June 1979
Volume 33
Number 2

Orthotics and Prosthetics

Journal of the American Orthotic and Prosthetic Association

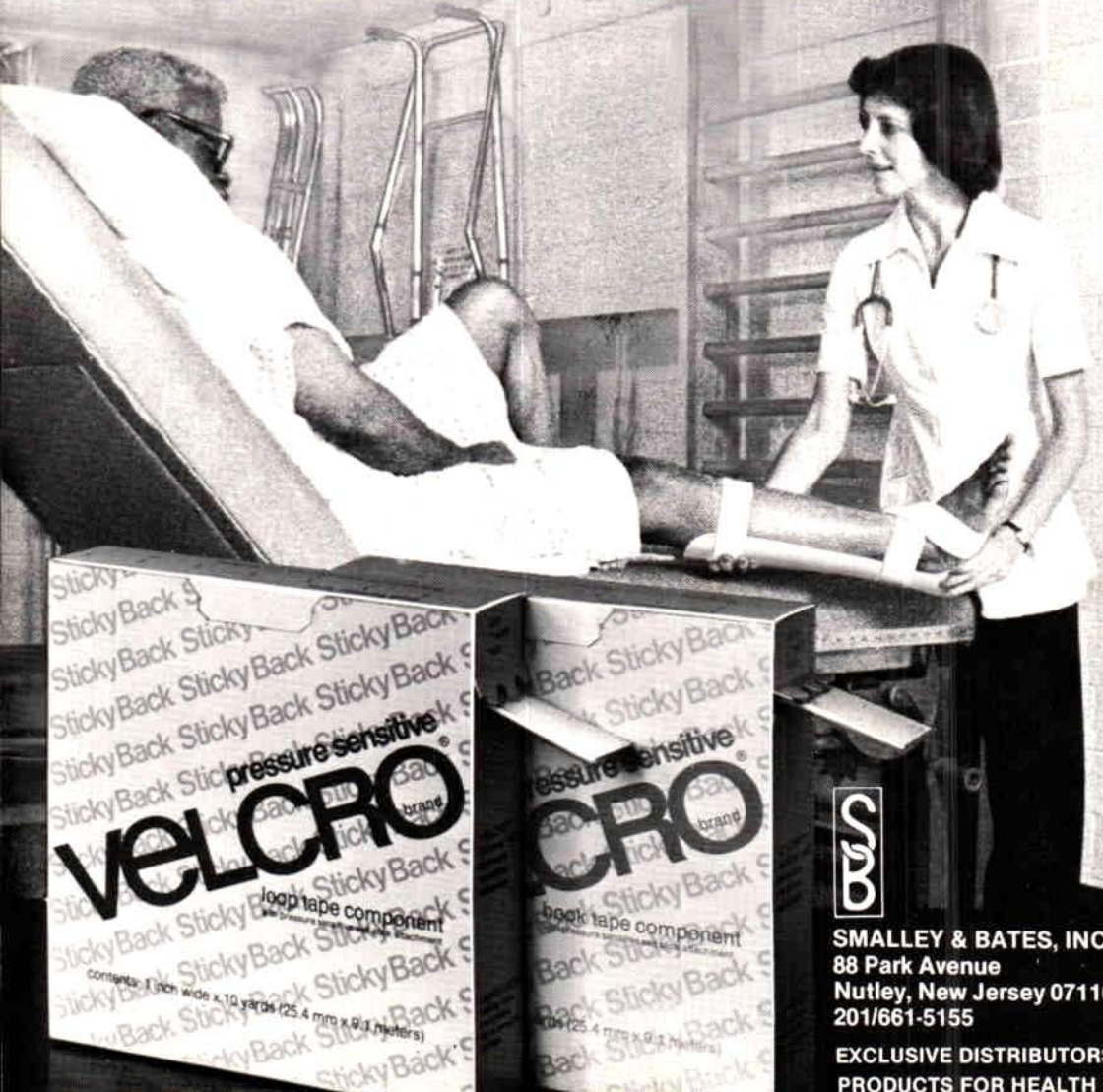
Keep Sticky Back™ VELCRO® Fasteners where they'll do the most good.

VELCRO brand fastener tapes, with self-stick adhesive backing, in convenient dispenser packs.

Versatile, hard-working VELCRO hook and loop fasteners, now available with a pressure sensitive adhesive backing that will stick almost anywhere. Ideal for attaching straps or padding to hard-surface materials—splints, braces, stands, frames. Simply peel off protective cover strip, press tape into place. Tape fasteners are ready to use immediately, open and close hundreds of times while adhesive backing holds like glue. Efficient, self-standing, shelf-size boxes keep your Sticky Back VELCRO fasteners on the job and hospital clean. Separate boxes for hook or loop tapes; convenient measuring device on each box.

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.



Sticky Back VELCRO fasteners attach instantly to splint, hold securely with VELCRO loop material.

S&B

SMALLEY & BATES, INC.
88 Park Avenue
Nutley, New Jersey 07110
201/661-5155

EXCLUSIVE DISTRIBUTORS OF VELCRO PRODUCTS FOR HEALTH CARE.

American Orthotic & Prosthetic Association

1979 National Assembly September 26 Thru 30, 1979

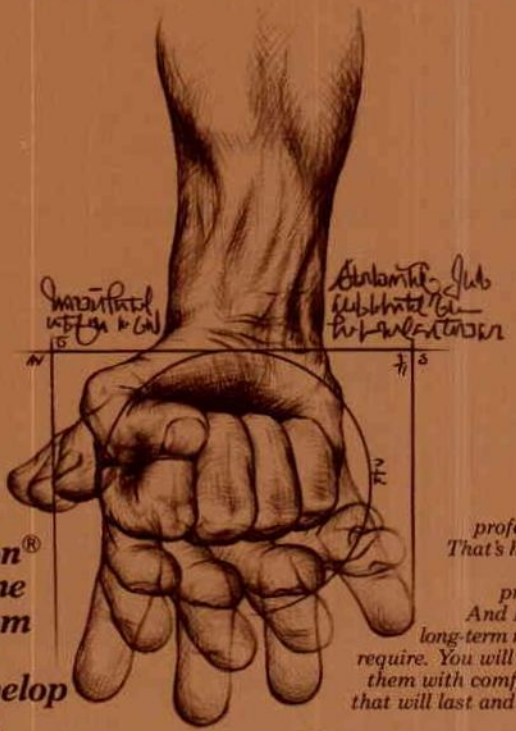
Washington Hilton, Washington, D.C.

For Program Details and Registration Information
write to

The American Orthotic and Prosthetic Association
1444 N Street, N.W.
Washington, D.C. 20005

The Assembly is open to all who are interested in the rehabilitation of the orthopedically disabled.

Develop A Better Image.



New Boltaron® polypropylene materials from General Tire help you develop a better cast.

Whether you are in orthotics, prosthetics, or both, you have an extremely high level of professionalism to maintain. So do we at General Tire.

That's why our new Boltaron sheeting uses only quality materials—materials that have been tested and proved in devices developed by medical professionals nation-wide. That's how we know Boltaron will perform to your professional standards. And Boltaron provides the long-term reliability your patients require. You will know you have fitted them with comfortable casts, fittings that will last and last—without loss of therapeutic support.

Boltaron materials are available now in new flesh tone and white, made from a polypropylene base which offers uniform stretch after heating.

CO's and CPO's are invited to write for free samples and complete information, to Mr. J. G. Hoy, Sales Manager, GTR Plastic Film Company, Newcomerstown, Ohio 43832.

GENERAL TIRE®

GTR PLASTIC FILM COMPANY
Chemical/Plastics Division
Newcomerstown, Ohio 43832

Orthotics and Prosthetics

Editor
A. Bennett Wilson, Jr.

Managing Editor and Design
Brian A. Mastro

June 1979 **Volume 33, No. 2**

CONTENTS

Editorial Board

Michael Quigley, C.P.O. *1979*
Thomas Bart, C.O. *1980*
Gunther Gehl, C.P. *1981*
Alvin L. Muilenburg, C.P.O. *1979*
Michael Pecorella, C.P.O. *1979*
Kurt Marschall, C.P. *1980*
William L. McCulloch *Ex Officio*

Copyright © 1979 by the American Orthotic and Prosthetic Association
Printed in the United States of America.
All Rights Reserved

Second Class Postage Paid
at Washington, D.C.
US ISSN 0030-5928

Advertiser's Index and Hotline

Advertisers shown in bold-face type are member of
The American Orthotic and Prosthetic Association

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, DC. 20005. Telephone, Area Code 202, 234-8400.

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

THE AMERICAN ORTHOTIC AND PROSTHETIC ASSOCIATION

OFFICERS

President—**William M. Brady,** C.P.
Kansas City, Missouri

President-Elect—**William D. Hamilton,** C.P.
Scottsdale, Arizona
Vice President—**John E. Eschen,** C.P.O.
New York, New York
Secretary-Treasurer—**Thomas R. Bart,** C.O.
Omaha, Nebraska
Immediate-Past President—
Daniel G. Rowe, C.P.O.
St. Paul, Minnesota

REGIONAL DIRECTORS

Region I—**John Ficociello,** C.P.O.
Burlington, Vermont
Region II—**Robert Mandfredi,** C.P.O.
Long Branch, New Jersey
Region III—**Ivan Sabel,** C.P.O.
Bethesda, Maryland
Region IV—**Frank Floyd,** C.P.O.
Wilmington, North Carolina
Region V—**Joseph Shamp,** C.P.
Canfield, Ohio
Region VI—**Jack Milburn,** C.O.
Springfield, Illinois
Region VII—**Thomas R. Bart,** C.O.
Omaha, Nebraska
Region VIII—**Clint Snell,** C.P.O.
Shreveport, Louisiana
Region IX—**Joseph Lydon,** C.O.
San Francisco, California
Region X—**Dale Jenkins,** C.P.
Phoenix, Arizona
Region XI—**Joseph H. Zetti,** C.P.
Seattle, Washington

THE AMERICAN ACADEMY OF ORTHOTISTS AND PROSTHETISTS

OFFICERS

President—**Michael Quigley, C.P.O.**
Downey, California

President-Elect—
Edward Van Hanswyk, C.O.
Syracuse, New York
Vice President—**Robert F. Hayes,** C.P.
West Springfield, Massachusetts
Secretary-Treasurer—**Richard LaTorre, C.O.**
Schenectady, New York
Immediate-Past President—
Siegfried W. Paul, C.P.O.
Newington, Connecticut

DIRECTORS

Eugene Filippis, C.P.O.
Detroit, Michigan
J. Donald Coggins, C.O.
Philadelphia, Pennsylvania
Gunter Gehl, C.P.
Chicago, Illinois
H.R. Lehneis, C.P.O.
New York, New York

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 J-235, Johnson & Johnson, New Brunswick, New Jersey 08903.

