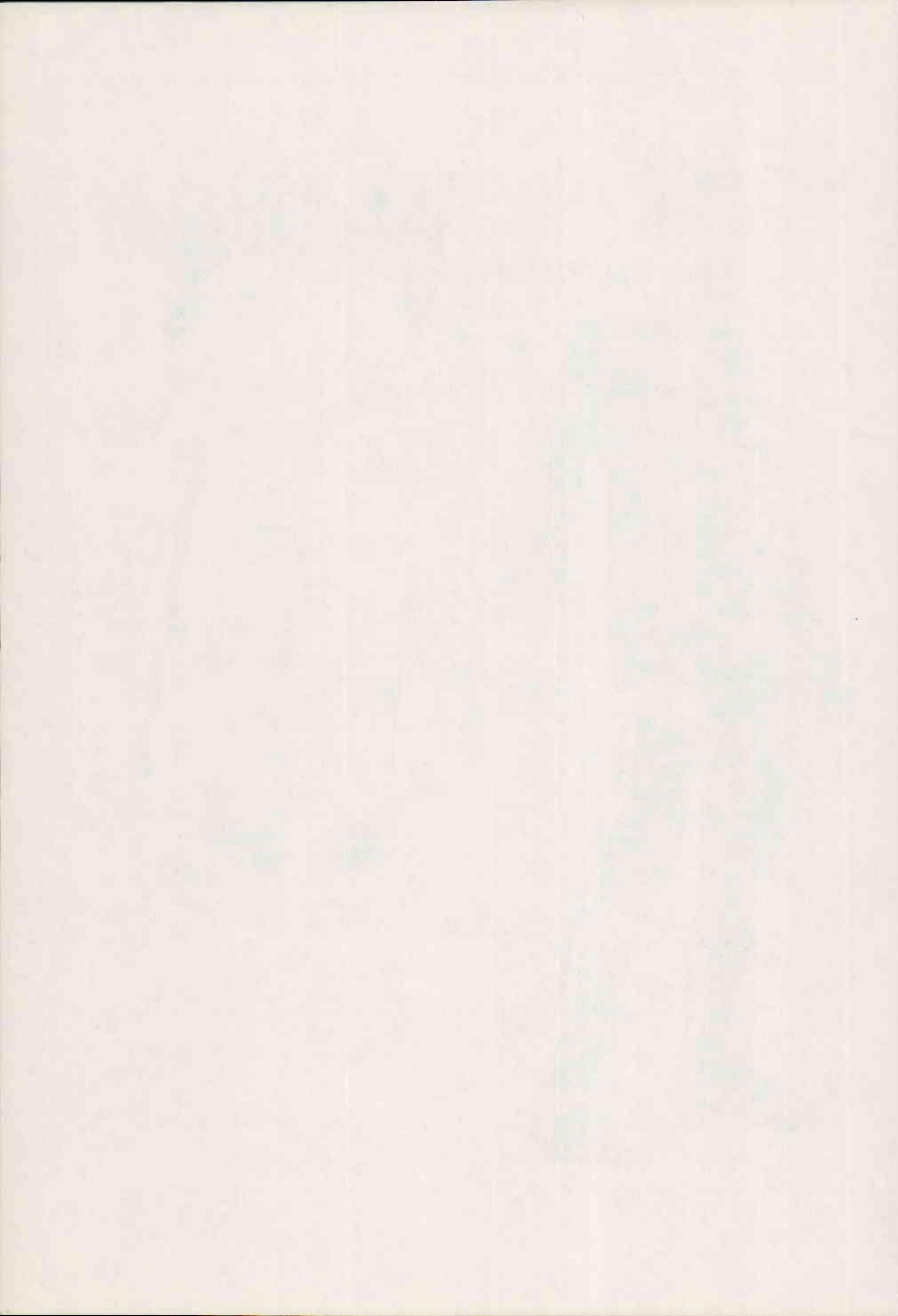
Fig. 24. The patient is wearing a lateral-bar KAFO with a quadrilateral cuff on the left side.

Footnotes

1 Orthopedic Consultant, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, N.Y. 10001

2 Health Sciences Specialist, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, N.Y. 10001

3 Supervisor, Orthotics Laboratory, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, N.Y. 10001



AN ORTHOSIS FOR A PATIENT WITH A FAILED TOTAL HIP-PROSTHESIS

by Tim Jacobson, B.S., C.O.¹
Alanson Mason, M.D.²

This paper describes the orthotic treatment of an elderly female who lacked a proximal section of the femur and the hip joint on the left side.

Patient History

Recently, a 65-year-old Caucasian female with diabetes was seen who had a chronic, recurring problem with her left hip and thigh for the past four years. Initially, she suffered an injury to the left hip that developed into degenerative osteo-arthritis of the hip joint. A total hip replacement of the Charnley-Muller type was provided.

She did well for a period of nearly two years until she fell at work and suffered a complex comminuted fracture of the femur below the stem of the femoral prosthesis which required hospitalization and treatment involving traction. The fracture failed to unite, and an intramedullary rod was inserted in the femur alongside of the stem of the prosthesis. Acrylic cement was used to provide additional fixation.

The fracture failed to unite, and the rod was removed several months later. Osteoporosis of the proximal femur made it extremely difficult technically to provide ade-

quate immobilization. However, a new prosthesis was inserted.

Ultimately, the prosthesis was removed and a new, custom-made prosthesis with an extremely long stem was provided (Fig. 1) approximately one and one-half years ago. The patient did well for a time but gradually developed increasing evidence of deep abscess formation and drainage. After repeated incision and drainage of recurring abscesses in the left thigh and prolonged antibiotic therapy over a period of a year, it was concluded that the prosthesis would have to be removed before additional treatment could be rendered (Fig. 2).

Goals and Treatment

It was decided to provide this patient with an external orthotic appliance to allow her to become ambulatory and as functional as possible.

Following the removal of the final hip prosthesis, skeletal traction was applied to the proximal tibia, to assist in maintaining leg length. The affected limb measured 6 cm. shorter than the sound side, at the time that orthotic treatment was initiated. The patient

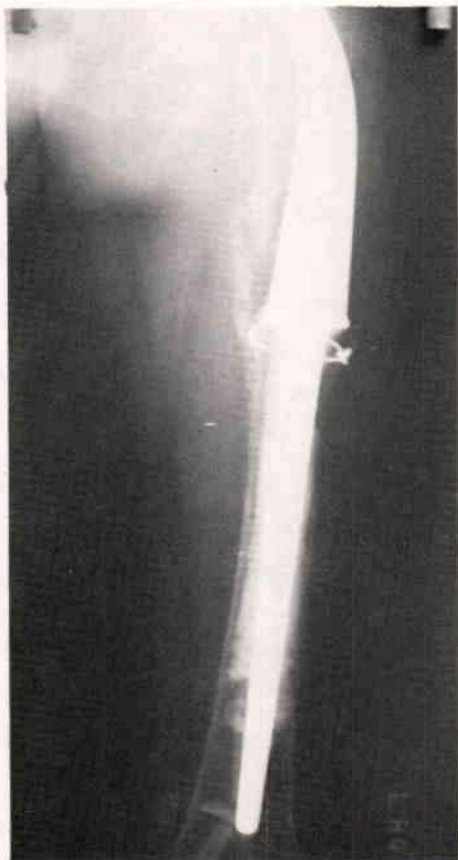


Fig. 1. X-rays showing the final hip prosthesis that was attempted.

was not obese, and seemed highly motivated.

The design of the orthosis consisted of an ischial weight-bearing, adjustable, plastic, total-contact quadrilateral thigh section, which was to be attached to a knee-ankle-foot orthosis with offset, drop-lock knee joints, free ankle joints and an external prosthetic above-knee hip joint with a leather pelvic band (Figs. 3, 4). A cast was taken, using a polyethylene quadrilateral brim, extending well over the femoral epicondyles. Approximately 15 pounds of distraction were applied to her affected limb during the casting to increase thigh length.

After the plaster had set, a tracing and

measurements were taken of the entire limb and hip.

Fabrication

The thigh section was modified and tension values established similar to the above-knee total-contact standards taught at Northwestern University. The anterior-posterior dimension (ischium to adductor longus tendon) was reduced considerably because the adductor longus was only partially intact.

The quadrilateral socket was fabricated in two sections. The posterior two-thirds was an 80 percent rigid—20 percent flexible polyester resin laminated over a previously vacuum-formed polypropylene anterior shell. The anterior piece was attached laterally by three Dacron hinges. Velcro fasteners made the anterior-posterior dimension adjustable

Fig. 2. X-rays of hip region following removal of the final hip prosthesis.



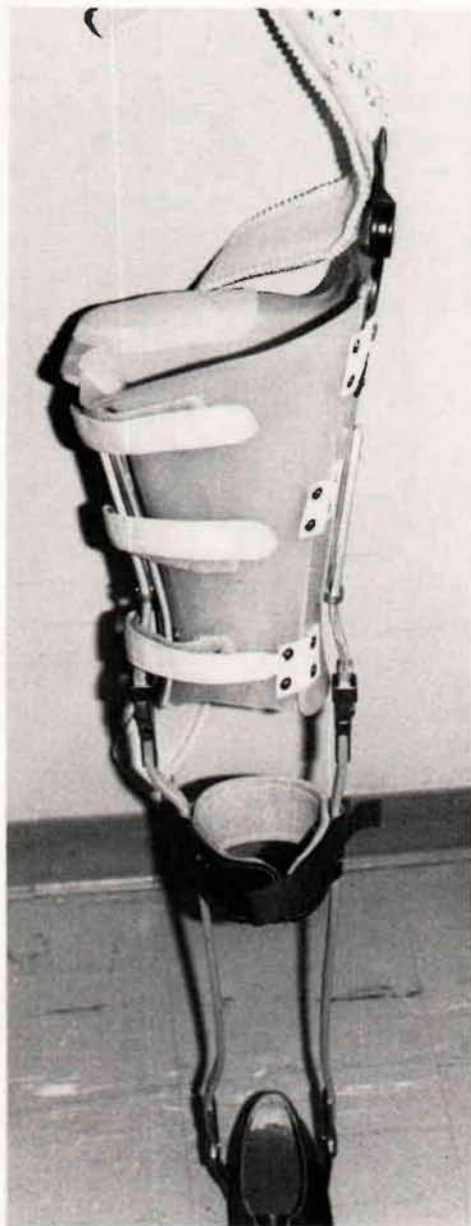


Fig. 3. Anterior view of the orthosis.



Fig. 4. Lateral view of the patient bearing weight in orthosis.

was placed high on the ilium to create a long lever arm from the hip joint axis.

Results

After two days of familiarizing herself with the orthosis, the patient was able to negotiate stairs in physical therapy with the aid of forearm crutches. She was discharged within a week after receiving her appliance.

The patient has used the orthosis for four months in carrying out normal daily activities which include driving an automobile and doing her own shopping. She wears a fracture cast sock on her limb for comfort. Virtually no adjustments to her orthosis have been necessary to date.

to insure a proper placement of the ischium on the seat. An above-knee extension adjustment was incorporated in the system.

The external prosthetic hip joint placement was not critical since there was no anatomical hip joint present. The pelvic band

The medical opinion for this patient is that no further reconstructive surgery be done as it is not necessary or possible. The infection is under control, and adequate pain relief has been achieved.

Considering the number of total hip surgeries currently being performed, it is logical to conclude that serious problems will develop from time to time.

The orthotic system described in this paper was successful, and it effectively prevented deformities of the limb frequently as-

sociated with hip reconstructive arthroplasty procedures. The orthosis provides a functional, stable, pain-free joint, and would be applicable to many postsurgical problems that do arise. This orthosis might also be applicable for stabilization of the limb following removal of a segment of the femur secondary to infection or carcinoma.

Footnotes

1 Clinical Orthotist, Orthomedics, Inc., North Hollywood, Ca.

2 Orthopedic Surgeon, Glendale, Ca.

THE DESIGN AND PRESCRIPTION OF ABOVE-KNEE ORTHOSES

E.G. Anderson, M.Sc., F.R.C.S.Ed.¹

J.T. Henshaw, Ph.D., M.Sc., F.R.Ae.S.,
C.Eng.²

Hugh Owen Thomas first described his caliper in 1899. It was designed by him, made by his smith, and finished by his saddler, using the materials of the day. It made no pretense at cosmesis, and being built for strength, was no lightweight structure. In more recent years, light alloy has been used in the fabrication of orthoses, but the basic design, with all its virtues, and vices, has remained unchanged. Just as the design has remained static, so the indications for prescription have remained uncertain and ill-defined. With the advent of plastics and other light-weight materials, with their cosmetic advantages, it has become important to define accurately the indications for the different kinds of above-knee orthoses, and to design each orthosis according to its particular function. Not to do so will result in the under- or over-bracing of patients, or the provision of overweight or understrength orthoses.

It is the purpose of this paper to discuss some of the factors involved in above-knee orthosis prescription and design, research into which has been carried out by the authors at Salford Royal Hospital and the University of Salford.

Technical Considerations

Above-knee orthoses at present available

as standard issue items, can be categorized simply:

1. "Total" weight-bearing orthosis—such as patten-ended ischial bearing orthosis. (It must be recognized however, that the weight referred to is that of the body; relief is not obtained from internally generated forces such as are produced by muscles.)

2. "Weight-relieving" ring or corset top orthosis. The proportion of load imparted to the ring or corset top will depend on the accuracy of the fitting, the structure of the ischial bearing area, and the length and stiffness of the orthosis. The axial load that this type of device is required to carry varies from body weight to some unknown partial figure, which is believed will give effective assistance to a weakened limb.

3. "Non-weight-bearing" or "knee-stabilizing" cuff top orthosis, designed primarily to stabilize the knee.