ORTHOPLAST Splints
TRADEMARK

You're in the Business

You're in the business. You know how much the orthotic and prosthetic field has grown in the last decade. You know that complex technology has replaced the methods and devices of yesteryear. You know that a facility can not function without a qualified orthotist or prosthetist. You can look ahead to more growth, more development, and a need for more qualified pracitioners whose education has prepared them for the future.

Where will we find these practitioners? At universities and colleges. Students are willing and eager to enter the professions; unfortunately, a professional education is expensive. You can assure our profession of a steady supply of well-educated, certified orthotic and prosthetic practitioners by giving to the American Orthotic and Prosthetic Education Fund, Inc., which seeks out and aids deserving students.

Your tax-deductible contribution will support the education of these bright young people. Your profession needs your help today, to educate the pracitioners of tomorrow. Send a check now.

Yes, I'd like to help our industry by helping a deserving student of orthotics and prosthetics. Enclosed please find my check for $_____.

Name _____

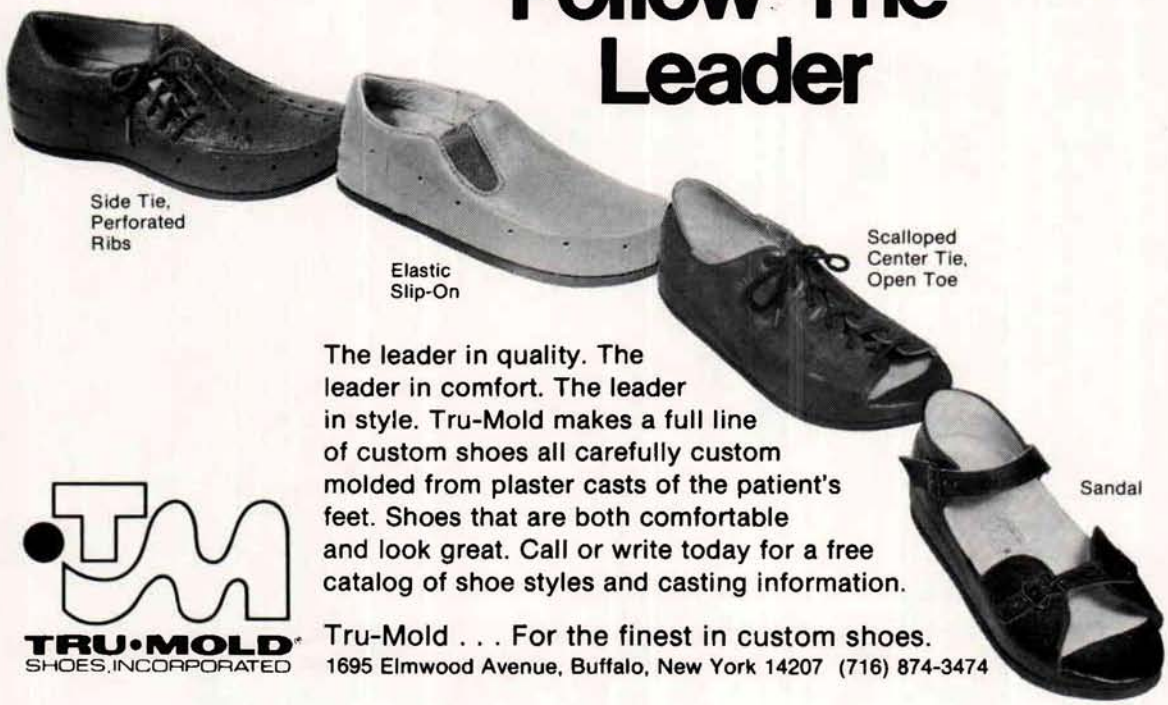
Firm _____

Address _____

City _____ State _____ Zip _____

(make checks payable to AOPEF, and mail to 1444 N St., NW, Wash., D.C. 20005)

Follow The Leader



The leader in quality. The leader in comfort. The leader in style. Tru-Mold makes a full line of custom shoes all carefully custom molded from plaster casts of the patient's feet. Shoes that are both comfortable and look great. Call or write today for a free catalog of shoe styles and casting information.

TRU·MOLD SHOES, INCORPORATED

Tru-Mold . . . For the finest in custom shoes.
1695 Elmwood Avenue, Buffalo, New York 14207 (716) 874-3474

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

The Convertible Crotch. It's a Snap.

Another first from Truform. The 3115 sacro-lumbar garment with unique nylon convertible crotch piece to allow snap-in, snap-out choice of a panty style garment or standard girdle.

50% cotton, 50% polyester construction by New York designer Marguerite Williams, features Jacquard design figured cloth. Elastic releases top & bottom with nylon Tricot® under lacing for a smooth, comfortable fit. Well cupped under the buttocks. Front 14½", Back 17". Dev. 9", 3 pull, 2 steels. Hip sizes 30-48.

3115 as panty

3115 as girdle

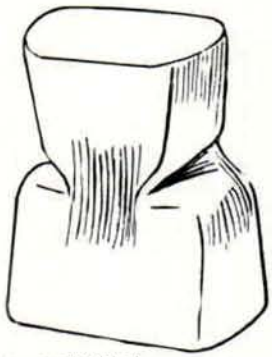
Also a
the style
groin len
lumbar g
featuring
tachable,
contoure
crotch pie
9¼", Back
Dev. 8", 3
2 steels. H
30-48.

TRUFORM
Orthotics and Prosthetics

When better garments ar
Truform will make them.

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.



ace

(Measurement & technique instructions available.)

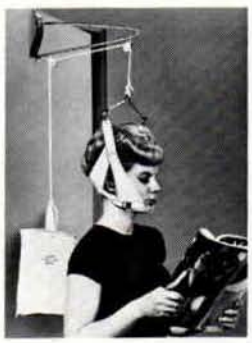
ace orthopedic company

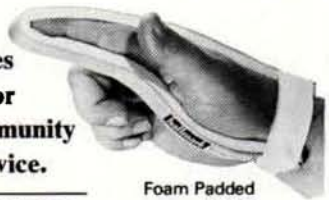
11913 So. Prairie Ave., Hawthorne, Calif. 90250 • Phone (213) 644-9336, 644-5597

the name* HALLMARK *for Excellence in Orthopedics

H-44 Neck Brace

Jewett Brace H-46





Foam Padded Splint Strips

HALLMARK Orthopedic Specialties Have been Known and Respected for Excellence in the Orthopaedic Community for over 33 Years of Continuing Service.

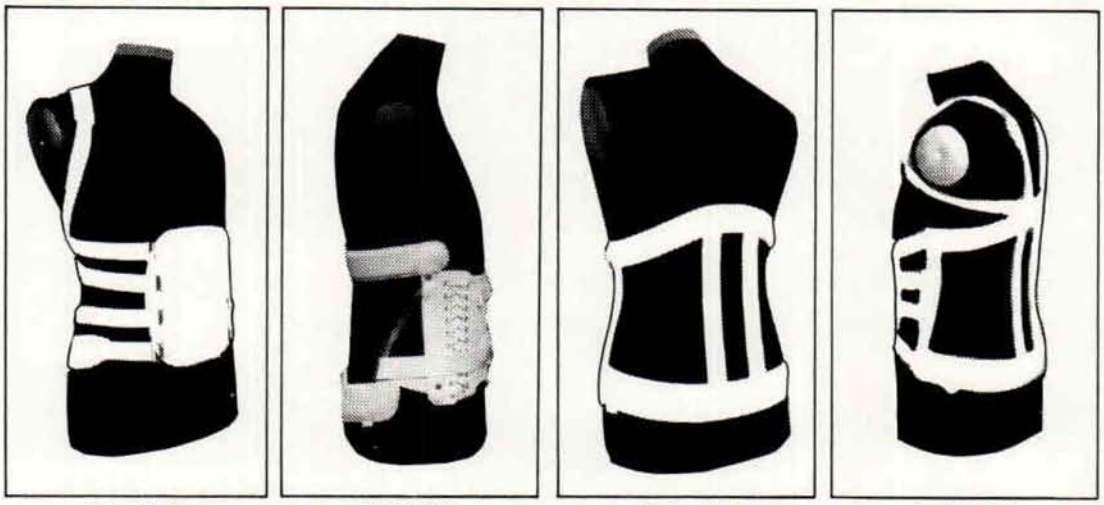
IMMEDIATE DELIVERY

H-431 Frame Collar

(213) 446-4882
Write for our latest Catalog showing over 150 Orthopedic items

hallmark
ORTHOPEDIC SPECIALTIES
P.O. BOX 898 • ARCADIA, CALIFORNIA 91006

Trademark Registered, U.S. Patent Office



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

FREE! HANDY POCKET-SIZED TUBE OF AMP-AID

* A preventative salve to be used in areas that may become irritated due to wearing a prosthesis, jogging, hiking, playing tennis, etc.
* Use AMP-AID at the first sign of redness.
* For an existing skin irritation or discomfort, AMP-AID gives added comfort and promotes healing, while you continue your activities.

Try AMP-AID yourself
Give your patients AMP-AID

Mail this coupon for a free sample

For a FREE 3/8 oz. sample tube of AMP-AID ointment, send this coupon to:

PEL SUPPLY CO.
4666 Manufacturing Rd.
Cleveland, Ohio 44135
Phone: a.c. 216-267-5775
Orthotic & Prosthetic Parts & Supplies
Paul E. Leimkuehler, C.P. president

Name _____

Address _____

City, State, Zip _____

AMP-AID is distributed by:

Kingsley Mfg. Co.
Knit Rite, Inc.
Ohio Willow Wood Co.
PEL Supply Co.

Commentary

Our Present Challenge

The field of Prosthetics and Orthotics has moved in giant strides in the last three decades. New materials have been introduced, new techniques have been developed, resulting in new fitting methods and complete redesign of our Prosthetic-Orthotic armamentarium.

However, it behooves us not to rest on our laurels and past accomplishments, but to pause to take a look into our humble beginnings, when the predecessor of AOPA, OALMA, was organized in the forties. It took men of great determination and foresight to mold countless small Prosthetic and Orthotic splinter organizations into one nationwide association called AOPA.

To these founding fathers, AOPA must have seemed like a rough and uncut precious stone looks to the diamond cutter's eye. They recognized full well that the potential was there, but to bring out the beauty in the precious stone, to make it shimmer and sparkle, they knew it would take the skillful hands of master craftsmen to cut the numerous facets into its sides.

The first facet, and one of the most beautiful, was the realization that at long last they had attained some form of professionalism. Although vague at first, what did they come to learn? They learned that to be a professional you have to behave like one, not only towards your peers but also towards the professionals of other disciplines with whom you come in daily contact. Foremost, however, is the professional treatment and management of your patients.

The founding fathers also realized that in order to preserve your professionalism, your knowledge in your chosen field must be superior to those outside it, and you must speak a unified language, which we call nomenclature. Our Prosthetic and Orthotic Teaching Institutions were a result of this realization, and so another facet was added to this rough and uncut stone of which I speak.

Then came the introduction of new materials, namely plastics which revolutionized the field of Prosthetics and Orthotics as a whole and our approach to fitting and alignment principles in particular. Some gifted research scientists and engineers entered our field, joined hands with us and solved some of our troublesome technical and biomechanical problems that we neither had the time nor knowledge to solve. This made for a happy marriage between two highly skilled disciplines. By this time our precious stone was already recognized all over the world for its dazzling beauty and sparkle. But today we should take a long, hard look at where our profession stands and where it is heading in the years to come. Never before have I seen a situation which cries so loudly for intelligent planning and determined handling of affairs of our profession by our members and representatives.

Today we are standing at a cross-road of whether to continue a policy that spells non-recognition of standards by the State and Federal Governments, or whether we are willing to end this status quo, in reality a no-mans-land, by fighting and striving for licensure by these governments through the only qualified body that I know of, namely our own American Board for Certification. As it stands today, the hippy is more protected from ending up with a crew cut at the hands of an unqualified barber, than are the crippled and disabled from mal-treatment by unqualified infiltrators into our field.

In striving for this goal of licensure, however, we are not attempting to prevent anyone from entering our field. But we should make it unmistakably clear that our rules and regulations, self imposed for many years, are the only ones of sufficiently high caliber to command adherence to. It would be fool-hardy to step back even one iota from these rules and regulations that we established and fought for so long, under the guise that we might violate democratic principles. On the contrary, it is exactly our constant willingness to impose

these high standards of performance and ethical conduct for the benefit and betterment of our patients that makes us more democratic to man-kind as a whole.

In the absence of this recognition by State and Federal Government, we can only fall back on the old method of persuasion, trying to emphasize to physician, surgeon, and clinic chief alike the need to utilize, for the protection of his patient, only qualified practitioners and facilities. This also imposes the adherence to ethical standards on the part of the practitioner as far as his product and service are concerned. But in either case, our house must be kept free of unethical conduct, shoddy workmanship and deliberate non-compliance with a doctor's prescription. And, I much prefer our own broom for the job in the absence of government licensure, for eventually we can expect standards imposed upon us that might not be to our liking.

To keep pace with constantly changing times, materials, designs and other developments, it is imperative that we take very serious our continuing education programs as they are now offered all over the land by the American Academy of Orthotists and Prosthetists. These work shops and seminars are designed not only for the facility owner or manager, but also for any member of his establishment who hungers for knowledge and appreciates such exposure.

Only by accepting this continuous flow of learning and untiring effort to serve the disabled can you demand that you be respected as a professional. And the world will gladly give you that respect. From this resulting superior knowledge and constant pursuit of excellence, you can demand that you be treated as a professional. And the world will gladly afford you that treatment. These qualifications will entitle you to expect to be paid as a professional. And the world will gladly give you your due.

Inherent rights bring with them inherent obligations. In this high standard of performance, we must not overlook a necessary professional relationship with our fellow practitioner. It is my firm belief that today new ideas and new concepts in Prosthetics and Orthotics should be willingly shared with everyone who wants to learn and listen. I shudder when I recall the days when trade secrets were jealously guarded and I cringe with pain when I remember when a successful Orthotist and Prosthetist was measured, not by his ability to rehabilitate the handicapped, but by how many of their shoes he could deposit on his employers bench on a weekly basis.

Today every self respecting Orthotist and Prosthetist should give freely of his time and knowledge to teach his art and science to others, as the Medical Profession has done in such an outstanding manner long before us. Ever since the initiation of the Hippocratic Oath, which states in part: ". . . to consider dear to me . . . him who taught me this art . . . to look upon his children as my own brothers, to teach men this art if they so desire without fee or written promise."

Our obligation as a professional continues with the dedication, devotion and support we are willing to give our organization and ruling body to which we profess to belong. But belonging means to participate. Belonging means to be productive. Belonging means to be active. Belonging means to speak out and to be heard of. Ours is this marvelous publication "Orthotics and Prosthetics," an ideal vehicle to disseminate your knowledge and your "know-how" in an unselfish manner to your peers.

You must realize by now that this Journal is distributed not only in the United States, but enjoys a worldwide circulation. Its contents will always be the show-window for our professional state of affairs. It needs your input and your contribution. It needs you, who has been sitting on the sidelines for too long.

And finally, a professional's obligation extends to untiring dedication to our patients. He entrusts his rehabilitation into our hands. It is he who relies on us to perform at the highest level always. It is he who can expect of us that we keep pace with changing times, that we persevere despite difficulties in attaining results, and that we display an unlimited ability for the absorption of the new. And he has every right to do so. It is only we who can lead the way to new heights in our chosen field of endeavor if the betterment of our patient remains paramount in our mind. This is what I believe in . . .

Kurt Marschall, C.P.
Member of the Editorial Committee

Orthotics and Prosthetics, Vol. 33, No. 2, pp. 1-19, June 1979

Suspension of the Below-Knee Prosthesis: An Overview

CHARLES H. PRITHAM, C.P.O.[1]

The student of contemporary prosthetics cannot help but be struck by the plethora of techniques available for the suspension of the below-knee prosthesis. Since the introduction of the patellar-tendon bearing below-knee prosthesis in 1959 the field has been besieged by a variety of methods, all to accomplish a common purpose. The question that inevitably arises is "why?" Is it that the basic methods are so unsuccessful or that the possibilities for innovation so great?

As an abundance of statistics will show, the predominant cause of amputation in western society is peripheral vascular disease, and increasingly the preferred site of amputation is below the knee. The below-knee prosthesis can, therefore, be characterized as the "bread and butter prosthesis," the one upon which the prosthetist counts to pay salaries and overhead. The tendency is to use the method which the prosthetist finds best enables him to satisfy the many needs of the patient most expeditiously and economically. The concern, of course, extends beyond the point of delivery and the prosthetist desires to find a technique that will be both durable and readily adjustable so as to facilitate repairs. There are, of course, other motives than base economics at work.

Given this preponderance of experience with one basic prosthesis the practitioner in time develops the confidence for innovation. (The converse, of course, is true; one is more inclined to eschew experimentation when confronted with an unfamiliar situation.) Secure in the knowledge that he can always fall back on basic techniques the prosthetist is more likely to try out the newer methods he has learned of as well as his own ideas. This tendency is an outgrowth of not only a desire for innovation, but also in reply to perceived inadequacies of the older techniques that come with clinical experience. The majority of below-knee amputees seen not only provides motivation for new developments, but also scope. It is difficult to experiment with non existent patients as well as to gain the experience to either criticize established methods or to perceive the solutions.

The answer to the question then would seem to be multifaceted. If financial forces were the only ones at work the ready and economical solution to obtaining proper suspension for a PTB with cuff suspension strap would simply be to add a waist belt, and we would not have witnessed the development of newer and more sophisticated methods. We may safely asume that prosthetists have been

motivated by such factors as a desire for personal satisfaction, to advance the profession, and a genuine wish to improve the lot of individual patients.

In the following discussion two works in particular are regarded as benchworks: *Orthopaedic Appliances Atlas Vol. 2* (1), and *Human Limbs and their Substitutes* (2). Published in 1960 and 1956 respectively (after many years in preparation) they seem to mark the transition from a period of fertile investigation to a later period of intensive clinical application. Encapsulating the experiences of the first period on the one hand and presaging the events of the second on the other, the work of Dr. Eugene Murphy in both references must be cited as being of particular relevance to the question at hand.

Thigh Corset and Knee Joints

The Verduin Leg (1969) (Fig. 1) shown in Vol. 2 of the *Orth. Ap. Atlas* (3) quite clearly shows the use of a thigh corset and below-knee joints, and since then their use (until the introduction of the PTB) has become synonymous with the "conventional" below-knee prosthesis (Fig. 2). If properly contoured proximal to the adductor tubercle of the knee the thigh corset can provide suspension as well as weight bearing and stabilization against anterior-posterior and medial-lateral forces. The thigh corset is not primarily prescribed for its suspension component, of course, and today thigh corsets and joints are added to the basic PTB in an attempt to bolster a stump that for one

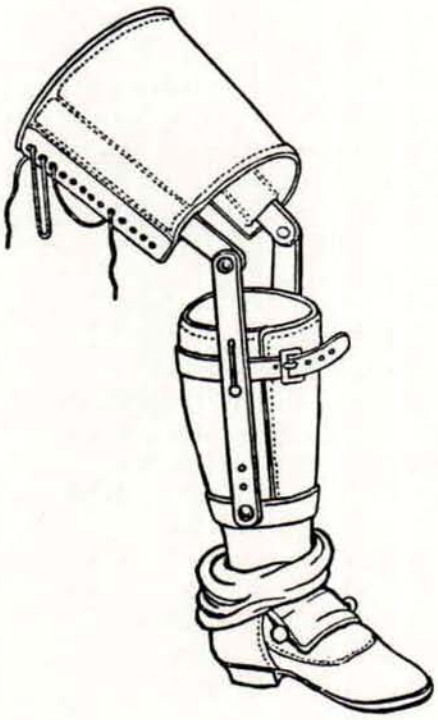


Fig. 1. The Verduin Leg [From (3)]

Fig. 2. The "conventional" below-knee prosthesis

reason or another is unable to cope with the external forces applied to it. None the less, in the spirit of extracting maximum performance from each component it would seem logical to properly contour a thigh corset when used to achieve suspension without a waist belt. The matter does not rest here, however.

In *Newsletter . . . Amputee Clinics* Vol. VII, No. 3 June 1975 (4) the question of using a thigh corset with a PTB was raised with specific reference to whether or not the two were incompatible due to no allowance being made for relative motion between the prosthesis and patient's limb. In response to the question Hugh Panton described methods of dealing with the problem, including loosening the fit of the socket.

In a subsequent issue of the newsletter (5) respondents to the questions, while not addressing themselves directly to the matter, tended to support Mr. Panton's rationale for modifying the socket. If this is the case then a thigh corset that fits intimately enough about the knee to provide adequate suspension can only exacerbate the problem. It may very well be then that a thigh corset incorporating suspension should not be fitted without a slip socket. There can be no ready solution to this conjecture and inevitably the decision must be made on an individual basis.