Load-bearing Orthoses

From the engineering viewpoint, the main force systems on a load-bearing orthosis, and a knee-stabilizing orthosis differ fundamentally. The axial loading on a load-bearing orthosis may reach 1.2 times body weight in the course of normal walking on the flat (Fig. 1). This loading is taken primar-

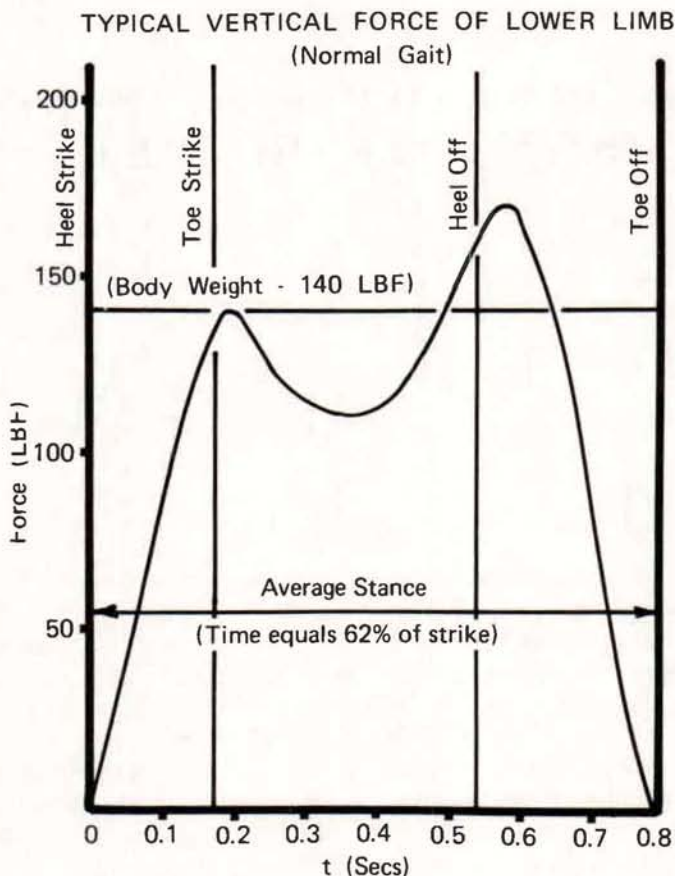


Fig. 1. The vertical load on a caliper.

ily by the pad supporting the ischial tuberosity, and passes from thence via the ring or corset, down the two sidemembers, to the ground (Fig. 2). Some loading may also result from the wedge fit of the thigh in a corset top.

Sidemembers are therefore required to act as struts; that is, members under compressive load. Because free length is critical in strut design, the free length should be as short as possible in order to achieve the required stiffness and thus prevent deformation under load. Stiffness can also be achieved by fitting a calf band to the orthosis structure (Fig. 3), although reliance is often placed (or rather, misplaced) entirely on the knee restraint in non-articulated designs.

A structure designed to be weight-bearing or weight relieving, should be able to carry the maximum expected load, increased by a suitable safety factor, to ensure that no failure under load occurs. The maximum expected load in normal level walking is known; what it becomes when the user hurries, corners sharply, or descends stairs, is not, but it will certainly be increased appreciably. Furthermore, the orthosis should be designed to be "fail-safe" to prevent injury to the user, in case of fatigue failure, for example by the provision of independent knee locks in each sidemember (5,6).

Rotational forces may be applied to the orthosis by the limb, depending on the gait pattern, and the activity of the patient at the

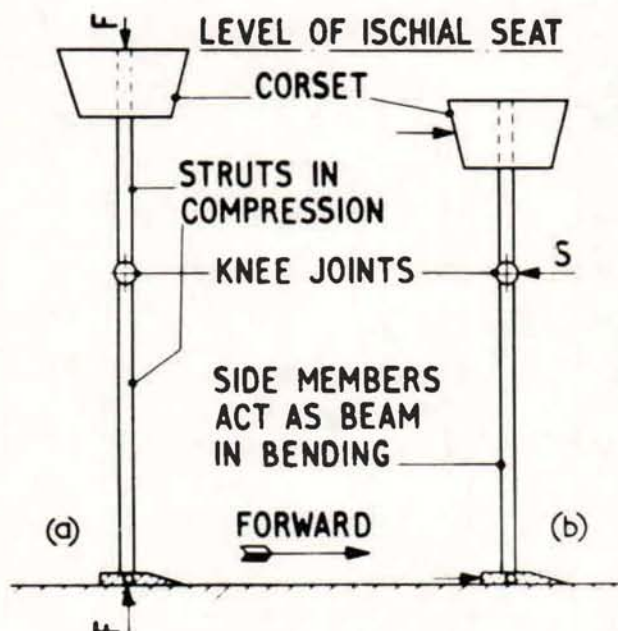


Fig. 2. Above-knee orthoses as engineering structures.

time. But such forces may also be imposed upon the limb by the orthosis; a sloping ischial seat will result in the ischial tuberosity sliding distally, which effectively causes the limb to be rotated internally on each heel strike. This is not an uncommon finding with load-bearing orthoses, and is easily overcome by providing a horizontal ischial seating, at least 10 cms. long, which allows the ischial tuberosity to find its own position (Fig. 4).

Knee-Stabilizing Orthoses

The structure of the knee-stabilizing orthosis has to withstand a force pattern different from the load-bearing types (Fig. 2b). The limb is prevented from deflecting at the knee joint, when under load, by simple three-point fixation (Fig. 5), which allows body weight to be supported by the skeleton. No force is required to maintain the knee in its fully extended "locked" position when static, but on movement, and with knees with fixed angular deformities, consid-

erable force may be required, increasing with increased flexion (Fig. 6). It then becomes important to consider the whole length of the orthosis; the longer the orthosis, the less the horizontal force applied by the cuff to the thigh, and presumably, the more comfortable the orthosis (Fig. 7).

In engineering terms, a structure which is required to stabilize only, should not be nearly so heavily loaded as a structure which is itself required to carry load. Axial loading can be imparted to a stabilizing orthosis by the vertical component of the knee restraint; more significantly, the longer the orthosis is, (i.e. the nearer the cuff top approaches the ischial tuberosity) the greater the axial bearing on the orthosis (2). This relationship is not linear, and must of course be a function of the fit of the orthosis, and the patient's activity.

A stabilizing orthosis can therefore be lighter and simpler in its construction than its load-bearing counterpart, but only if its length is such that it does not carry any sig-

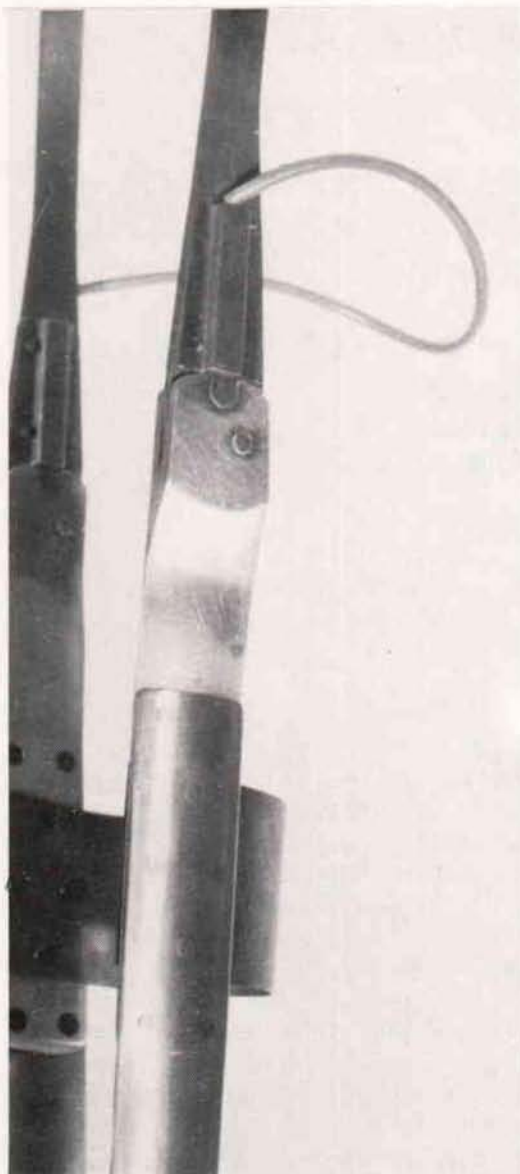


Fig. 3. A calf band.

nificant vertical load. By the same reasoning, a stabilizing orthosis cannot be expected to support the patient in the same way as a load-bearing orthosis would do, and to expect it to do so is put the patient at risk.

It will be apparent from the foregoing, that the two types of orthosis are very differ-

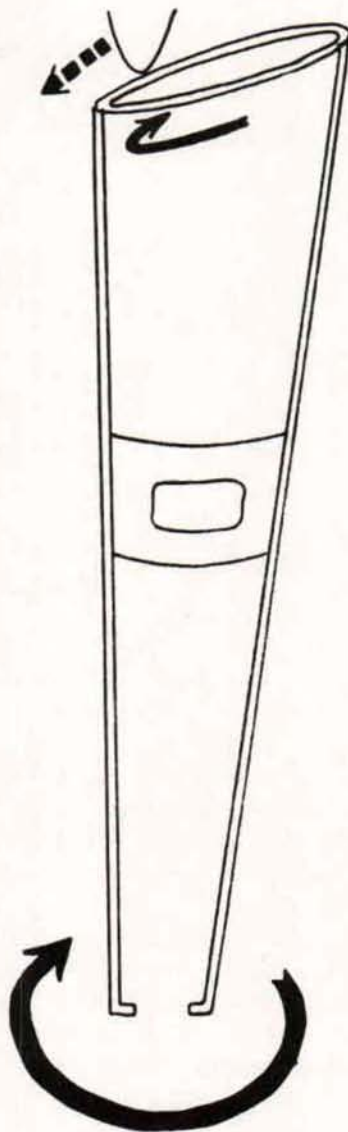


Fig. 4. The effect of weight-bearing on an oblique ischial seat.

ent in function and design. It must also be emphasized that whilst the latter will usually do the work of the former, the converse is not true.

With the introduction of knee-stabilizing orthoses with lighter structures of either metal or plastic, a design complication may arise

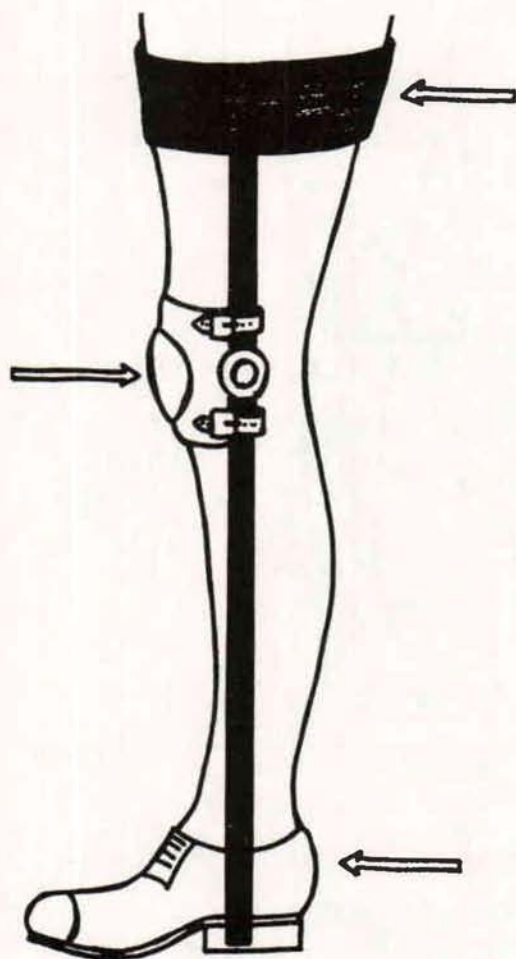


Fig. 5. Three-point fixation.

which could have undesirable effects on the patient. Under load, all structures will deflect in proportion to their stiffness. It follows that if a patient loads an orthosis which is not stiff enough for the purpose, the structure may deflect excessively. This can have two effects: 1) Because of the structural instability, the frame is likely to deflect either medially or laterally, depending on which way the orthosis is originally "set" (i.e. the angulation of the sidemembers required to accommodate the shape of the limb). This in turn will reduce the support which the structure would give to the knee joint, e.g. an or-

thosis structure set to accommodate a genu valgum will deflect medially allowing the knee to deflect with it (Fig. 8). The extent of this deflection in the coronal plane can be in excess of 3 cms. at the knee on an orthosis 80 cms. long when the effective length of the orthosis is reduced by only a few millimeters. 2) As the orthosis deforms, more weight will be imposed upon the limb, which is no longer effectively supported, and any angular deformity of the knee will only increase.

The technical options are, therefore, two. First, the provision of an orthosis designed to accept axial loading; second, the provision of a knee-stabilizing orthosis, which, being shorter, allows full weight-bearing on the limb, and which therefore can sacrifice some strength and stiffness for light weight and cosmesis.

Medical Considerations

There are many indications for above-knee bracing, but they can be conveniently classified according to the particular function(s) required of the orthosis.