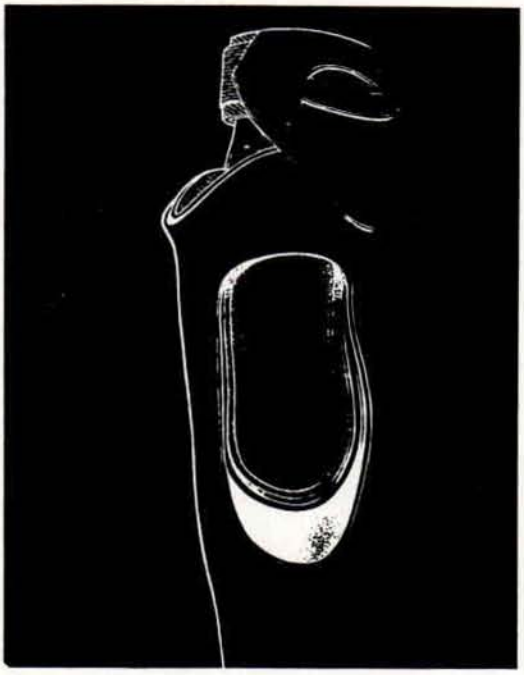


Fig. 3. The cuff suspension strap of the original PTB prosthesis

Cuff Suspension Strap

The cuff suspension strap (Fig. 3) is, of course, an integral part of the PTB prosthesis as described by Radcliffe and Foort (6) and as such has come to figure prominently in the present day practice of prosthetics. Prior to the introduction of the PTB Dr. Eugene Murphy has described the use of a soft suspension strap in conjunction with the "Muley" prosthesis (Fig. 4) (1, 2). As described by Dr. Murphy this precursor of the PTB had apparently been fitted for many years

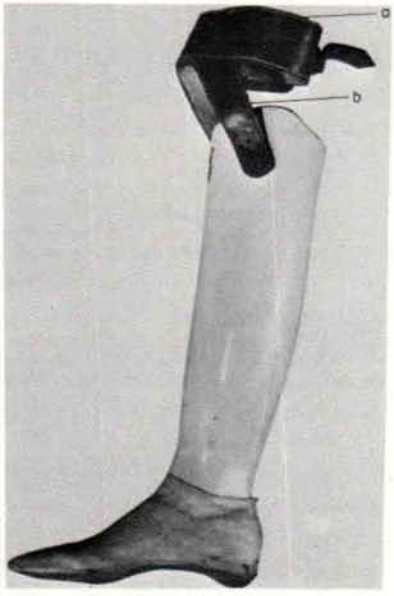


Fig. 4. The Muley Prosthesis [From (2)]

with mixed results with some patients resorting to the use of a thigh corset after only two or three years, while others continued to wear a Muley successfully for considerably longer periods. The disparate results were contributed by Dr. Murphy, not only to more accurate initial fitting, but also to more vigilant and frequent followup. (These same factors, of course, apply today and perhaps the true significance of the PTB is that they have become the norm rather than the exception.) In any event, the straps in the illustrations of Muley prostheses shown by Dr. Murphy are attached rather well forward of the position in vogue today.

In their manual on the PTB, Radcliffe and Foort (6) give explicit directions for locating the attachment points as well as criteria for the proper function of the strap. These exacting conditions are somewhat difficult to fulfill and not all patients lend themselves to them; nor do all prosthetists rigorously make the attempt. The authors of the PTB manual implicitly recognized these facts when they gave equal space to fabrication of a waist belt as to a cuff suspension strap. It is interesting to speculate what percentage of PTBs fitted include a waist belt as well as a cuff suspension strap. Almost all temporary BK prostheses include a waist belt. It is the author's impression that even with definitive prostheses waist belts are used more often than circumstances dictate. That cuff suspension straps are soft and flexible items, and thus readily subject to stretching and wear, can only compound the problem. Recognition of these facts has given cause over the years to much innovation.

The basic strap has been modified by the addition of elastic elements and replaced entirely by Velcro straps and single piece figure-of-eight straps. In their report on prosthetic devices suitable for India, Girling and Commings (7) describe such a strap that consists of a 25 mm. wide cotton tape that wraps around the patient's knee, passes through two slots in the side of the prosthesis, passes posteriorly and is tied together anteriorly. A device is available commercially to facilitate location of the proper attachment points, and not least, such radically different means of suspension as the PTS socket have been advanced.

Waist Belt

A waist belt is most frequently added to the basic below-knee prosthesis in order to supplement the inadequate efforts of another suspensory component. As such it is most broadly referred to as a secondary or auxiliary means of suspension. This designation is questionable since it is possible to gain sufficient suspension with a waist belt without recourse to other means in just about every case, while a waist belt is added to a prosthesis after another form of suspension has proven its inadequacy. It would seem then that a case could be made for designating the waist belt a primary suspensor that relegates other suspensory components to a secondary role when used. Waist belts are objected to by prosthetists as unaesthetic and by patients as uncomfortable, difficult to keep clean, and frequently in need of repair. Perhaps then they should be reserved for last resort when other more appealing means have failed. All of this having been said, it must be acknowledged that there exists a place for the waist belt in the everyday practice of prosthetics.

The first would, of course, be with a thigh corset and joints. In this instance the waist belt is most frequently attached to the prosthesis by means of a fork strap that divides proximal to the patella and courses down from there on either side of the patella to attach to the anterior portion of the prosthetic shin.

Alternative means of attachment do exist although they are infrequently, if

ever, used. Dr. Murphy (2) describes what might be termed an abbreviated fork strap as it attaches on either side to the uprights proximal to the knee joint rather than distal to, as in the former case. He also mentions how rollers may be attached to the uprights and cords passed through them to correct with the waist belt posteriorly as well as anteriorly. This latter case would have the advantage of maintaining equal tension in all positions of hip flexion and of distributing the load more broadly about the belt.

The second common use of a waist belt would be with a temporary PTB prosthesis and cuff suspension strap as mentioned earlier. The desire here, of course, is to provide a readily adjustable means of gaining good suspension during a period of rapid change and thus avoid the possibility of damage to the immature stump.

The third use of a waist belt is with a definitive PTB for one reason or another. While other means of suspension exist, some prosthetists and clinic teams will resort to a waist belt rather than to other methods when the cuff fails as a means of suspension. The most compelling reason for this is mental confusion on the patient's part. Most people are familiar with fastening belts and straps and thus readily adapt to the use of a waist belt when they may have difficulty with other forms of suspension. When a waist belt is worn with a cuff suspension strap (particularly in this last cited case) it is not infrequent to see the cuff worn altogether too loose, either as a result of improper adjustment or of wear and stretching. In this case, then, the waist belt converts the cuff suspension strap to a form of fork strap that happens to be attached posterior to the knee center rather than anterior.

One variant that gives recognition to this fact is that described by Jack Caldwell, C.P., in 1965 (8). The cuff suspension strap (Fig. 5 and 6) is done away with and replaced by two straps and a stainless steel ring as used in upper extremity prosthetic harnesses. As described, each strap is fastened at some point at the anterior portion of the socket, pass proximally up through the ring, and then distally to a point in the popliteal area of the socket. The straps are allowed to pass freely through the ring during flexion and extension and the ring is joined to the elastic thigh strap of the waist belt with a quick disconnect snap fastener. The author further states that hyperextension of the knee can be controlled by varying the location of the anterior attachment points.

Suspenders

Over the shoulder suspenders used with a below-knee prosthesis are so rare as to constitute a genuine curiosity when encountered. Their use can not be dismissed altogether, however. It may very well be that for any number of concomitant reasons a particular patient can use no other means of suspension; and there always exists the true individual who will hear of no other means however powerful the clinic team's arguments against it. The author encountered such a person a number of years ago who suspended his prosthesis (which also included a thigh corset) with an arrangement much the same as a baldric used to suspend a sword from the shoulder. A single broad belt passed proximally from the ASIS on the involved side up over the contralateral shoulder, distally down the back, and around the side to the originating point where the two ends were secured together. From there an elastic strap and "Y" strap were used to secure the baldric to the prosthesis.

It is, of course, possible to devise considerably more complex arrangements using two suspenders, chest belt, waist belt, and either elastic straps anterior-posterior to the prosthesis or rollers and

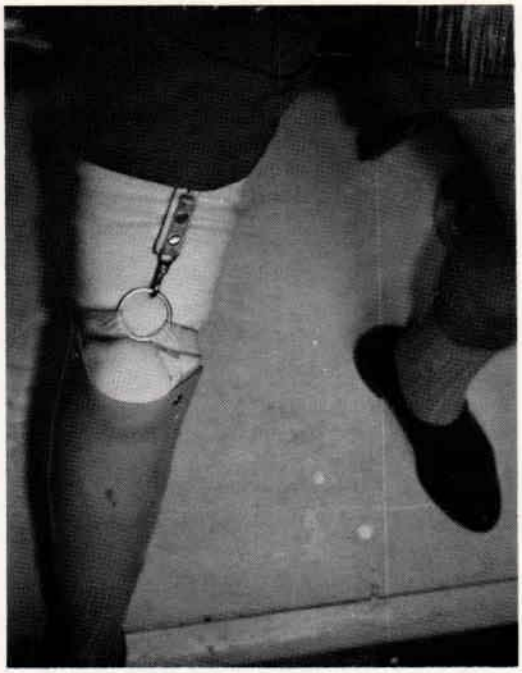


Fig. 5. Top view of the V-straps with the knee extended

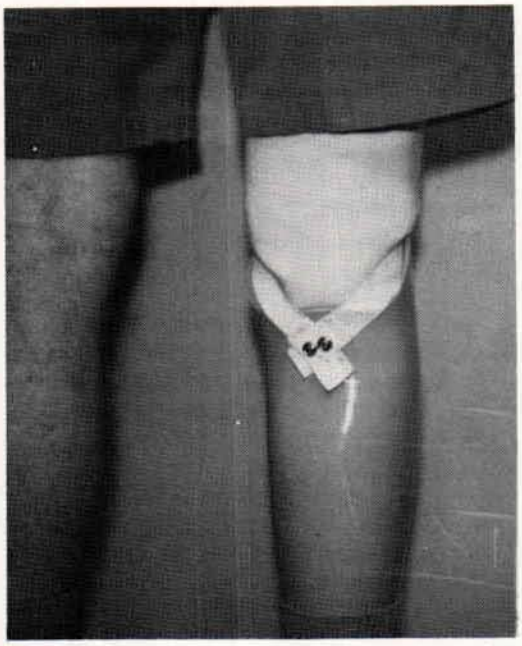


Fig. 6. Posterior view of the V-straps while patient is standing

roller cords. Franz and Aitken refer to such a setup for infants calling it a "toddler harness." The premise is that the chubby child and relatively indistinct skeletal features of the infant necessitate such drastic measures. An additional reason is, of course, the need to make the total prosthetic system "wriggle proof."

Blevens Undercut Calf Socket

The socket (Fig. 7) developed and patented by Emmett Blevens and evaluated by N.Y.U. can be regarded as a precursor of a number of concepts just recently beginning to receive serious attention. As described by Murphy (1) the socket was carved of wood to accommodate a stump encased in two wool stump sockets with a hollow carved in the posterior wall distal to the popliteal. A foam rubber pad was sandwiched between the two sockets so as to fill the hollow once the socket was properly donned. Since the pad was fitted so as to remain compressed, tension was developed between the socket and stump and a suspension effect was obtained. Apparently some amputees, with time and proper effort, were able to redevelop previously atrophied muscles and, thus, eventually discard the rubber pad. In addition, a sunction valve was fitted to some sockets and negative pressure was used to enhance suspension.

This, the work of a private individual, failed to find favor with the "prosthetic establishment" and little or nothing has been heard of it since. The reasons for this conservatism are not hard to fathom. The PTB had not yet been properly introduced and once it was, considerable effort was necessary to overcome the obstinacy with which a corsetless BK prosthesis was greeted. In addition the

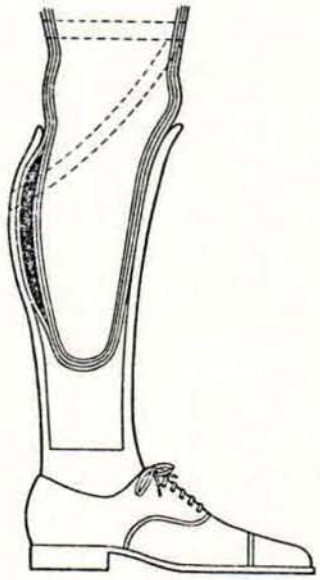


Fig. 7. The socket designed by Blevens

Blevens' socket, being carved of wood, required, as all such sockets, considerable skill and trial and error to fit and as such it was undoubtedly considered unprofitable to formalize the Blevens' method and teach it. While little information about the technique appears to be available and the efficacy of compressing the highly vascular structures of the posterior calf is open to question; the two hurdles mentioned have been conquered and perhaps the time is now ripe for further study of the methods of Blevens. As will be seen in the following discussion such study on the part of some researchers is underway. In a related development Fred Hampton of the University of Miami has in private communication described the use of a similar if not identical suspension technique (by serendipity and as auxiliary suspension only) for edematous and bulbous immature stumps frequently seen when fitting early temporary prostheses. In such instances to avoid damage to the fragile tissues, Mr. Hampton has used a liner building up the posterior and medial areas proximal to the bulbous end of the stump. This liner is removed from the socket and donned separately and the stump and liner are then pushed into the socket. Mr. Hampton reports that considerable suspension can be gained by this expedient.

Muscular Grasp

Relatively little attention has been paid to this concept over the years. Dr. Murphy describes it in conjunction with the Blevens' socket (1) and Grevsten (9) mentions it in his description of the suction socket below-knee prosthesis. There can be little doubt that many amputees use it to supplement or eliminate more conventional means of suspension. More than one patient, when questioned closely, has described being able to walk short distances about the house without fastening the cuff; and this mechanism presumably accounts for the ability to ambulate without ill effects or complaints with an improperly fitting cuff suspension strap. The author encountered some years ago two young amputees (secondary to congenital defects) who had discarded any other forms of suspension. One, a young female in her teens, had literally thrown the medial brim of her supracondylar suspension prosthesis away, and the other, a female in her 30's, was an active skier who evinced a desire for an auxiliary suspension aid only in that activity.

Recently Dr. Ernest Burgess of Seattle, Washington, has described his research in this area (10, 11) referring to it as physiological suspension. This is an outgrowth of his earlier work to create more functional stumps by such methods as myoplasty and myodesis, and has led him to re-evaluate the concepts of Blevens.

Certainly, the idea is philosophically attractive. Not only would it result in a cleaner looking, more cosmetic prosthesis

without a cuff or supracondylar brims to protrude above the knee in sitting, promote greater activity of the remaining musculature with physiological benefits, it would also maximize the patient's potential to minimize his dependence on an external aid with important psychological and philosophical overtones. Certainly, the technique is not applicable to all patients and much work needs to be done to develop logical criteria for the method's application.

Suction Socket

In his discussion of suction socket below-knee prostheses Dr. Murphy (2) states that the U.S. Army's Commission on Amputations and prostheses in its tour of Germany after the war observed a few suction socket BKs and considered them relatively unsuccessful. Dr. Murphy attributed this to the relatively high ratio of bony prominences to soft tissues (as compared to the above-knee stump) and the consequent need to establish an initial accurate fit and subsequently maintain it with great accuracy despite changes in stump volume and contour. The attractions of suction are great and certainly are not to be dismissed lightly. If suspension can be established in the distal portion of the socket the proximal trim lines can be lowered with greater cosmesis and free the patient of constraints about the knee. Further, suction should reduce the possibilities of skin abrasions and increase the patient's awareness of the prosthesis.

While American interest in the suction socket for the below-knee amputee has been dormant, since about 1968 Swedish investigators (9, 12) have been working with the PTB suction prosthesis. Considerable work has been done by them over the years to demonstrate the effects of suction sockets and this work was recently summarized by Grevsten in *Prosthetics and Orthotics International* (9). Similarly Gunnar Holmgren has discussed the matter from the prosthetist's viewpoint (12). Both authors stress the necessity to displace the soft tissues of the stump distally, both for safety in weightbearing and to develop tension between the skin and socket walls for suspension. Indeed Holmgren is quite emphatic about this being a major factor in the proper function of the PTB-suction socket. This use of tension between the socket walls and the skin is very similar if not identical to the principle used in the Blevens socket. However, as the information or technique is scanty it is difficult to fully assess these matters. One distrubing note concerning the Grevsten article (9) suggests itself. In the picture sequence showing the patient donning the prosthesis the use of a rubber suspension rubber suspension sleeve to preserve suction in extreme knee flexion is mentioned. The true advantage of a suction socket would seem to be the elimination of the necessity to encompass the knee for suspension.

Rubber Sleeve Suspension

Since about 1968 (13,14) the workers at the University of Michigan, Ann Arbor, have accumulated considerable experience with a form of suspension using a rubber sleeve (Fig. 8) in conjunction with and without a gel liner. In an article (13) describing an investigation of the functioning principles three suspensory forces are attributed to the rubber sleeve: negative pressure, friction between the stump and socket, and longitudinal tension in the sleeve. With the use of pressure transducers and by means of selectively introducing leaks in the sleeves of nine subjects the investigators were able to demonstrate to their satisfaction that negative pressure played an important role in the suspension of the protheses. It is interesting to note, as the investigators point out, that one subject with a very full and fleshy stump showed

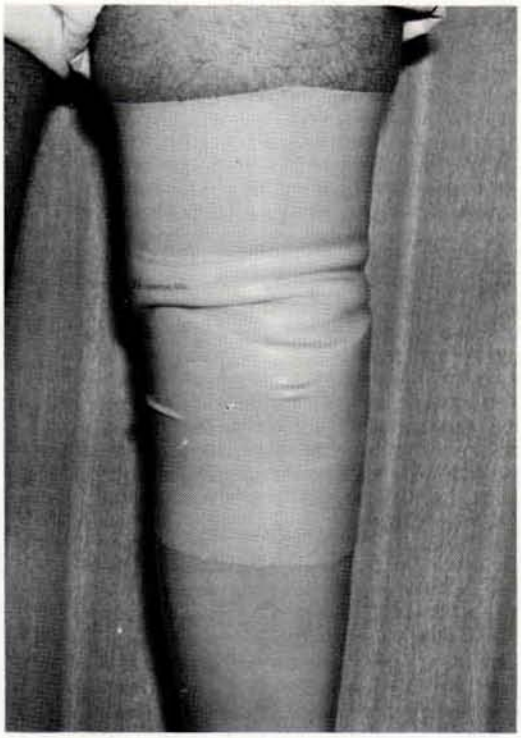


Fig. 8. The rubber sleeve suspension technique

no degradation of suspension affect when the sleeve was punctured.

It is obvious, then, both from a clinical point of view and from laboratory studies that the rubber suspension sleeve is a relatively simple and effective means of suspension. The only question that remains is whether or not the suspension effect is worth more than the side effects. While doubtlessly many patients are more than satisfied using suspension sleeves other patients have been disturbed by the sense of constriction, heat and perspiration build-up under the sleeve, and the relative fragility of the sleeves. The question must, of course, be answered on an individual basis, but it is possible in a broader sense to register an objection on aesthetic or idealistic grounds. It would seem that the true advantage of suction suspension is the freeing of the knee joint from the constrictions necessary for suspension. A rubber suspension sleeve that passes proximal to the knee joint would seem to violate this principle. Whether or not it is possible to maintain suction without a sleeve remains to be established and the simplicity of application of the sleeve is certainly a point in its favor.

Brim Suspension

In contrast to the suspension techniques discussed until now, brim suspension techniques find no mention in the two works of Dr. Murphy cited earlier (1,2). It would seem then that the concept is a new one and a logical outgrowth of experience with the PTB (the author can not assert positively that there is no precursor as the world literature is unavailable and by no means has a search for historical predecessors been made). It is interesting that the extensive armamentarium of brim suspension techniques developed while such earlier forms of self-suspending sockets as suction and muscular grasp were slighted. It is also interesting that the pendulum has begun to swing in the other direction.

In any event the central issue of brim suspension is how to permit passage of the wide femoral condyles through the relatively narrow inlet necessary to secure a proper grip immediately proximal to the adductor tubercle. It is the various solutions to this question that has given rise to the many variations reported on in the literature. In addition to suspension, extending the trimlines proximal affords other benefits as well. An increase in surface area encompassed leads to a decrease in the unit pressure, while the extension of lever arms proximally and intimate grip of the bony structure of the knee increases stabilization against such undesirable motions as lateral shift in the case of supracondylar suspension and

supracondylar-suprapatellar suspension and, in addition, hyperextension in the case of supracondylar-suprapatellar suspension. The net effect then of such a prosthesis when properly fitted is an increase in patient control and comfort with a decrease in pistoning and other undesirable motions. These positive benefits must be balanced by such negative factors as a possible decreased cosmesis, increased weight, greater expense, difficulty in fitting, and difficulty in adjustment to the supracondylar pressure. It must also be remembered that brim suspension techniques have made it possible to fit patients that otherwise would be unamenable to anything but knee joints and a thigh corset (15,16, 17). For the most part, it is now necessary to resort to this latter extreme only in cases where the patient's stump needs positive relief from superimposed weight.