1. The Whole Limb
 - a) Relief of stress
 - b) Correction/prevention of deformity
 - c) Protection
2. The Joints
 - a) Stabilization
 - b) Rest
 - c) Control of movement (direction, range, and rotation)

Put another way, an orthosis is asked to provide two basic functions: regulate angular movement; relieve axial loading. The former is more or less readily achieved by three-point fixation (Fig. 5), and the use of stops to limit the movement at articulations; the latter, conventionally, by the provision of an ischial bearing orthosis. What seems undetermined are the indications for, and the amount of weight to be relieved. There are accepted, clear indications for "total" weight-bearing as provided by a patten-ended orthosis, e.g. in Perthes' disease (although, even in this instance, opinion is di-

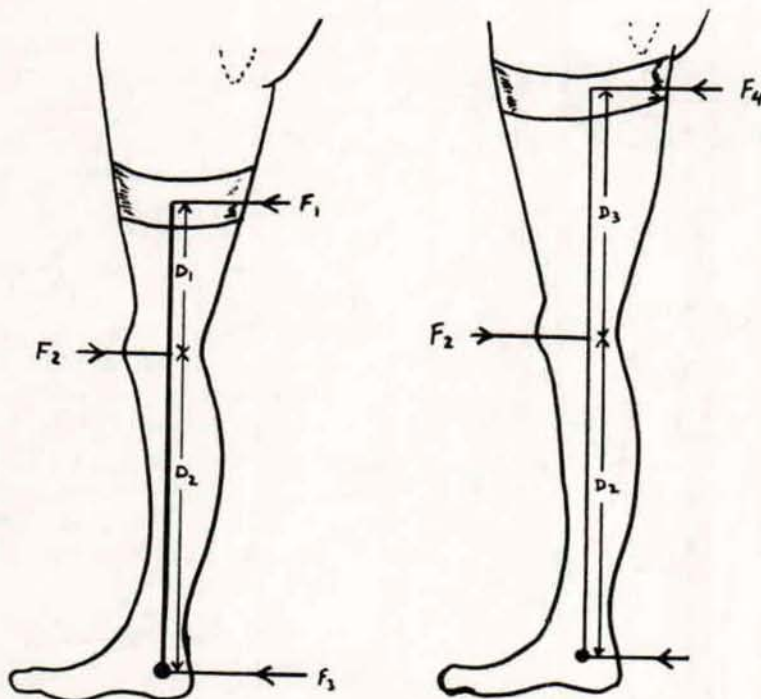


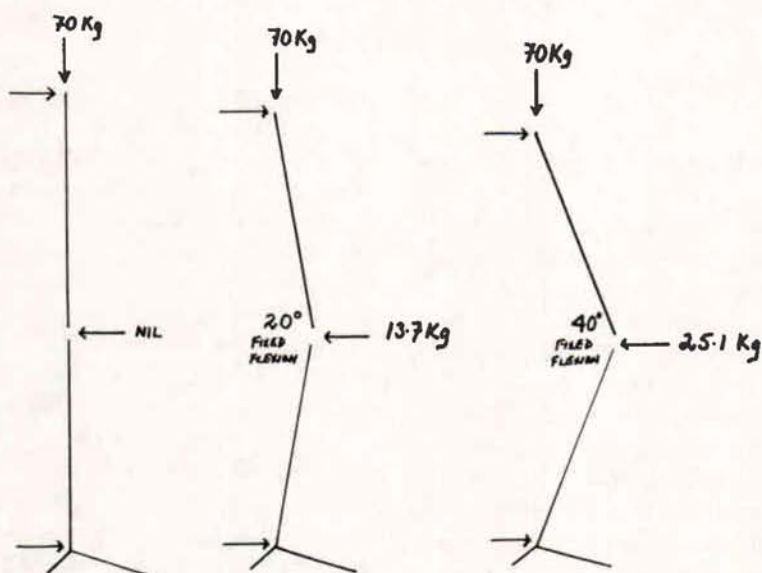
Fig. 6. Moments of a short and long knee-stabilizing orthosis.

vided over its value). There do not seem to be the clear indications for the provision of a weight-relieving orthosis, but the following

is suggested as a reasonable classification:

1. Discontinuity of, or inherent weakness in the bony structure of the lower limb; e.g.

Fig. 7. Effect of knee flexion on the force required for restraint.



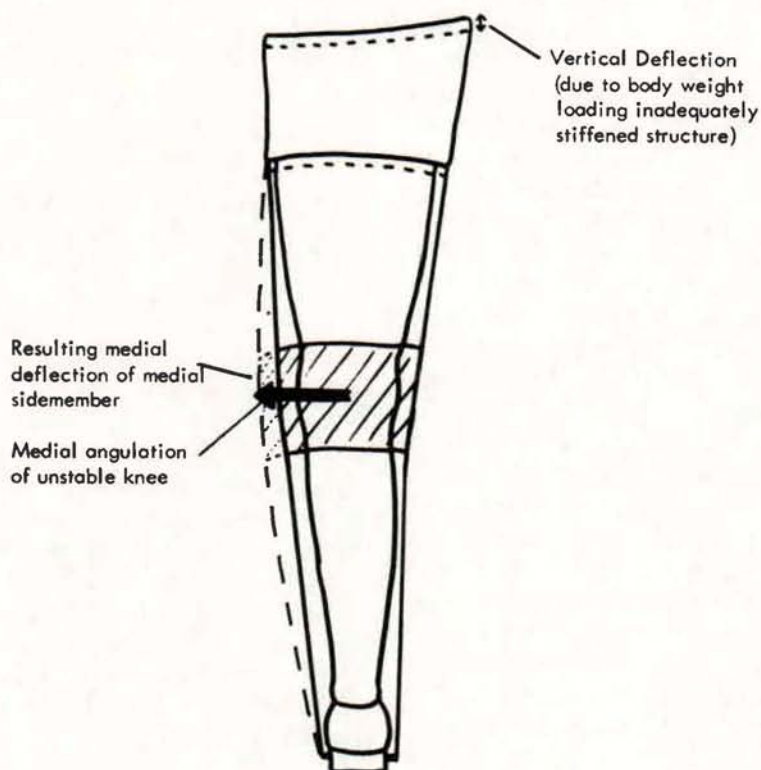


Fig. 8. Effects of loading an inadequately stiffened orthosis.

ununited fracture, unstable pseudarthrosis.

2. Gross knee instability, as for example, a "Charcot" knee.

3. Paralytic disease, e.g. poliomyelitis.

There can be little argument over the first group, the only question for discussion could be the degree of weight relief afforded, and how it can be achieved. Likewise with the second group; unless such a joint is relieved of axial load, the deformity will tend to increase, requiring much greater, even unacceptable forces to restrain it (Fig. 6). It is however in the paralytic situations that opinion is so uncertain. Sharrard (8) suggests that patients with unstable hips due to muscle paralysis can learn to stabilize their hips by trick movements, even with very weak hip muscles, and that in such cases, a weight-relieving orthosis is of considerable benefit.

We reviewed 36 patients who had had poliomyelitis, and whose residual deficits were apparent in only one lower limb, and an attempt was made to find some relationship between their physical deficits and the type of orthosis worn.

There was no relationship between the ability to walk unaided without orthosis, and the type of orthosis normally worn (Table 1).

TABLE 1

Patients Who:	Used A Weight- Relieving Orthosis	Used A Non- Weight-Relieving Orthosis
Can Walk Unaided Without An Orthosis	16	8
Cannot Walk Unaided Without An Orthosis	11	1

It was assumed that all weight-relieving orthoses prescribed were necessary, which was, *a priori*, an unacceptable assumption. More reasonable would appear the premise that those who could not walk unaided without an orthosis, were more likely to require a weight-relieving orthosis, and this appeared so. The solitary exception did not differ from the others in any significant clinical finding. Of those who could not walk unaided, all scored less than Grade 2 (M.R.C. Scale) for muscle power of the extensors of the hip, knee, and ankle; that is, they had no useful active extension in the affected limb. The converse was not valid. An undoubted contributory factor to the inability of those patients to walk unaided, but one which should have had no bearing on the question of weight-relieving, was that 8 of the 12 had fixed equinus deformities, and six had significant (1 cm) shortening of the affected limb. No other physical finding was constant in any particular group of patients. We concluded that there was no apparent relationship between the physical deficits of these patients and the types of orthoses that had been prescribed for them, and it is this fact which demanded that further investigation be made into the function of weight-relieving orthoses and the indications for their prescription.

Prescription Considerations

In the prescription of lower-limb orthoses, it is suggested that the following factors should be considered when deciding the type to be supplied, having first recognized which function will be required of it.

Body Weight of the Patient

It would appear self-evident that a 140 Kg. patient requires a stronger load-bearing orthosis than one of 70 Kg. weight assuming all other factors equal. Other factors are not usually equal however, and because of this,

the weight of the patient may be a very unreliable guide to the type and strength of orthosis required.

Joint Stability

The relationship of unstable joints to the orthosis is complex, and inextricably related to the need to get the center of gravity of the body over the area of support during the stance phase of gait. Nevertheless, some general observations may be made. Firstly, a mobile angular deformity of the knee can be well controlled by appropriate restraining straps. They can impose very significant forces on the orthoses, which are greatly increased when the deformity is fixed. Secondly, the hip extends almost 30 deg. before it is restrained by the ilio-femoral ligament, in the absence of active muscles; an ischial-bearing platform restricts this range by limiting the downward movement of the ischial tuberosity on extension, and therefore helps stabilize the hip.

Physical Exertion

One might reasonably assume that a person who indulges in considerable exertions, e.g. hill-walking, will subject his orthosis to more fatigue stresses than the young girl who sits in an office all day. Not so frequently considered (or encountered) is the man who carries bags of cement around on his back, and is surprised when his orthosis fails. It is not possible, of course, to take account of all such unusual or excessive forces, but the point must be made and considered. Even in everyday living, an orthosis is subjected to many "abnormal" forces—descending stairs, (particularly if taken two at a time), jumping off a moving bus, swerving on the pavement, not to mention the physiological effects of pregnancy.

Patient Fatigue

The effect of physical fatigue is rarely

given adequate consideration. One would expect a weak limb to tire more readily than the normal one of a pair, but the "normal" one, being subjected to more than a fair share of the work, may tire first, thus creating a vicious circle of increasing fatigue. Similarly, a fatigued limb could be expected to be more dependent on its orthosis, and if this is not of an adequate length, strength, or stiffness, it will not provide the necessary support, and it is in such circumstances that one must consider whether a knee stabilizing orthosis would be adequate for the job, or whether a weight-relieving orthosis might not be more opposite.

Age

It is known that paretic muscles lose more power more quickly than normal, with increasing age (1). Some patients who have never had to have a limb braced may find it inevitable as they grow older, and others find they require an increasing degree of support.

The Opposite Limb

The contralateral limb is often affected in the disease process, too. This inevitably has a bearing on the bracing requirements of the limb in question, generally resulting in a greater degree of support being required. Not unreasonably, one might expect the onset of fatigue, and the effects of aging to be enhanced, and this appears so.

Psychological Aspects

Account must be taken of the personality of the patient. In some cases, orthoses are an encumbrance to be tolerated, and in others, their link with normal activity. This is a very individual feature, which needs to be understood and considered in the initial prescription of an orthosis.

Conclusion

It is apparent that in order to prescribe a suitable orthosis for any given patient, much more information about the patient needs to be considered than is often the case. Furthermore, the effects of the patient on his orthosis have not been clearly understood either, although they are equally important, both for the welfare of the patient, and the satisfactory function of the orthosis. This particularly so when deciding between weight-relieving and knee-stabilizing orthoses. The latter are frequently made longer than necessary to make the orthosis more comfortable for the patient, but this subjects it to increasing axial load, which it was not designed to take, in most instances. We would suggest that when prescribing for these patients, if only a knee-stabilizing orthosis is required, the cuff top is situated no higher than mid-thigh; if there is any fixed angular deformity of the knee, or complete loss of extensor power in the limb, or if any of the factors considered above appear dominant, then a weight-relieving orthosis, designed to carry the axial load with a safety margin, is prescribed. Furthermore, an accurate fitting must be ensured, particularly in regard to the ischial seating, and to the orthosis length, which should be no less than the distance from the ischial tuberosity to the ground, as measured in the erect posture.

Summary

The force systems on above-knee orthoses are considered in relation to their functional requirements. The medical indications for different types of above-knee orthoses are discussed together with other relevant medical factors, and suggestions are made for suitable orthotics prescription.

Literature Cited

1. Anderson, A.D., Levine, S.A., Gellert, H., (1972) *Loss of ambulatory ability in patients with old anterior poliomyelitis*. Lancet, (ii), 1061—1063.

2. Anderson, E.G., (1974) *A study of the vertical loading forces in a long leg brace and its enclosed limb, and their application to brace prescription and design*. M.Sc. Thesis, University of Salford.
3. Bresler, B., and Frankel, J.P., (1950) *The forces and moments in the leg during level walking*. American Society of Mechanical Engineers Translation, 72, 27—36.
4. Harper, F.C., et al (1961) *The forces applied to the floor by the foot in walking on a level surface*. Department of Scientific and Industrial Research, Building Research Station. National Building Studies, Research Paper 32. London, Her Majesty's Stationery Office.
5. Henshaw, J.T., (1970 a) *Problems in the design of a cosmetic caliper*. Bulletin of Prosthetic Research, B.P.R. 10-14 Fall, 107—120.
6. Henshaw, J.T., (1970 b) *Design and development of the Salford Cosmetic Caliper*. Biomedical Engineering, 5(2), 60—64.
7. Henshaw, J.T., (1973) *The biomechanics of the Salford Cosmetic Caliper*. Proceedings of First International Congress on Prosthetic Techniques and Functional Rehabilitation. 2, 127—132.
8. Sharrard, W.J.W., (1971) in *Paediatric Orthopaedics and Fractures*, p 481 Oxford & Edinburgh, Blackwell.

Footnotes

- 1 Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, England.
- 2 Senior Lecturer in Engineering, University of Salford, Lancashire, England.

A HEAT GENERATING SOCKET

John Ficociello, C.P.¹

Thomas Trudell, C.O.¹

Albert Hebert, Pros. Tech.¹

A problem encountered often in northern climates is adaptation to cold environments. For amputees, this can be a severe problem because the laminated resin socket transmits heat readily from the residual limb to the cold environment.

In an attempt to improve the patient's tolerance to extended periods of outdoor activities, such as snowmobiling and skiing in extreme weather conditions, means of providing heat in addition to the heat generated by the body within the prosthesis was investigated and an auxilliary heating system was developed for a very active below-elbow amputee.

A number of solutions were considered and rejected before success was realized. The use of a commercially available heated foot sock proved to be inadequate because of the pressure of the wires on the residual limb as well as wrinkling of the sock inside the socket. Insulating the inner socket from the outer lamination with polyurethane foam, though functionally quite adequate, presented a cosmetic problem as a result of the increased size of the prosthesis.

The solution that seemed to be the optimum was the use of high resistance electrical wires within the laminated wall of the socket and an external source of electricity. This

system worked satisfactorily for a short period of time, but wires soon fractured at the point where they emerged from the socket, rendering the embedded wires unusable. After additional research, we now have what we feel is a practical and durable heat generating system.

We used the conventional procedures for casting, modifying the cast, and we used a check socket. After an accurate, positive mold was obtained, we began with a layup of one layer of Perlon stockinet.

To this initial layer, we spot-glued #25 gauge, non-coated wire (Fig. 1). The wire was initiated at the distal end of the mold and brought proximally, in a spiral fashion, care being taken not to cross the wire on itself. A #20 gauge, coated wire was then soldered to the #25 gauge wire at the distal end of the model and then brought directly proximally to a female plug receptacle at the trimline (Fig. 2). The proximal end of the #25 gauge, non-coated wire was also brought to the receptacle and both wires were soldered to it.

Because the proximal trim line of the socket was determined accurately at the time of the check socket fitting, we were able to spot glue and laminate the receptacle so that only

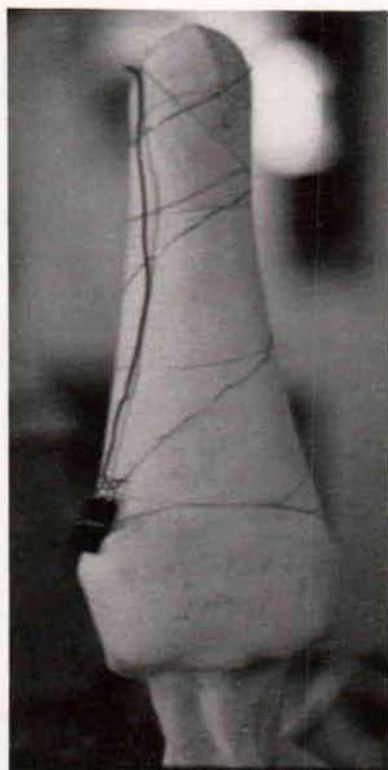


Fig. 1. A No. 25 gauge non-coated resistance wire is spot-glued to the initial layer of Perlon stockinet of the below-elbow socket. A No. 20 gauge coated resistance wire is soldered to the No. 25 gauge wire at the distal end of the model and brought proximally to a female electrical receptacle located at the trim line of the prosthesis socket to be fabricated.

the two plug holes were exposed at the proximal edge of the socket (Fig. 3).

The rest of the lay-up and lamination was carried out along conventional lines. Extreme care should be taken when breaking the mold out of the socket. Obviously when any part of the wire is damaged, the system will not function.

To the male plug, we soldered #16 gauge, coated wire (Fig. 4). The #16 gauge wire was then hooked to a six-volt dry cell battery, which our patient preferred for his purposes. For skiers, hunters, or anyone that does not

want the inconvenience of the six-volt dry cell, this system could easily be modified to utilize the power packs used to power myoelectric prostheses. Such a system permits location of the power source within the prosthesis or on the person.

This system, when followed correctly, supplies heat sufficient to warm the residual limb, but not enough to burn the amputee, or to affect the cured laminate. The amputee simply "plugs" in the prosthesis when the residual limb feels cold, and "unplugs" it when the residual limb is warm enough (Fig. 5). We feel that this system is not limited to upper-limb prostheses, but will be useful in lower-limb applications as well.

Footnotes

1 Roy's Orthopedic, Inc., 33 North Avenue, Burlington, Vermont, 05401.

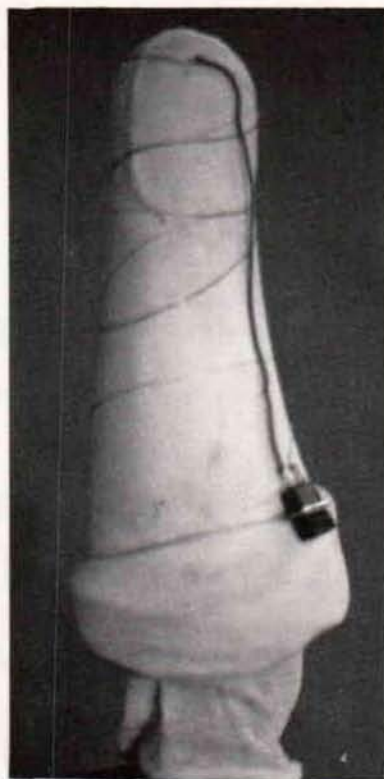


Fig. 2. Another view of the assembly shown in Figure 1.

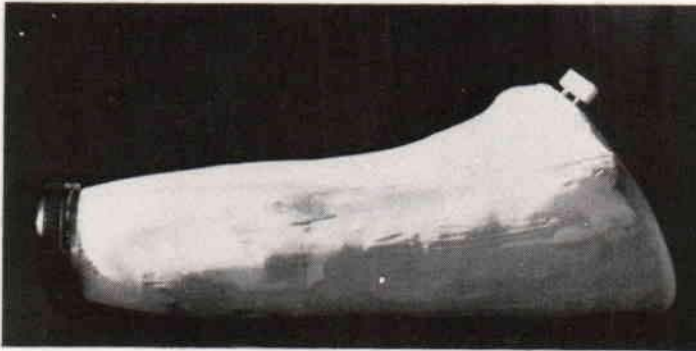


Fig. 3. The male electrical plug in this view taken during the fabrication process shows the position of the female receptacle at the trim line of the prosthesis socket.

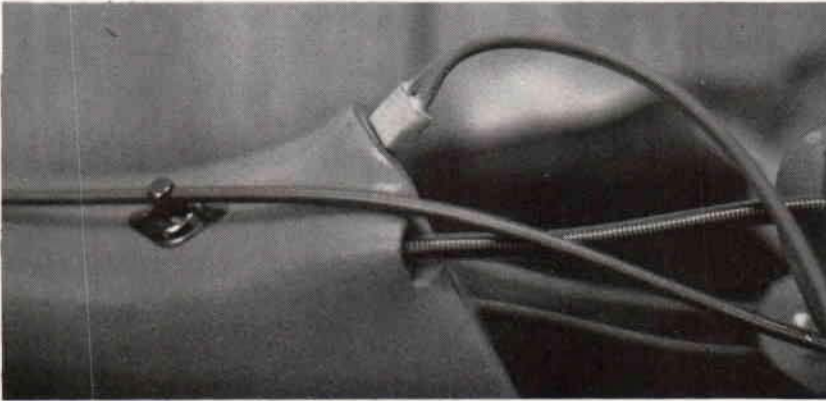


Fig. 4. Close-up view of electrical connection at the socket brim. This arrangement avoids breakage of wires that could be expected if the wires were simply brought out between the laminates.

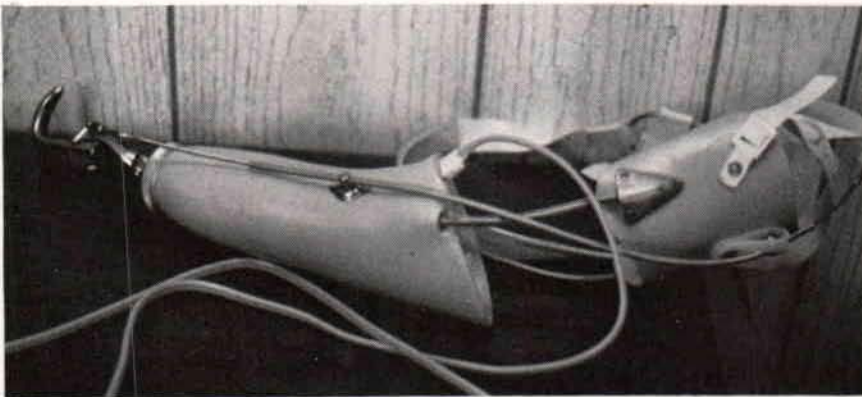
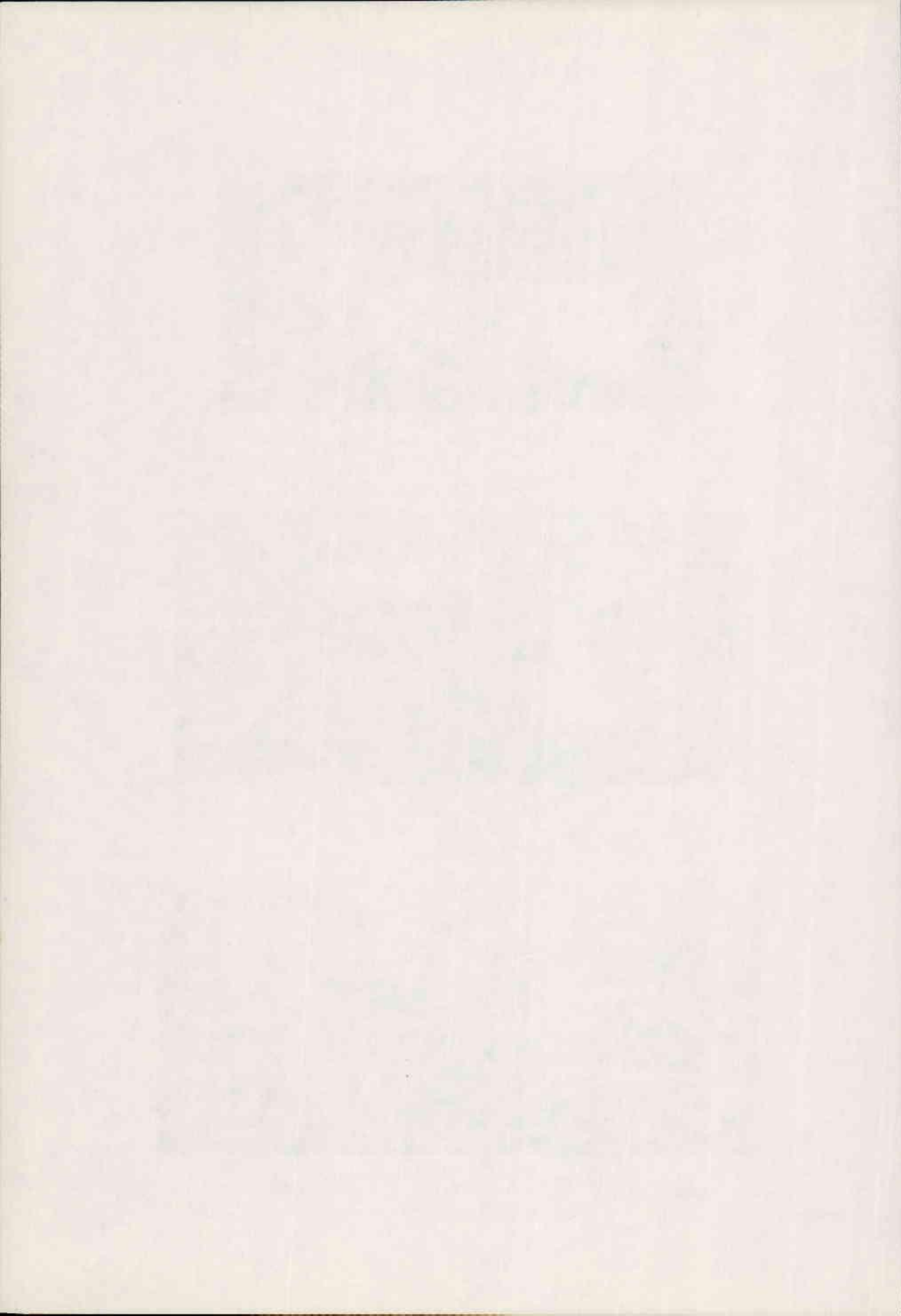


Fig. 5. The completed prosthesis with the power source plug in place.



SOME BIOMECHANICAL CONSIDERATIONS IN THE DESIGN OF ANKLE-FOOT ORTHOSES

David N. Condie¹

C. B. Meadows²

The proliferation of new designs for ankle-foot orthoses fabricated with thermoplastic materials presents a bewildering picture for the clinician faced with the prescribing of a particular device for an individual patient. Indeed, the orthotics specialist with his special knowledge may require to adopt a trial and error policy extending over a considerable number of patients before the advantages of the various designs become apparent and a practical prescription philosophy can be formulated.

Two important factors that appear to govern the success or failure of a fitting with a particular device are the accuracy with which the patient's requirements have been assessed and the ability of the device to fulfill these requirements. A successful orthotic prescription may thus be considered as a process of patient-orthosis matching involving measurement of the patient's functional deficit and selection of an orthosis whose characteristics, also determined by measurement, are such as to reduce the patient's deficit to the minimum.

Characteristics of the Jointed Orthoses

It is possible to illustrate the meaning of the term "characteristic" of the device by reference to the conventionally constructed

ankle-foot orthosis (AFO) fitted with a fulcrum lever and toe-raising spring.

The effect of the spring is such that as the foot is pushed into an attitude of plantar-flexion the spring will tend to create an opposing dorsiflexing effect or "moment," which will increase as the deflection of the foot is increased. This characteristic of the orthosis may be measured accurately and recorded in the form of a graph, and in this case will result in an approximately straight line (Fig. 1). The stronger the spring stiffness, the greater will be the moment it develops for a particular deflection and hence the steeper will be the slope of the line on the graph. Thus the orthosis with a free joint has a characteristic of zero slope as illustrated by the horizontal line on the graph and a joint which is locked has as a characteristic an infinite slope as illustrated by the vertical line.

Obviously it is possible to apply this system to define the behavior of an orthosis in other planes of deflection such as inversion or eversion, and, as in the case under examination, this would result in a straight vertical line since the conventionally constructed AFO may be considered to be virtually rigid in this plane when subjected to the loads encountered in walking.