The proliferation of PTB variants led the Veterans Administration to issue a Program Guide in 1970 (18) that organized the variants in a logical fashion, developed a consistent nomenclature, and gave recommendation for their prescription. Since then the nomenclature presented has come to be adopted by most writers in the field. Every attempt is made in the ensuing discussion to adhere to this standard nomenclature in referring to brim configurations. A revised version of the chart to reflect developments made since 1970 is shown in Figure 9. In a similar vein James Breakey (19) set forth the method he used to objectively determine the specific brim configuration (supracondylar vs. Supracondylar-suprapatellar) that best met a particular patient's needs. Despite these efforts, there is no universally agreed upon procedure or set of recommendations for prescribing brim configuration, wedge or suspension type, or socket type (hard vs. soft). Nor is there one manual or standard procedure for casting and fitting the various brim suspension techniques despite their many points of similarity. It may be argued that it is unnecessary to develop such universal procedures but it should be kept in mind that the present system, shrouded as it is in parochialism, denies all patients equal access to all the options and means that a prosthetist attempting an unfamiliar technique for the first time may have nothing in the way of written guidance to go on. This may very well mean needless experimentation, frustration, and eventual abandonment of an otherwise successful variant.

Supracondylar-Suprapatellar PTB (PTS)

Apparently the first formal introduction of the supracondylar-suprapatellar technique (Fig. 10) occurred in a 1964 edition of *Atlas d'Appareillage Prosthe'tique et Orthope'dique* (20) by Pierquin, Fajal, and Paquin who referred to it as the PTS (Prosthe'se tibiale Supracondylienne). Points of contrast between the PTS and the PTB were covered in a subsequent issue of Orthotics and Prosthetics in 1965 (21). Kurt Marschall and Robert Nitschke described the PTS in the American literature first in 1966 (22) and again in 1967 (23) and have become in time inextricably linked to the development of it in this country.

As described by these various authorities the supracondylar-suprapatellar (SC-SP) PTB includes a flexible insert and extends proximal to the patella and femoral condyles. Great emphasis is put on the role of the suprapatellar identation for suspension of the prosthesis and for prevention of undesirable hyperextension of the knee by the patient in gait and stance. In contrast to the work of other developers relatively little emphasis is given in these early reports to the suspension possibilities inherent in the supracondylar extensions. More emphasis

Fig. 10. The PTS system

is given to their contribution to stabilization of the prosthesis.

While the names of Nitschke and Marschall have become almost synonymous with the use of a liner, in both articles (22,23) they describe in passing the use of a hard socket and even mention in one (23) the possibility of using compressible medial and lateral wedges in a hard socket, if necessary. Similarly, Breakey and Foort in 1970 (24) described a SC-SP PTB featuring a socket laminated of flexible polyester connected to a pylon by a rigidly laminated socket receptacle that also provided support in the weight-bearing areas. Hard socket PTB's with SC-SP suspension continue in use but their use is very much taken for granted as there is little or nothing published describing the particular features or problems involved in their use. Presumably the lack of a yielding or removable element above the condyles would imply that a hard socket PTB with SC-SP suspension would be used for a patient for whom only a small reduction in supracondylar ML was necessary or who could achieve sufficient suspension elsewhere (suprapatellar, muscular grasp, etc.). Patients who wear such a socket generally don it from the posterior aspect through the suprapopliteal opening with a corkscrewing motion.

Removable Medial Wedge

In 1966 Dr. C.G. Kuhn (25) published details of a prosthesis he named Kondylen Bettung Munster (KBM) and in June 1966 Carlton Fillauer (26) published in *Orthotics and Prosthetics* details of the development and fabrication of a similar design (Fig. 11) based on Dr. Kuhn's work. Mr. Fillauer proposed to call this prosthesis the S.T.P. or Supracondylar Tibia Prosthesis. Neither name ever really caught on and today the design is generally referred to as PTB with removable medial wedge or PTB with Fillauer wedge.

In any event, whatever the name, it describes a hard socket PTB cut low over the patella with supracondylar wings and a removable medial wedge. The wedges are prefabricated of Plastisol, in a range of sizes and thicknesses and available from Fillauer Orthopedic Supply. In use the cast is taken over the wedge which is secured in place proximal to the medial condyle by a strip of tape. Elastic plaster-of-Paris bandage is used and snugly wrapped proximally to reduce the supracondylar ML diameter. Similarly the cast

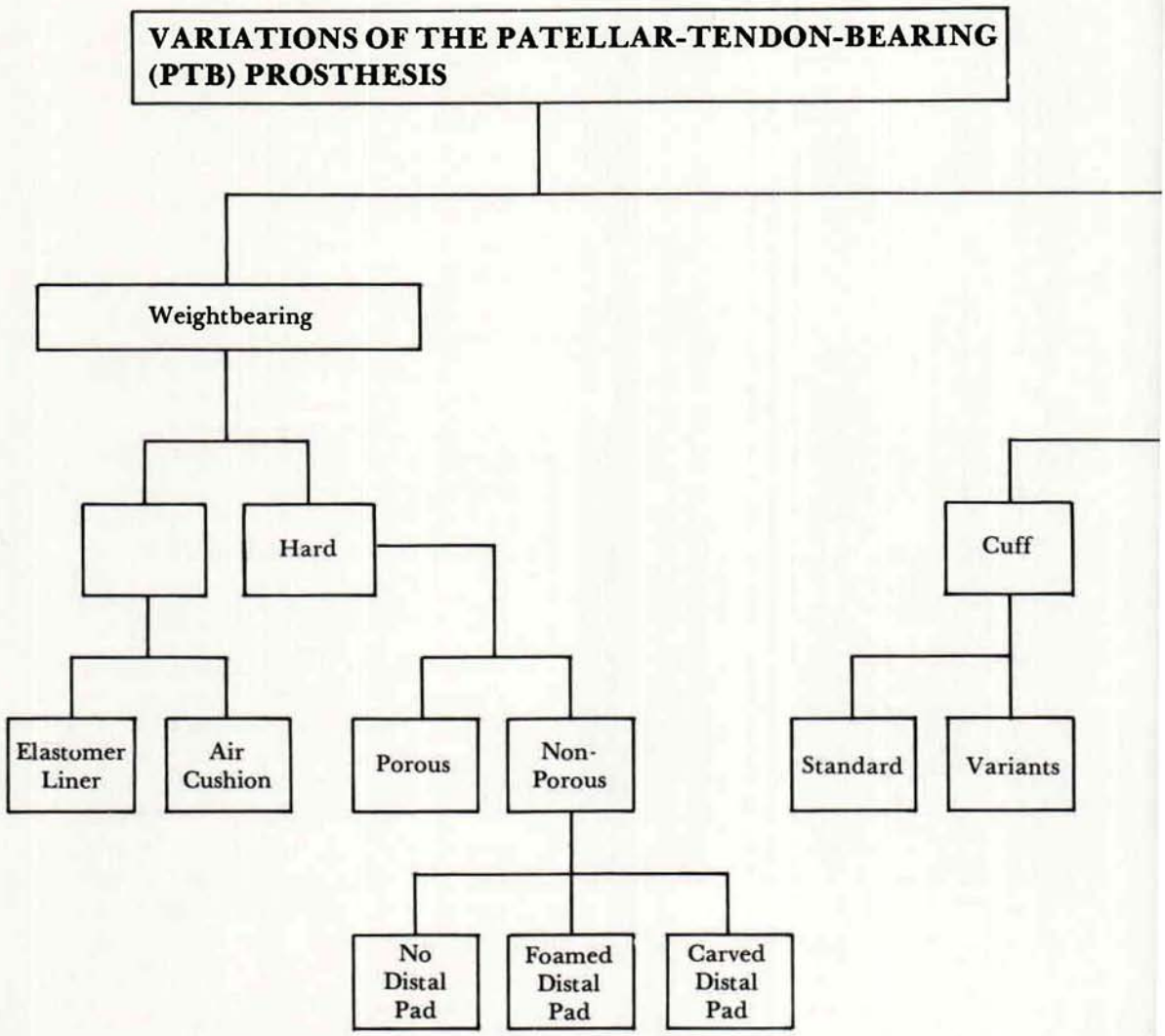
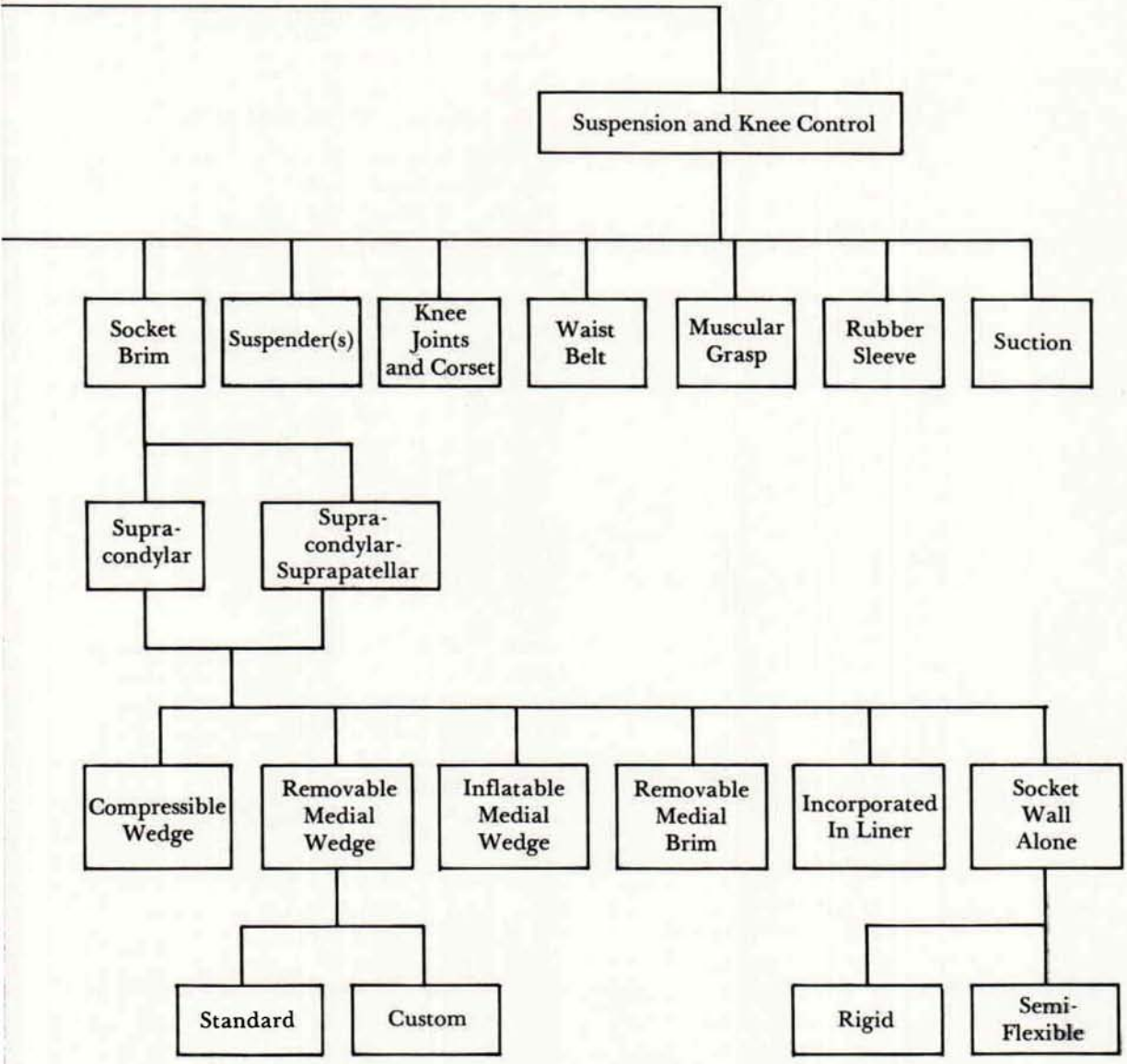


Fig. 9. Variations of the Patellar-Tendon-Bearing (PTB) prosthesis (Revised from (18) to reflect


Suspension and Knee Control
Socket Brim
Suspender(s)
Knee Joints and Corset
Waist Belt
Muscular Grasp
Rubber Sleeve
Suction
Supra-condylar
Supra-condylar-Suprapatellar
Compressible Wedge
Removable Medial Wedge
Inflatable Medial Wedge
Removable Medial Brim
Incorporated In Liner
Socket Wall Alone
Standard
Custom
Rigid
Semi-Flexible

is filled with the wedge in place and the model is modified to provide a narrow lip in the socket proximal to the wedge to hold it in place. The socket is also laminated with the wedge in place.