BELOW KNEE DOUBLE IRONS

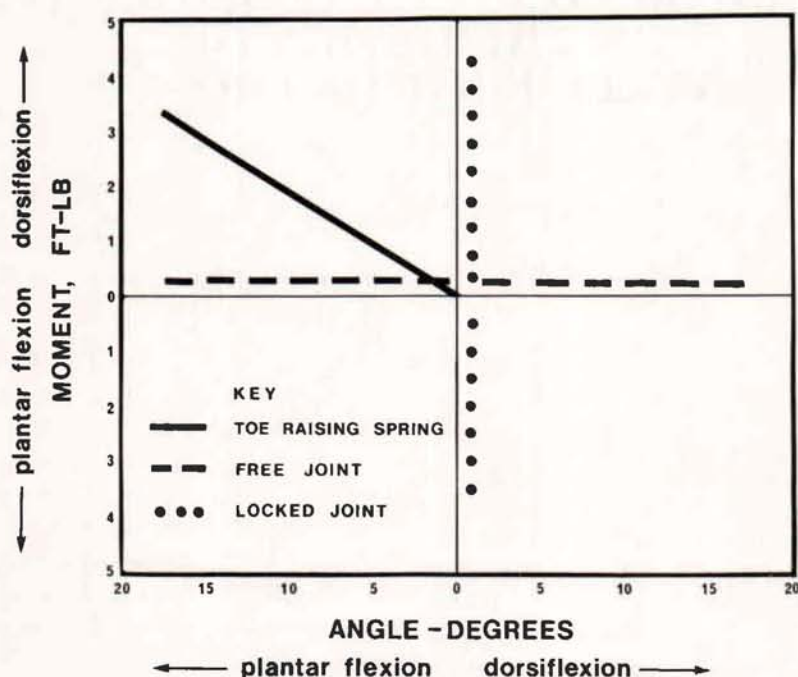


Fig. 1. Plot of moment about the ankle vs. ankle flexion for three types of ankle-foot orthoses.

Characteristics of Thermoformed Orthoses

Clearly, it is relatively simple to predict the characteristics of conventional orthoses with their readily identifiable joints and controls. The plastic AFO's however which have no discrete joints are not so readily open to predictions regarding their behavior.

Because of this difficulty equipment has been developed at the Dundee Limb Fitting Centre to measure the characteristics of an orthosis (Fig. 2). The AFO is clamped in the machine at the cuff and foot piece and deflected throughout its normal range of motion. The stiffness/deflection characteristic developed in this fashion is plotted directly on a graph plotter. It is thus possible to compare the characteristics of differing types of orthoses (Fig. 3), and to examine also the al-

tered behavior of an individual orthosis achieved by varying its trimline (Fig. 4).

The Teufel AFO

The first design of an AFO fabricated from a thermoplastic material to achieve significant acceptance was the Teufel posterior leaf-spring orthosis (4) made of Ortholen, a high density polyethylene. The Teufel orthosis was described as being appropriate for "flaccid conditions of the foot."

The Hartshill AFO

In 1968, Yates (5) published his description of the use of polypropylene in the construction of ankle-foot orthoses. The method of construction adopted required no cast rectification and resulted in a rather rigid de-

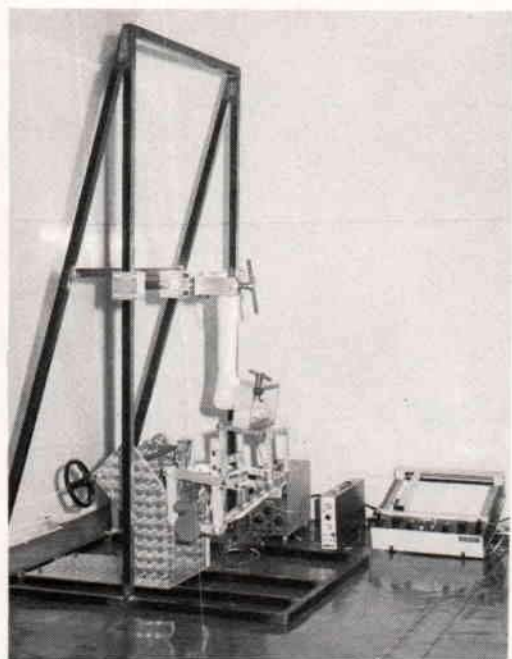


Fig. 2. AFO machine for measuring properties of ankle-foot orthoses.

vice extending forward to the medial malleoli. At fitting, the orthosis was normally flexed vigorously into extreme dorsiflexion to reduce significantly the resistance which the device would afford to movement in that direction while retaining the high resistance to plantarflexion inherent in the geometry of the device. In the United Kingdom this device is customarily referred to as a "Hartshill" AFO. According to the developer, this orthosis is intended for use primarily in cases of flaccid "drop foot" or where there is minimal spastic muscle behavior.

The TIRR AFO

The potential of this new material was recognized immediately by many other developers, notably in North America, and further variations emerged, one of the best known of which was the polypropylene AFO with corrugations, developed at the Texas Institute for Rehabilitation and Research (1). The developers of this device sug-

gested that it was indicated for "a lack of dorsiflexion."

Prescription

Thus it seems at least three different new AFO's are available which appear to be appropriate for the same group of patients. These claims will now be investigated by examining the "characteristic" of the orthoses.

Simple Drop Foot

If the patient's disability may be truly described as a drop foot, that is to say, isolated weakness of the dorsiflexor muscles, the requirements of the matching orthosis should be rather simply specified. Firstly, the orthosis should replace the action of the dorsiflexors following heel contact, thus avoiding a foot slap, and secondly, by raising the foot at toe-off to ensure foot clearance during the swing phase. For this comparatively simple requirement there appears to be no doubt that the TIRR and the Ortholen devices with their comparatively low plantar/dorsiflexion stiffness characteristics are a much more appropriate prescription than the more rigid Hartshill device. Similarly, both of these alternative devices provide the least unnecessary resistance to the movements controlled by the unaffected musculature of the ankle.

Drop Foot With Other Weaknesses

The choice of an ankle-foot orthosis becomes more complex when one considers cases of more generalized ankle-foot functional deficit including weakness of the muscles controlling plantarflexion and the movements at the subtalar joint. A further important consideration will be the presence of spasticity in the affected musculature.

In 1972 Lehneis (2, 3) presented his design of a spiral brace fabricated in Plexidur which was intended for use with these kinds of patients. Regretably experience with this device has been marred by repeated fracture problems and many prescribers have been forced to consider alternative solutions. The policy adopted at the Dundee Limb Fitting

COMPARISON OF PLANTAR/DORSIFLEXION CHARACTERISTICS

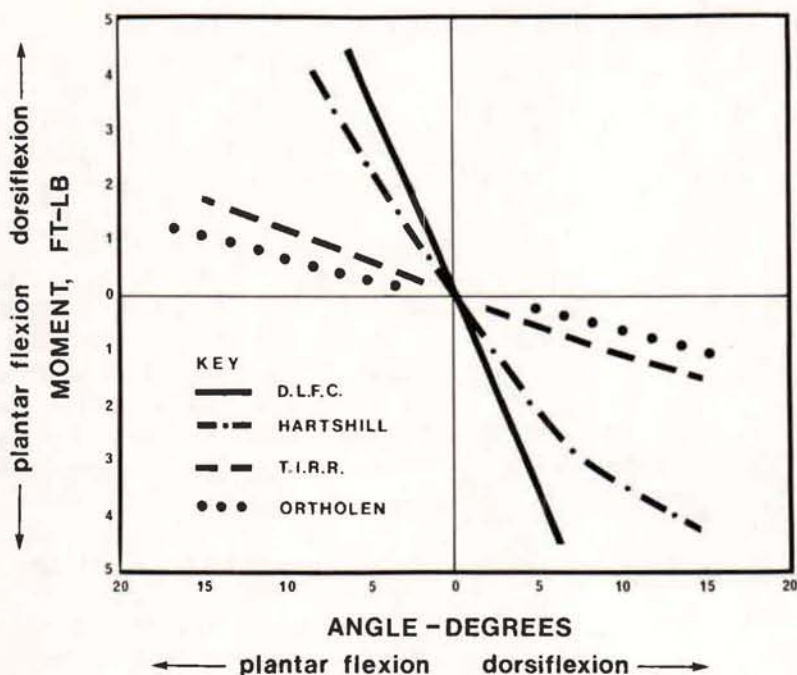


Fig. 3. Plot of moment about the ankle vs. ankle flexion for four types of plastic ankle-foot orthoses.

Centre has been to adapt the basic Hartshill design of AFO to produce an orthosis capable of providing the greater degree of control required for this group of patients. This effect is achieved principally by selecting a trimline which leaves slightly more material around the ankle joint (Fig. 5).

The increase in the stiffness characteristics which are achieved by this simple measure may be demonstrated easily by reference to the graph lines obtained from the testing equipment, which show an increased slope. An example, in this case the plantar/dorsiflexion characteristic, is illustrated in Figure 3.

Foot Length Discrepancy

Complicating disabilities such as limb or foot length discrepancy may be treated si-

multaneously by adopting a particular foot attitude and using a plastic foam build-up on the sole piece. Similarly, a foam plastic calf restoration may be built into the shank section of the orthosis for cosmetic reasons (Fig. 6).

More Severe Cases

There are however some patients for whom the orthotic prescriptions already considered would appear to be still inadequate. These patients may be considered in two categories: those patients where more severe spasticity will require larger forces to achieve full correction; and those patients where the joint deformities are not fully correctable and may indeed become increased when the patient attempts to bear weight upon the foot.

TYPICAL PLASTIC AFO showing effect of trimming

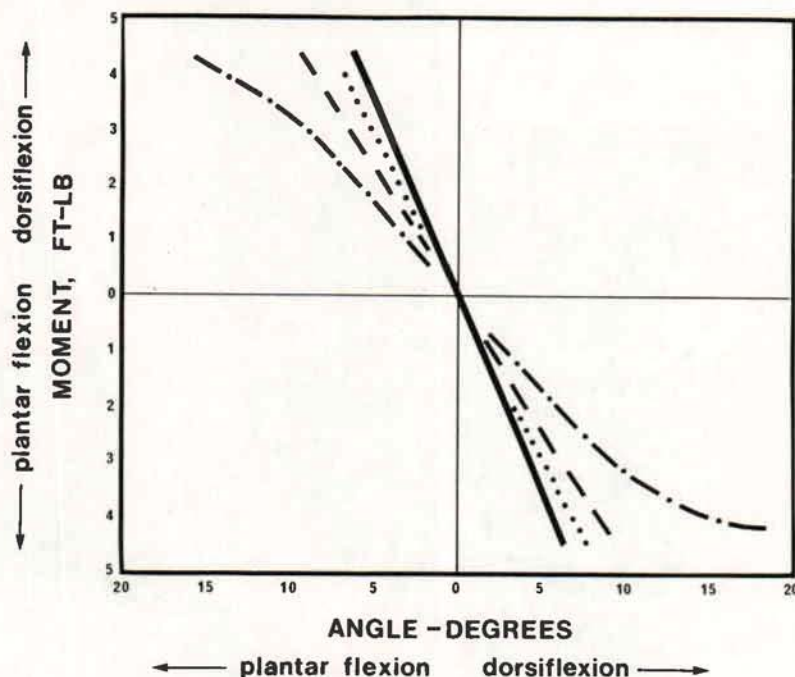


Fig. 4. Plot of knee moment of a plastic orthosis vs. ankle flexion for various trim-line configurations.

Severe Spasticity

Severe spasticity is commonly encountered with the more severely involved hemiplegic patient. Experience has demonstrated to us that even the modified polypropylene ankle-foot orthosis is unable to control adequately the typical equino-varus deformity.

A careful study of this problem suggested that a further increase in the stiffness of the device would be unlikely to improve its effect upon the patient unless the fit were modified to apply the corrective forces in a much more specific manner than is customarily achieved by standard casting and fabrication procedures.

It was this consideration in mind that the hemispiral orthosis was developed at the New York University Institute for Re-

habilitation Medicine (3). This orthosis, made also from Plexidur, is designed to impose a three point system of corrective forces upon the patient's leg and foot to control an equino-varus deformity, and, when correctly fitted, can be very effective. It does unfortunately have several disadvantages. It is difficult and time-consuming to produce and therefore relatively expensive. It can also be awkward for the patient to apply, especially when many of the potential patients have the effective use of only one hand. Consequently, in Dundee it was decided to attempt to produce a further modification of the polypropylene AFO which would utilize a similar three-point force system to control this type of deformity.

The extent of the correction which can be achieved is assessed by manually applying



Fig. 5. Polypropylene, Ankle-Foot Orthosis as used at the Dundee Fitting Centre.



Fig. 6. Polypropylene AFO with compensations for length discrepancy and calf restoration.

the necessary three-point force system. Obviously, where fixed deformity exists, this position may be short of plantigrade. Additionally in cases of severe muscle spasm the force required to maintain a fully corrected position may not be tolerable.

The wrap cast is taken in the usual manner in the position thus determined and the required force system applied by hand as the cast sets. The orthosis is formed on the resulting positive cast which may have been further rectified to achieve the desired pressure distribution (Figs. 7 & 8).

In those cases where the final attitude is not plantigrade the sole of the orthosis is wedged with high density foam plastic to ensure correct shoe contact with the ground.

This modified AFO is only marginally



Fig. 7. Three-point-pressure polypropylene AFO.

more difficult for the patient to don than the standard polypropylene AFO, and the production techniques are only a little more demanding.

Joint Deformity

The three-point pressure technique may also be adopted "in reverse" to treat those patients with uncorrectable valgus deformities of the foot which are otherwise difficult to control, and cases of this type successfully treated include both children with spina bifida and cerebral palsy. In these cases an identical production technique is adopted

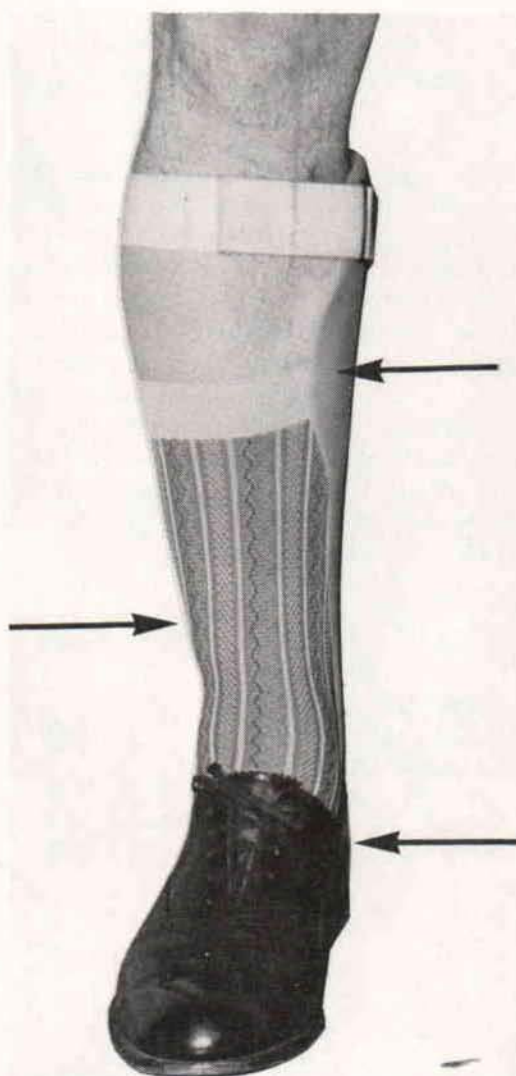


Fig. 8. Three-point-pressure system to control a varus deformity.

with the pressure points positioned to achieve the required control.

Conclusion

The range of modern thermoplastic AFO's exhibit a wide spectrum of functional characteristics. In spite of the apparent simplicity of the orthoses, the factors governing their functional characteristics are exceedingly complex. A deeper understanding of

the means of obtaining specific characteristics will permit more accurate matching to the patient's requirements.

Summary

This paper presents a biomechanical approach to development of prescription criteria for ankle-foot orthoses based on a system of measuring the "characteristics" of an orthosis. The result of applying this system to the existing range of AFO's of both conventional and molded plastic construction are described with the consequent prescription practices. Finally, some further development is described in the use of the molded polypropylene AFO to control severely deforming varus/valgus conditions of the ankle-foot complex.

Literature Cited

- 1 Engen, Thorkild J., *The TIRR polypropylene orthosis*, Orth. and Pros. 26:4, Dec. 1972.
- 2 Lehneis, H. R., W. Frisina, H. W. Marx, and G. H. Goldfinger, *Plastic spiral below-knee orthosis*, Institute of Rehabilitation Medicine, New York University Medical Center, Jan. 1972.
- 3 Lehneis, Hans Richard, *Plastic spiral ankle-foot orthoses*, Orth. and Pros. 28:2, June 1974.
- 4 Rubin, Gustav, Domenick Bonarrigo, Michael Danisi, and Malcolm Dixon, *The shoe as a component of the orthosis*, Orth. and Pros., 30:2, June 1976.
- 5 Yates, Gordon, *A method for the provision of lightweight aesthetic orthopaedic appliances*, Orthopaedics: Oxford, 1:2:153-162, 1968.

Footnotes

- 1 Senior Bioengineer, Dundee Limb Fitting Centre, 133 Queen St., Broughty Ferry, Dundee, Scotland.
- 2 Bioengineer, Dundee Limb Fitting Centre, 133 Queen St., Broughty Ferry, Dundee, Scotland.

INFORMATION FOR AUTHORS
ORTHOTICS AND PROSTHETICS
INVITES THE SUBMISSION OF ALL ARTICLES AND MANUSCRIPTS
WHICH CONTRIBUTE TO ORTHOTIC AND
PROSTHETIC PRACTICE, RESEARCH, AND
EDUCATION

All submitted manuscripts should include:

1. THE ORIGINAL MANUSCRIPT AND TWO COPIES. If possible, the duplicate manuscripts should be complete with illustrations to facilitate review and approval.
 2. BIBLIOGRAPHY. This should be arranged alphabetically and cover only references made in the body of the text.
 3. LEGENDS. List all illustration legends in order, and number to agree with illustrations.
 4. ILLUSTRATIONS. Provide any or all of the following:
 - a. Black and white glossy prints
 - b. Original drawings or charts
- Do not submit:
- a. Slides (colored or black & white)
 - b. Photocopies

PREPARATION OF MANUSCRIPT

1. Manuscripts must be TYPEWRITTEN, DOUBLE-SPACED and have WIDE MARGINS.
2. Indicate FOOTNOTES by means of standard symbols (*).
3. Indicate BIBLIOGRAPHICAL REFERENCES by means of Arabic numerals in parentheses (6).
4. Write out numbers less than ten.
5. Do not number subheadings.
6. Use the word "Figure" abbreviated to indicate references to illustrations in the text (. . . as shown in Fig. 14)

PREPARATION OF ILLUSTRATIONS

1. Number all illustrations.
2. On the back indicate the top of each photo or chart.
3. Write the author's name on the back of each illustration.
4. Do not mount prints except with rubber cement.
5. Use care with paper clips; indentations can create marks.
6. Do not write on prints; indicate number, letters, or captions on an overlay.
7. If the illustration has been published previously, provide a credit line and indicate reprint permission granted.

NOTES:

- Manuscripts are accepted for exclusive publication in ORTHOTICS AND PROSTHETICS.
- Articles and illustrations accepted for publication become the property of ORTHOTICS AND PROSTHETICS.
- Rejected manuscripts will be returned within 60 days.
- Publication of articles does not constitute endorsement of opinions and techniques.
- All materials published are copyrighted by the American Orthotic and Prosthetic Association.
- Permission to reprint is usually granted provided that appropriate credits are given.
- Authors will be supplied with 25 reprints.

RESOLUTION CONCERNING THE METRIC SYSTEM

The following resolution was adopted by the Board of Directors of the American Orthotic and Prosthetic Association at its meeting in San Diego October 3, 1973:

WHEREAS by Act of Congress it has been determined that the United States should proceed towards adoption of the metric system as used almost universally throughout the rest of the world, and

WHEREAS the technological professions and many segments of the health professions have commonly used the metric system over an extended period of time, and

WHEREAS it is important for members of the orthotic/prosthetic professions to interact with their colleagues in the medical and technological communities for optimum patient service be it hereby

RESOLVED that the American Orthotic and Prosthetic Association endorses the use of the metric system by its members and other orthotic and prosthetic practitioners in the United States, and in witness of this endorsement and Association urges the editors of its journal *Orthotics and Prosthetics* to commence the dual reporting of weights and measurements in both the English and metric systems at the earliest possible date with the objective of employing the metric system solely by the time of the 29th Volume in 1975.



Camp helps you fit the hard-to-fit patient.

**Custom make spinal orthoses
in minutes with MOD-U-SYSTEM.**

No matter how many spinal orthoses you stock, you never have enough. Because there are always some patients you just can't fit. Instead of a special order, custom make the orthosis yourself, with MOD-U-SYSTEM. MOD-U-SYSTEM includes all the components you need to assemble the nine most often prescribed Taylor and Knight-Type orthoses. So you can use your professional skills to fit even the hard-to-fit patient. And with a lot less inventory. Send for the details on MOD-U-SYSTEM.

CAMP

CAMP INTERNATIONAL, INC.

Please send me the details on MOD-U-SYSTEM.

Name _____

Address _____

City _____

State _____

Zip _____

Nothing's built like Camp

What Camp innovates, others imitate. Camp has been perfecting orthotic supports for over 65 years. Our standard of design, materials and workmanship is unparalleled.

Here are the nine different spinal orthoses that can be tailor-made from the MOD-U-SYSTEM. Each can be made into a wide variety of sizes quickly, easily and exactly for greater patient comfort.

1. Knight-Taylor Apron Front
2. Knight-Taylor Garment Front
3. Knight-Taylor Apron Front (no side uprights)
4. Knight-Taylor Garment Front (no side uprights)
5. Knight Apron Front
6. Knight Garment Front
7. Knight Apron Front (no side uprights)
8. Taylor Apron Front
9. Taylor Garment Front



1.



2.



3.



4.



5.



6.



7.



8.



9.

No
Postage Stamp
Necessary
If Mailed In The
United States

BUSINESS REPLY MAIL
First Class Permit No. 166, Jackson, Mich.

Postage will be paid by:

CAMP INTERNATIONAL, INC.
Jackson, Michigan 49204

CAMP
TRADE MARK

Affiliates and Licensees:

Basko-Camp, Amsterdam, Netherlands
S. H. Camp & Company Limited, Andover, England
S. H. Camp & Co. of Canada Ltd., Trenton, Ont., Canada
Camp Scandinavia AB, Helsingborg, Sweden
Corset Scherer AG, Littau-Lucerne, Switzerland
Iran Ortho Co., Tehran, Iran
Prim SA, Madrid, Spain
Warrior Surgical Supply Co., Warrior, Ala., USA

STRESS (OR PRESSURE)

To convert from	To	Multiply by
pounds-force/square inch (psi)	newton/square meter	6894.8
pounds-force/square inch (psi)	newton/square centimeter	0.68948
pounds-force/square inch (psi)	kilogram-force/square centimeter	0.070307

TORQUE (OR MOMENT)

To convert from	To	Multiply by
pound-force-feet	newton meter	1.3559
pound-force-feet	kilogram-force meters	0.13826

ENERGY (OR WORK)

Definition

One joule (J) is the work done by a one-newton force moving through a displacement of one meter in the direction of the force.

$$1 \text{ cal (gm)} = 4.1840 \text{ joules}$$

To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	$1 \times 10^{-7} \dagger$
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

To convert °F to °C	$^{\circ}\text{C} = \frac{^{\circ}\text{F} - 32}{1.8}$
°F	°C
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

*A slug is a unit of mass which if acted on by a force of one pound will have an acceleration of one foot per second per second.

METRIC SYSTEM Conversion Factors

LENGTH

Equivalencies

angstrom	= 1×10^{-10} meter (0.0 000 000 001 m)
millimicron*	= 1×10^{-9} meter (0.000 000 001 m)
micron (micrometer)	= 1×10^{-6} meter (0.000 001 m)

To Convert from	To	Multiply by
inches	meters	0.0254 [†]
feet	meters	0.30480 [†]
yards	meters	0.91440 [†]
miles	kilometers	1.6093

AREA

To convert from

square inches	square meters	0.00063616 [†]
square feet	square meters	.092903

VOLUME

Definition

1 liter = 0.001[†] cubic meter or one cubic decimeter (dm³)
(1 milliliter = 1[†] cubic centimeter)

To convert from	To	Multiply by
cubic inches	cubic centimeters	16.387
ounces (U.S. fluid)	cubic centimeters	29.574
ounces (Brit. fluid)	cubic centimeters	28.413
pints (U.S. fluid)	cubic centimeters	473.18
pints (Brit. fluid)	cubic centimeters	568.26
cubic feet	cubic meters	0.028317

MASS

To convert from

pounds (avdp.)	kilograms	0.45359
slugs*	kilograms	14.594

FORCE

To convert from

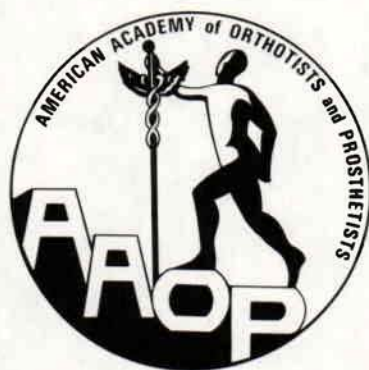
ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).

[†]For practical purposes all subsequent digits are zeros.

1978

ROUND-UP SEMINAR



**HYATT HOUSE
ORLANDO, FLORIDA**

January 19-21, 1978

Fracture bracing



lets your patients function while they heal.

Encourages mobility and functioning of the extremity during the healing process—Adjacent joints remain mobile, reducing the need for post-fracture physical therapy—eases the economic burden for the patient by permitting faster resumption of full activities.

ORTHOPLAST® Splints: the ideal material for fracture bracing—Lightweight, strong and durable, the ORTHOPLAST material is an easy-to-mold thermoplastic that can be worked with bare hands, is strong, conformable, self-adherent and washable, and has established its clinical benefits in tibial, femoral, Colles' and forearm fractures.¹⁻⁵

References: 1. Sarmiento, A.: Functional below-the-knee brace for tibial fractures, J. Bone Joint Surg. 52-A:295, 1970. 2. Sarmiento, A.: Functional bracing of tibial and femoral shaft fractures, Clin. Orthop. 82:2, 1972. 3. Sarmiento, A., Cooper, J., and Sinclair, W.F.: Forearm fractures, J. Bone Joint Surg. 57-A:297, 1975. 4. Sarmiento, A., et al.: Colles' fractures, J. Bone Joint Surg. 57-A:311, 1975. 5. Sarmiento, A.: Functional bracing of tibial fractures, Clin. Orthop. 105:202, 1974.

ORTHOPLAST® To immobilize the fracture, not the patient SPLINTS

Please send more information on functional bracing with ORTHOPLAST® Splints.

Name _____ Title _____

Hospital _____

Address _____

City _____ State _____ Zip _____

D

Educational literature, reprints, brace patterns and samples may be obtained by writing to Johnson & Johnson, Department J-408, New Brunswick, New Jersey 08903.

Johnson & Johnson

© Johnson & Johnson 1976

David Nairne counted on us.

When David had open heart surgery not long ago, he needed six vital units of blood, type O Neg. All of it was obtained, processed and provided by the Red Cross blood center.

We're not the heroes of this lifesaving story (the six wonderful blood donors should get the medals). But we (and other voluntary blood centers) do need your continued support. Blood, you know, doesn't grow on trees. It comes from donors. Like you. And we need more people like you. Call your Red Cross or other voluntary blood center soon. Please.