An interesting variation on the basic concept of a removable medial wedge is that developed at the Prosthetic Research Study in Seattle, Washington. Described as early as 1969 (27) this technique was described in greater detail by Joseph Zettl at the "Workshop on Below-Knee

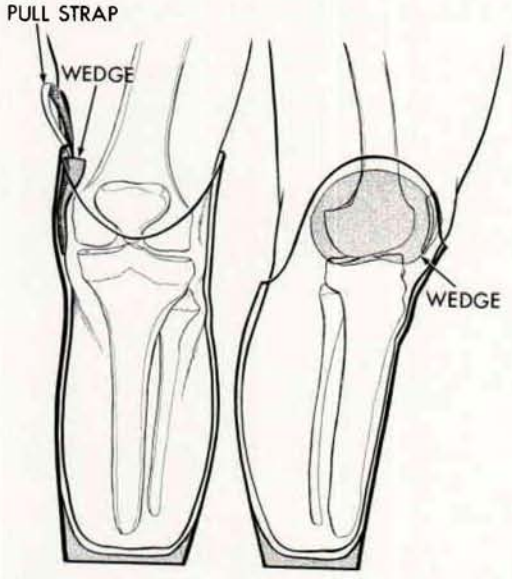


Fig. 11. The Fillauer removable medial wedge system

and Above-Knee Prostheses" held in Seattle, Washington January 1973 (28).

Basically, a custom fitted wedge is fabricated over the modified model of the patient's limb using nylon stockinette, Dacron felt, polyester resin, and Sulkafloc. One or two pins protrude medially from the wedge and lock it into place on the medial wall of the socket. If only one pin is used, the wedge is free to pivot during flexion of the knee, affording greater comfort to the amputee. This latter point is a refinement from the original technique where two pins were routinely used. Mr. Zettl emphasized that the wedge could be used with both supracondylar and supracondylar-suprapatellar sockets, any kind of soft insert, readily modified, and, if necessary, padded.

Compressible Medial Wedge

The Compressible Medial Wedge is a suspension variant peculiar to southern Florida where it has achieved a considerable measure of popularity. Perhaps the earliest mention of it in the literature occurs in the August 1970 issue of *Newsletter . . . Amputee Clinics* (29) in which Dr. Newton C. McCullough III briefly describes it and attributes its development to William Sinclair, then chief research prosthetist at the University of Miami. Similarly Dr. Augusto Sarmiento writing in the Spring 1971 issue of *Bulletin of Prosthetic Research* (30) describes the wedge and states that some 200 patients had been fitted with it by that time.

Essentially the medial and lateral brims of the PTB socket are extended proximally above the level of the adductor tubercle and during the fitting process a soft wedge similar in shape and cross-section to the removable medial wedges sold by Fillauer Orthopedic Supply is located in place above the adductor tubercle so as to achieve proper suspension. When proper shape and location of the wedge is determined it is glued in place and covered with leather. In use then, to don or doff the prosthesis the patient would merely push or pull his limb in or out of the prosthesis and the wedge would compress to allow passage of the femoral condyles. William Sinclair has stated (28) that in most instances a medial wedge alone has proven sufficient, but, if necessary, a lateral wedge

can be used and in cases of supracondylar-suprapatellar suspension the compressible wedge has been extended anteriorly proximal to the patella. These wedges are most often carved of the polyurethane foam used for SACH foot heel cushions using a wire wheel, although Hugh Panton in personal communication has mentioned molding them of the RTV Silicone Elastomer formerly used for below-knee distal end pads.

This then would seem to be a very useful and easily adopted suspension technique, and the reasons why it has not enjoyed wider popularity are somewhat puzzling. There would seem to be nothing radically different to be done in the casting and modification procedures and the carving and fitting of the wedge would seem to offer no particular difficulties. Once glued in place and covered the wedge is an integral part of the prosthesis and can not be removed and lost, which should be a welcome thought to those used to the vagaries of some patients' behavior.

Removable Medial Brim

Apparently the first mention of the removable brim (Fig. 12) technique occurs in June of 1971 in an edition of *Newsletter . . . Amputee Clinics* (31). Carlton Fillauer then gave fuller details of the rationale behind the brim's development and the fabrication technique in December 1971 (32). In this article Mr. Fillauer stated that the development of the removable medial brim resulted not from dissatisfaction with the removable medial wedge, but rather from the need for a technique to accommodate patients in whom the difference between the condylar ML diameter and the supracondylar ML diameter was greater than could be accommodated with the available prefabricated removable medial wedges. The method consists of fabricating a supracondylar PTB hard socket with a curved metal bar and channel positioned medially so that the entire medial wall proximal to the widest point of the femoral condyles could be removed and replaced. No attempt is made to cushion or upholster the medial wedge and Mr. Fillauer stated his belief, in opposition to those who advocated such soft wedges, that hard wedges when properly fitted were well tolerated by patients.

The hardware has changed some since its original introduction but the method remains substantially unchanged. Material can be added or removed from the medial brim as necessary and indeed the fit can be altered if needed by bending the metal bar to bring the wedge in or out

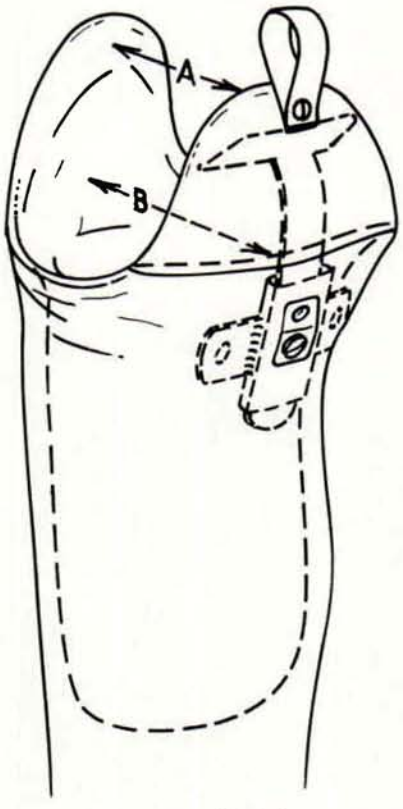


Fig. 12. The Fillauer removable brim system

or to change the angle relative to the sagittal plane. Further, the height of the wedge can be changed in a similar fashion. When properly finished the brim of the prosthesis presents a very acceptable cosmetic effect both sitting standing. While intended to be used with hard socket supracondylar PTB's it can be used with liners or in supracondylar-suprapatellar sockets. In this latter configuration the medial horizontal cut is extended anteriorly and meets with a vertical cut that splits the patella. The only problem that may be encountered with this variation is gapping of the vertical cut when the patient's knee goes into hyperextension in late stance phase. This gapping can be minimized by being certain that the bar and channel assembly are properly positioned on the midline of the medial wall or even slightly anterior to it.

Inflatable Medial Wedge

In March of 1973 (33) and again in December of 1973 (28) Timothy Staats described the development of inflatable medial wedge (Fig. 13) which he ascribed to Lincoln Baird. Basically two fluid filled bulbs are used with a short length of tube connecting the two and a needle valve used to control the passage of fluid between them. One, an ordinary rubber squeeze bulb as used in measuring blood pressure, is secured in the popliteal area of the prosthesis. The other resembles the removable medial wedge as described by Carlton Fillauer and is placed inside the prosthesis proximal to the medial femoral condyle. In use fluid would be pumped into the suspension wedge to affect suspension and evacuated to permit donning and doffing. The critical feature is that it permits the patient to adjust the suspension so suit himself and to accommodate fluctuations.

Fig. 13. The inflatable medial wedge

Mr. Staats mentioned that a limited number of patients were fitted with very encouraging results, but that numbers were limited by the number of units available. Leakage apparently was a problem with the first units fabricated but this was subsequently eliminated. Since these early publications little or no information is available in print nor do the units seem to be commercially available.

A telephone conservation with Mr. Staats in January of 1979 elicited the following facts. The inflatable wedge continued to be used for some 2 or 3 years after 1973 and some 50 patients were fitted with it. Contrary to the early expectations leakage continued to be a problem and eventually the Removable Medial wall supplanted it. The inflatable wedge is no longer available and the remaining stock of some 50 units was donated to the prosthetic curriculum and UCLA where its use is still taught as one of the options to be considered for suspension of the PTB.

Conclusion

A general overview of Below-Knee Prosthetic suspension techniques has

been conducted. In general, three broad trends can be discerned. First, a group of older suspension techniques have remained static and been supplanted by new ones since the introduction of the PTB and variants. Second, another group of techniques abandoned when the PTB was introduced have recently gained fresh appreciation. Third, an entire new group of suspension variants, all employing common principles, have emerged and gained widespread acceptance. It may very well be that the ultimate suspension technique is skeletal attachment but in the meantime there is no lack of options to be considered. What apparently is lacking is a universally accepted set of clearly enunciated guidelines to illuminate the situation.

[1]Rehabilitation Engineering Center, Moss Rehabilitation Hospital-Temple University-Drexel Hospital, Philadelphia, Pa. 19141.