**We're
counting
on
you.**

Red Cross.

The Good Neighbor.

AMERICAN RED CROSS CAMPAIGN

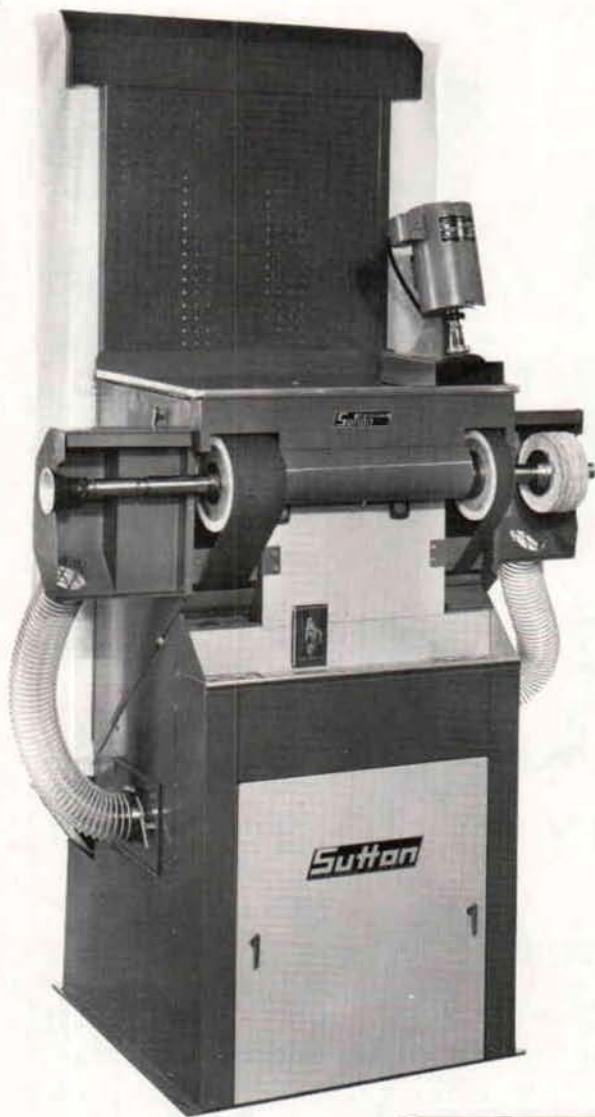
MAGAZINE AD NO. ARC - 2662 - 77 - 7" x 10" [110 Screen]

Volunteer Agency: J. Walter Thompson Company, Volunteer Coordinator: G. F. Tyrrell, Johnson & Johnson

B-69

Sutton's S/J-2-O

ORTHOPEDIC FINISHING MACHINE



This high-speed sander has been developed especially for the limb and brace manufacturing industry. Two sanding belts, each 60" long, cut quickly and run cool. One is 4" wide, the other is 1-9/16". Shaft extends 8" on left for cone-shaped cutter or other bayonet fittings. Right shaft end machined to accept burnishing and polishing wheels. All dust-generating areas are exhausted by 1½-h.p. motor with air release through five 60" bags. Naumkeag also has vacuum hookup. Flap emery wheel available for metal polishing. Many variations of shaft available. Only 51" high, 31" wide, 27" deep. Sutton offers many variations of shaft configurations to fit varying needs of brace specialists. Sutton-Adler Division also produces a complete line of industrial sewing machines and stands for leather, fabric and plastic sewing.

**SEND
COUPON
TODAY!**



Sutton Shoe Machinery Co.
P. O. BOX 9940 • ST. LOUIS, MO. 63122 • (314) 225-5255

- ☐ Send information on Sutton's S/J-2-O
- ☐ Send information on Sutton-Adler sewing machines
- ☐ Send complete Sutton catalog

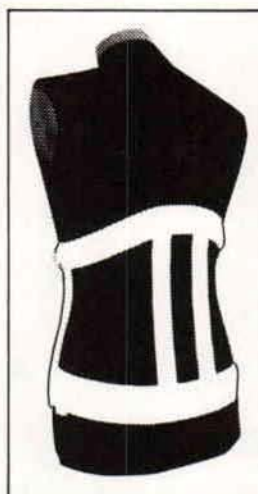
Name _____
Firm _____
Address _____
City _____ State _____ Zip _____
Telephone _____



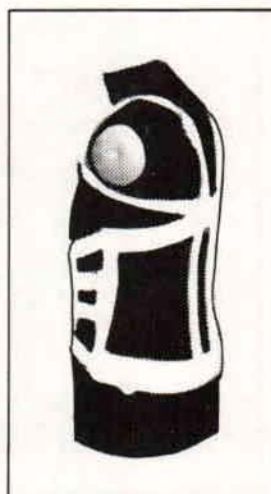
2-S2000
Taylor



2-S2400
Williams Flexion



2-S2150
Knight Spinal(Chairback)



2-S2170
Knight-Taylor

2000 SERIES SPINAL BRACES

HIGHEST QUALITY AT MODEST PRICES

Immediate Delivery From Stock

Pictured are just four of our many braces that can help your profit picture. Quantity discounts available. Easy to fit from five stock sizes. Write us for our complete catalog. Better yet, give us a call at (202) 628-1037. We'll be happy to help in any way we can.



**WASHINGTON
PROSTHETIC
SUPPLIES**

40 PATTERSON ST., N.E.
WASHINGTON, D.C. 20002
(202) 628-1037

CLASSIFIED ADVERTISEMENTS

Advertising Rates

Regular—First 35 words, \$24.00 (minimum). Additional words \$1.00 each. Situations wanted advertisements half rate. Space rate additional: 13 x 13 picas—\$105.00; 13 x 18 picas—\$180.00.

Special—Members of the American Academy of Orthotists and Prosthetists who wish to advertise their availability on a signed or unsigned bases are entitled to do so at the special rate of \$5.00 per five line insertion per issue. Each additional line, \$1.00.

Mail addressed to National Office forwarded unopened at no charge. Classified Advertisements are to be paid in advance; checks should be made payable to "Orthotics and Prosthetics". Send to: Editor, Orthotics and Prosthetics, 1444 N St., N.W., Washington, D.C. 20005.

BUSINESS FOR SALE—4 man operation in Prosthetics. High gross - High earnings. 20 years in top location (New York Area) with tremendous reputation. Will consider ten year payout to certified prosthetist - with management experience. AOPA Box #77-20.

ORTHOTIST—Certified or eligible for Certification. Immediate opening in a Modern Orthotic/Prosthetic Laboratory. Excellent Fringe Benefits, including paid vacation, sick leave, health insurance and retirement plan. All replies will be handled in strict confidence. Send resume and salary requirements to: Ron Cheney, American Prosthetics, Inc., 2733 6th Avenue, Des Moines, Iowa 50313.

CERTIFIED ORTHOTIST or PROSTHETIST/ORTHOTIST—Fringe benefits - profit-sharing, medical and disability benefits. Salary commensurate with qualifications. Contact: Progressive Orthopedic Mfg., 1248 32nd Street, Sacramento, California 95816. Tel: 916-452-5724.

CERTIFIED PROSTHETIST—We seek an experienced prosthetist to assist our present prosthetist in a large, well-established practice. We offer good salary and fringe benefits. Contact: Bob Gruman, The Winkley Company, 4130 Highway 55, Minneapolis, MN 55422 (612) 522-6616.

CERTIFIED ORTHOTIST: We seek an experienced orthotist to assist our present orthotist in a large, well established practice. We offer good salary and fringe benefits. Contact: Bob Gruman, The Winkley Company, 4130 Highway 55, Minneapolis, MN 55422, (612) 522-6616.

CERTIFIED PROSTHETIST AND/OR ORTHOTIST. Opportunity to join teaching staff of New York University Prosthetics and Orthotics education program. Excellent salary and benefits program. Send resume to Norman Berger, Prosthetics and Orthotics Department, NY University Medical Center, 317 E. 34th St., New York, N.Y. 10016. An equal opportunity employer m/f.

ORTHOPEDIC SHOE REPAIR MAN—Position available for experienced person in Certified Facility—Reply to AOPA, 1444 N Street N.W. Washington, D.C. 20005.

When prescribing, selecting, or creating orthoses . . .

PRINCIPLES OF ORTHOTIC TREATMENT

In this book you'll find brief, concise information for prescribing the most suitable orthotic device for diseases affecting the lower and upper extremities and the spine. The authors approach orthoses through the technique of functional analysis.

By Wilton H. Bunch, M.D., Ph.D. and Robert D. Keagy, M.D., M.S. 1976, 144 pages plus FM I-VIII, 6 3/4" x 9 3/4", 174 illustrations. Price, \$17.50.

ATLAS OF ORTHOTICS: Biomechanical Principles and Application

This volume investigates current orthotic devices and appliances from a biomechanical point of view. Selection, purpose, material fabrication, and application of design are described in detail after a thorough analysis of the upper and lower limbs, and spine.

The American Academy of Orthopaedic Surgeons: with 36 contributors. 1975, 508 pages plus FM I-XIV, 8 1/2" x 11", 836 illustrations. Price, \$44.00.

**depend on Mosby
references**

MOSBY
TIMES MIRROR

THE C V MOSBY COMPANY 11830 WESTLINE INDUSTRIAL DRIVE ST LOUIS MISSOURI 63141

DAYDREAMING.



Children do it especially well and if they're lucky, they don't lose the knack as they face the many problems of growing up.

With the Kingsley Juvenile Symes Foot, life can go beyond childhood dreams. The foot is molded around a 1/4" aluminum plate keel. This simplifies the low clearance requirements without compromising



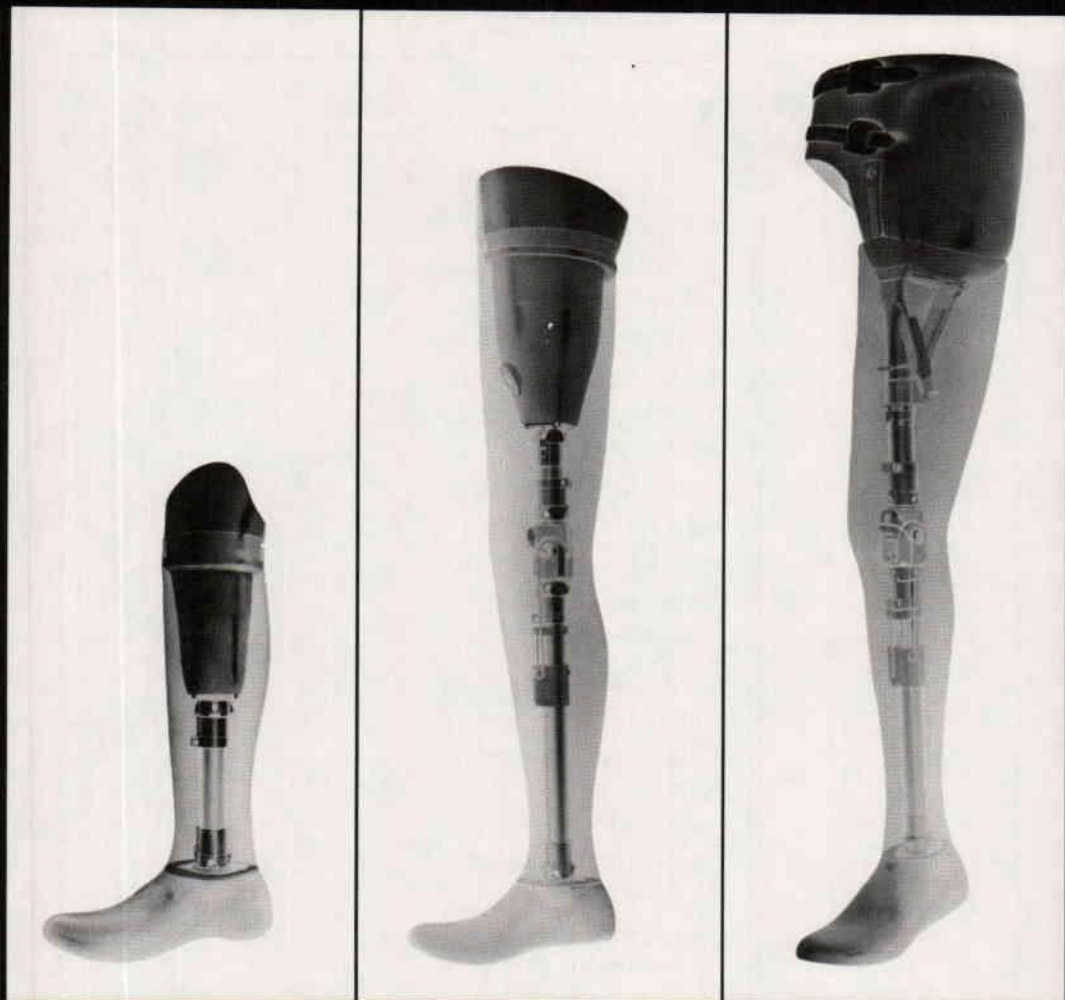
strength and durability.

The Kingsley Juvenile Symes Foot fills a special need for fitting lower level amputations in juveniles.

Today there's the beach, ballpark, camping, walking where dreams lead. And tomorrow, an equal chance to make those dreams come true.



KINGSLEY MFG. CO.
1984 PLACENTIA AVENUE
COSTA MESA, CA 92627
(714) 645-4401



The task of the future:

Humanizing Prostheses

A glance at the OTTO BOCK Modular limbs pictured above, immediately shows the differences in this system and the older crustacean type . . .

1. Cosmetic appearance. Note the clean, natural appearing outer contour with no distracting articulation separations.
2. The foam covering over the internal structure gives a soft, pleasant and much more natural FEEL to the touch than the hard surface of the conventional type of limb.
3. The internal design principle resembles that of a building block system. By using various combinations of Modular components, it is possible to fit all levels of lower extremity amputation according to the individual patient needs.
4. Static and dynamic alignment in all planes is easily achieved through simple, precise and controlled adjustment of the adaptors.

Successful application of the OTTO BOCK Modular limb offers proof that restoration of the amputee's outer appearance is an essential contribution to his complete rehabilitation.

Otto Bock

ORTHOPEDIC INDUSTRY INC.
UNITED STATES OF AMERICA

610 Indiana Avenue North
Minneapolis · Minnesota 55422

PEL

Feet
Knees
Endoskeletal Systems
Post Surgical Equipment
Wood
Prosthetic Joints & Valves
Leather Parts P & O
Suspension Aids
Webbing
Buckles
Fasteners
Stump Socks
Stump Shrinkers
Comfort Aids
Plastic Welding Rods
Plastic Sheets
Plastic Foam — Pads
Fabricating Supplies
Orthotic Joints
Orthotic Aids — Back,
Cervical & Foot
Fracture Braces
Upper Extremity Components
Canes
Skiing Aids
Miscellaneous Tools

Stocked in our warehouse
Ready for shipment
The same day your order is received

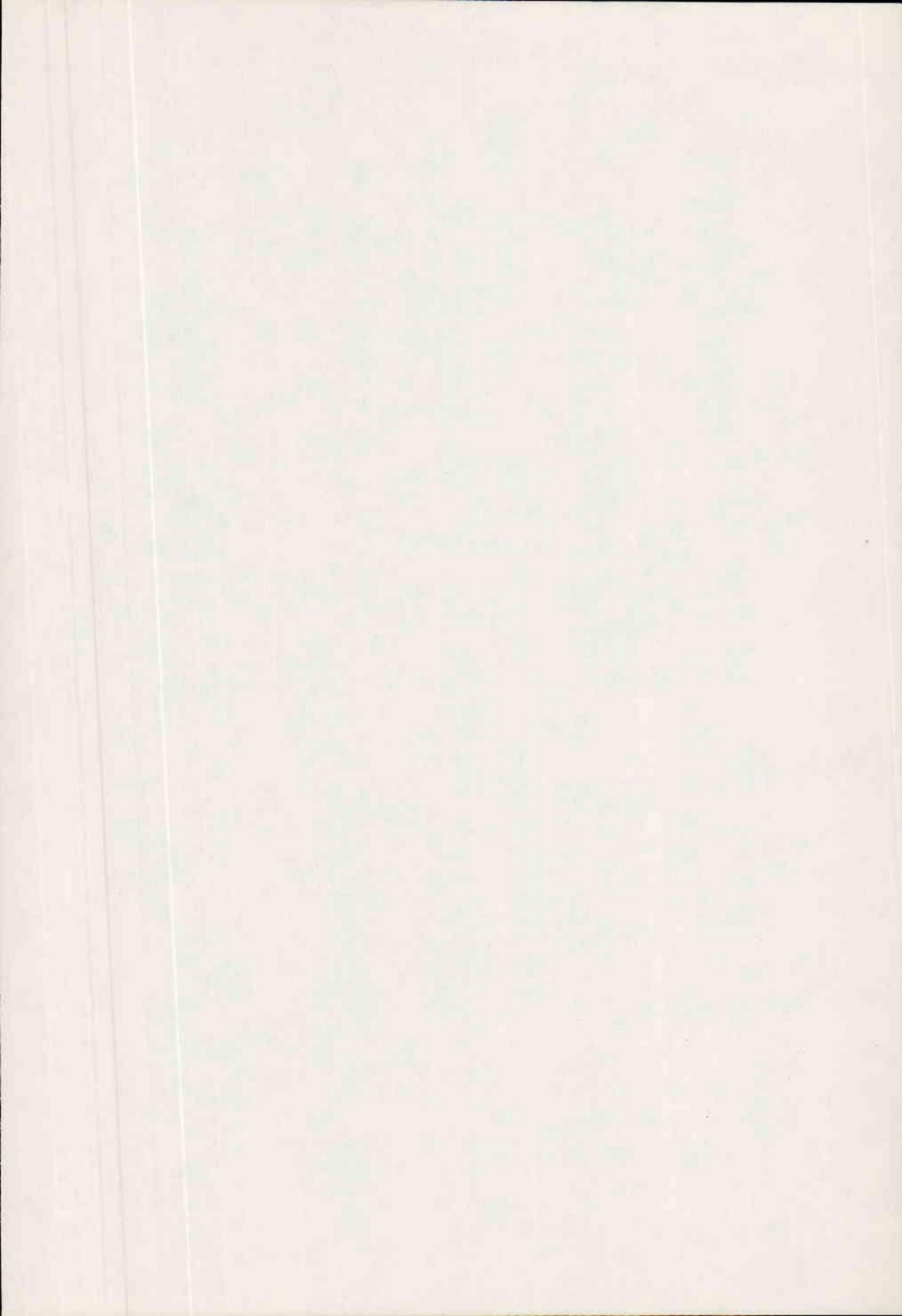
PEL

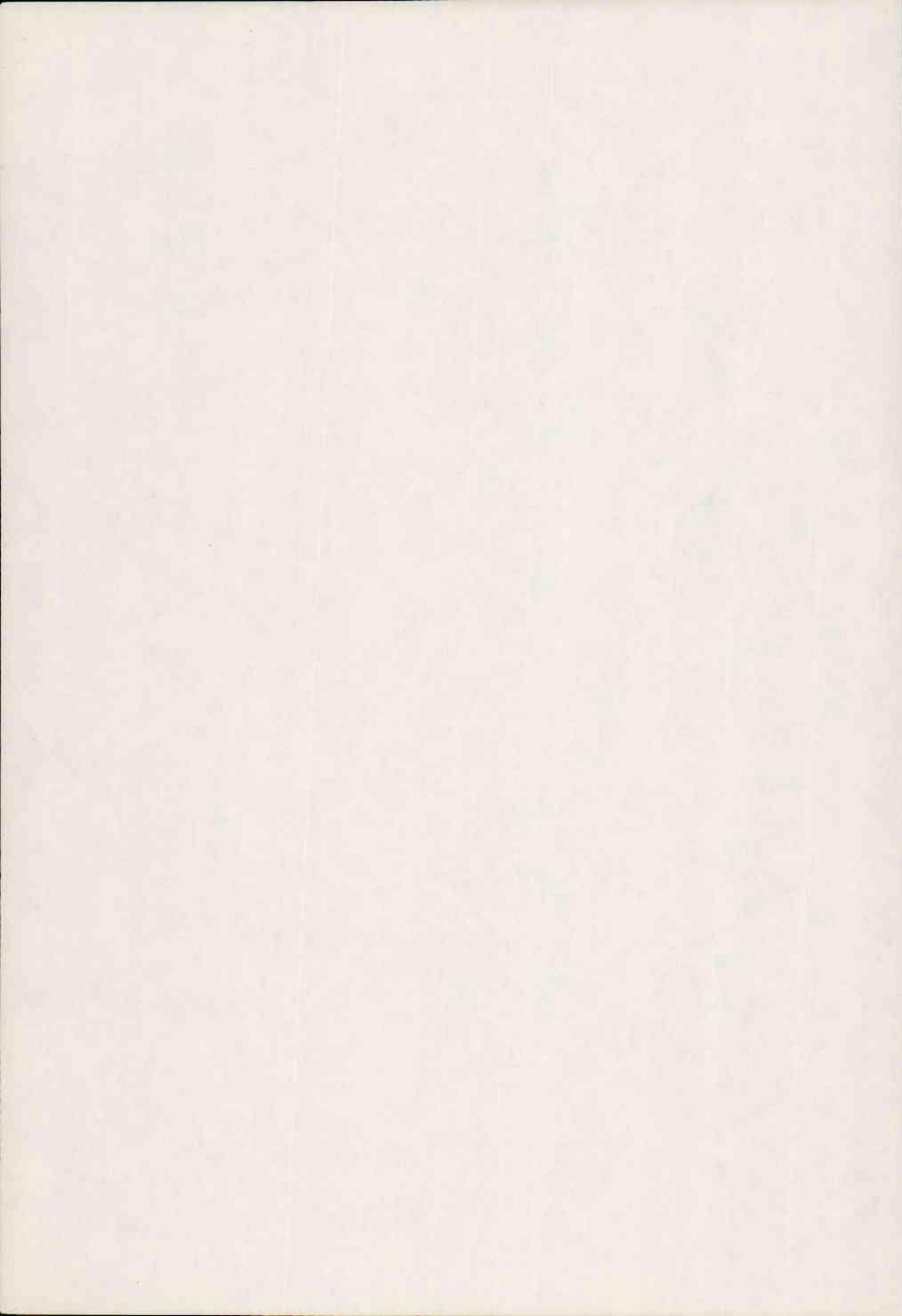
SUPPLY Co.

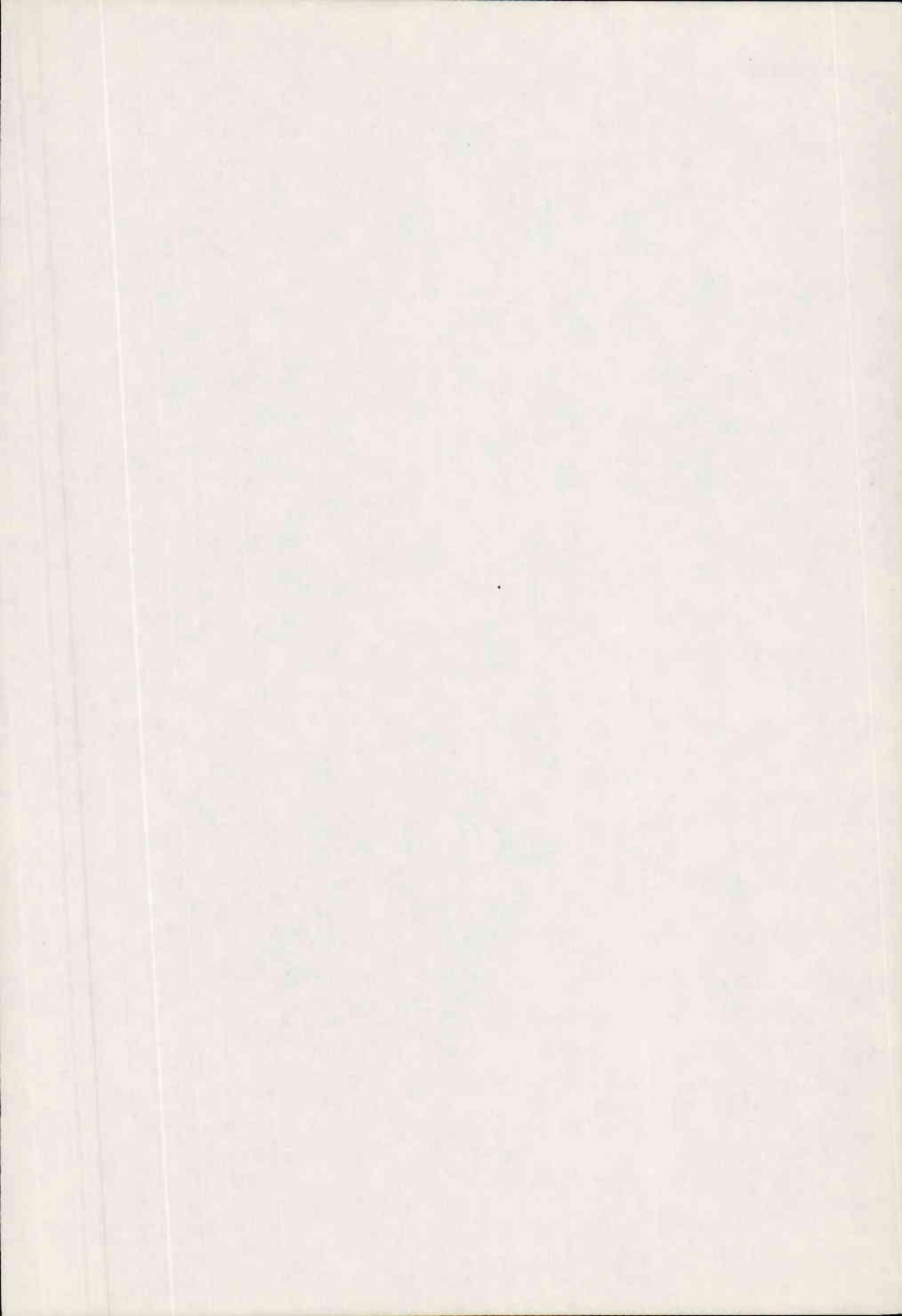
4472 WEST 160TH STREET
CLEVELAND, OHIO 44135
PHONE (216) 267-5755

Paul E. Leimkuehler, President

PROSTHETIC AND ORTHOTIC PARTS AND SUPPLIES









Hinged Ankle Joint Fracture Cast Brace



The Hinged Ankle Joint Fracture Cast Brace is a new addition to United States Manufacturing Company's family of fracture bracing components. Designed as a single axis joint orthosis, rather than a polycentric one, the hinged ankle joint brace allows normal tibial torsion which reduces fracture site strain. Strain applied to the brace itself is also reduced, eliminating the breakage problem encountered by polycentric type orthoses. Free plantar/dorsiflexion motion is achieved by positioning the axis of the orthosis directly over the anatomical axis of the ankle.

Strong, lightweight and ribbed for extra rigidity and strength, the hinged ankle joint brace is supplied with a Velcro strap which facilitates easy donning of the patient's shoe.

The brace is available in 3 sizes: small, medium and large — left or right, and may be used with plaster bandages, Hexcelite, Orthoplast, Zoroc, or any other equivalent substitute.



**UNITED STATES
MANUFACTURING CO.**

P.O. Box 110, 623 South Central Avenue
Glendale, California 91209, U.S.A.
Phone: (213) 245-6855 Cable: LIMBRACE
TWX No. 910-497-2279

AMERICAN ORTHOTIC AND PROSTHETIC ASSOCIATION
1444 N STREET, N.W.
WASHINGTON, D.C. 20005