BIBLIOGRAPHY

1. Eugene F. Murphy, Ph.D. "Lower-Extremity Components," *Orthopedic Appliances Atlas Vol. 2.* J.W. Edwards, 1960, pp. 217-224.
2. Eugene F. Murphy, Ph.D. "The Fitting of Below-Knee Prostheses," *Human Limbs and their Substitutues,* Hafner Publishing Co. first edition 1956, second edition 1968, pp. 719-724.
3. American Academy of Orthopaedic Surgeons, "Historical Development of Artificial Limbs," *Orthopedic Appliances Atlas Vol. 2.* J.W. Edwards, 1960, p. 7.
4. Hugh J. Panton, B.S., C.P.O. "Considerations for Joints and Corset," *Newsletter . . . Amputee Clinics* 8:3: June 1975, pp. 1-3, 6-7.
5. Committee on Prosthetics Research and Development, National Academy of Sciences, "Joints, Corsets, and PTB Sockets: Survey Report," *Newsletter . . . Amputee Clinics* 8:5: October 1975, pp. 5-7, 10-12.
6. Radcliffe, C.W. and James W. Foort. *The patellar-tendon-bearing below-knee prosthesis,* Biomechanics Laboratory, University of California, 1961, pp. 119-130.
7. John Girling and Gordon Cummings. "Artificial Limbs Fabrication without the Use of Commercially Made Components," *Prosthetics International,* 4:2, 1972, pp. 21-25.
8. Jack Caldwell, C.P. "Inverted V-strap Suspension for PTB Prosthesis," *Artificial Limbs,* 9:1:23-26, Spring 1965.
9. S. Grevsten. "Ideas on the Suspension of the Below-Knee Prosthesis," *Prosthetics and Orthotics International,* 2:1: April 1978, pp. 3-7.
10. Ernest M. Burgess, M.D. and A. James Moore. "A Study of Interface Pressures in the Below-Knee Prosthesis (Physiologic Suspension: An Interim Report)," *Bulletin of Prosthetics Research,* BPR 10-28 Fall 1977, pp. 58-70.
11. Ernest M. Burgess, M.D., Anne G. Alexander, R.P.T., and Charles P. Rubenstein, M.S. "The Effect of Stump-Muscle Activity on Socket Suspension and Prosthetic Control," *Inter-Clinic Information Bulletin,* 13:15: 11-17, December 1974.
12. Gunnar Holmgren. *The PTB Suction Prosthesis* from the written material of a lecture delivered at the third of the "Strathclyde Bioengineering Seminars 8-11 August, 1978.

13. Naoichi Chino, M.D. et al. "Negative Pressures during Swing Phase in Below-Knee Prostheses with Rubber Sleeve Suspension," *Archives of Physical Medicine and Rehabilitation,* Vol. 56, Jan. 1975, pp. 22-26.
14. Joseph P. Giacinto. "The Rubber Sleeve Suspension for Below-Knee Prostheses," *Orthotics and Prosthetics* 30:4:17-19, Dec. 1976.
15. Sam E. Hammontree, C.P., Howard J. Tyo, C.P. and Snowden Smith, C.P. "Twenty Months Experience with the PTS," *Orthotics and Prosthetics* 22:1:33-39, March 1968.
16. Gustav Rubin, M.D., Robert Nitschke, C.P., and Henry F. Gardner, C.P.O. "The Supracondylar-Suprapatellar PTB Prosthesis," *Bulletin of Prosthetics Research* BPR 10-14, Fall 1970, pp. 102-106.
17. James F. Richards, Jr., M.D., John N. Pierce, C.O. "Knee Disarticulation Successfully Fitted with a PTS Socket," *Inter-Clinic Information Bulletin* Vol. XVI Nos. 3-4, March-April 1977, pp. 7-10, 17.
18. Program Guide G-6 M-2, Part IX, April 1, 1970, "Variants of the PTB (Patellar Tendon Bearing) Below-Knee Prosthesis," Veterans Administration, Dept. of Surgery and Medicine, Prosthetic and Sensory Aids Service, Washington, D.C.
19. James W. Breakey, B.Sc. "Criteria for Use of Supracondylar and Supracondylar-Suprapatellar Suspension in Below-Knee Prostheses," *Orthotics and Prosthetics* 27:3:14-18, September 1973.
20. Pierquin, L., Fajal, G., and Paquin, J.M. "Prosthe'se Tibiale a' Emboitage Supracondylien," *Atlas d'Appareillage Prosthetique et Orthopedique,* No. 1, 1964.
21. Pierquin, L., Fajal, G., and Paquin, J.M. "Discussion Sur Les Prostheses Tibiales," *Atlas d'Appareillage Prosthetique et Orthopedique,* No. 9, 1965.
22. Kurt Marschall, C.P. and Robert Nitschke, C.P. "The PTS Prosthesis," *Orthopedic and Prosthetic Appliance Journal,* 22:2:123-126, June 1966.
23. Kurt Marschall, C.P. and Robert Nitschke, C.P. "Principles of the Patellar Tendon Supracondylar Prosthesis," *Orthopedic and Prosthetic Appliance Journal* 21:1:33-38, March 1969.
24. James Breakey, B.P.T. with an introduction by James Foort, M.A. Sc. "Flexible Below-Knee Socket with Supracondylar Suspension," *Orthotics and Prosthetics,* 24:3:1-10, Sept. 1970.
25. Kuhn, G.G., Burger, S., Schetter, R. and Fajal, G. "Kondylen Bettung Munster am Unterschenkel Stumpf," "KBM Prosthese," *Atlas d'Appareillage Prosthetique et Orthopedique* No. 14, 1966.
26. Carlton Fillauer, C.P.O. "Supracondylar Wedge Suspension of the P.T.B. Prosthesis," *Orthotics and Prosthetics,* 22:2:39-44, June 1968.
27. Joseph H. Zettl, C.P. "Prosthetics Research Study, Progress Report, December 1, 1967—June 30, 1969," *Bulletin of Prosthetic Research* BPR 10-12, Fall 1969, p. 281.
28. Hector W. Kay and June D. Newman. "Report of Workshop on Below-Knee and Above-Knee Prosthetics," *Orthotics and Prosthetics,* 27:4:9-25, Dec. 1973.
29. Newton C. McCollough, III, M.D. "Method for Suspension of Below-Knee Prostheses" *Newsletter* . . .

Amputee Clinics 2:4:8, August 1970.

30. Augusto Sarmiento, M.D. "Progress Report from the University of Miami, Miami, Fla." *Bulletin of Prosthetics Research* BPR 10-15, Spring 1971, p. 237.
31. Carlton Fillauer, C.P.O. "Variations in Suspension of the PTB Prosthesis," *Newsletter . . . Amputee Clinics* 3:3:8, June 1971.
32. Carlton Fillauer, C.P.O. "A Patellar-Tendon-Bearing Socket with a Detachable Medial Brim," *Orthotics and Prosthetics* 25:4:26-34, December 1971.
33. Timothy Staats, M.A., C.P. "Inflatable Wedge Suspension System," *Orthotics and Prosthetics* 27:1:34-37, March 1973.

Orthotics and Prosthetics, Vol. 33, No. 2, pp. 20-30, June 1979

Vacuum-Forming Procedure for the Fabrication of Non-Standard Spinal Orthoses

Larry Mortensen, C.O.[1]

Today in orthotics there are many plastic orthotic modules readily available to the orthotist in the management of scoliosis and other spinal problems. The modular systems can be used most effectively in correcting and/or positioning, achieving good results in many cases. What about the patient who is hard to fit with a modular orthosis or the orthotist who would like a more intimate fit by controlling the modifications of the positive model?

The "Drape Vacuum-forming Procedure" is a simple procedure for the fabrication of a "custom" orthosis that can be carried out easily by two people.

Fabrication

The first step in preparing the positive model for the vacuum-forming procedure is to draw a mid-line with indelible pencil down the posterior aspect of the model (Fig. 1).

A long shaft ½-in. diameter drill is used to drill a hole from the distal to proximal surfaces parallel to the midline and from 1-½ inches to 2 inches below posterior aspect of the model (Figs. 2-4). If the drill shaft is shorter than the length of the cast a hole can be drilled from the proximal end to meet the one started from the distal end, or vice versa.

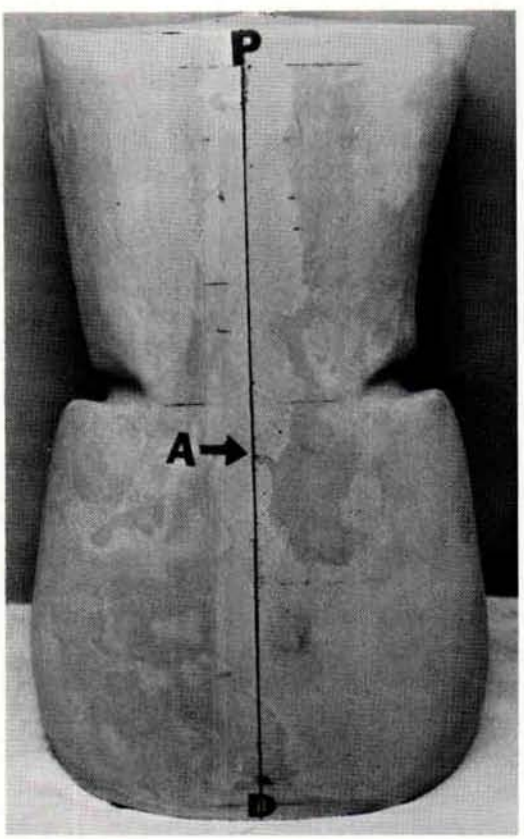


Fig. 1. The mid-line is used as a reference point for aligning bit when drilling longitudinal shaft.

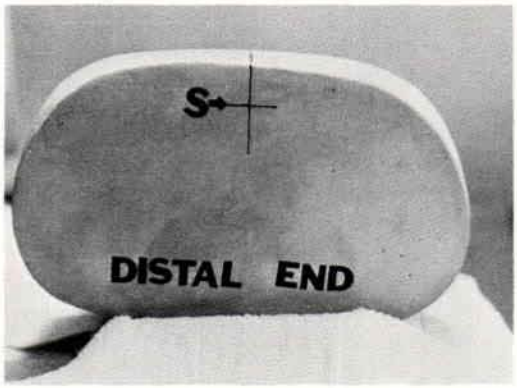


Fig. 2. Longitudinal shaft must be well below posterior surface to accommodate for irregularities in the posterior surface of the model, and to prevent cave-in from the drilling of the surface holes.

A #29 drill is used to provide holes approximately ½ in. apart down the mid-line drawn on the posterior aspect of the model to connect with the longitudinal shaft (Figs. 5 and 6) to permit evacuation of air between the model and the plastic when the plastic is draped over the model.

An air hose should be used to clear plaster debris from all surface holes and the main shaft. Once all holes are drilled and cleared, the interface is applied. The interface I prefer is medium density Pelite, non-perforated, 5 mm (3/16 inches), because of its resistance to compression during the vacuum-forming procedure.

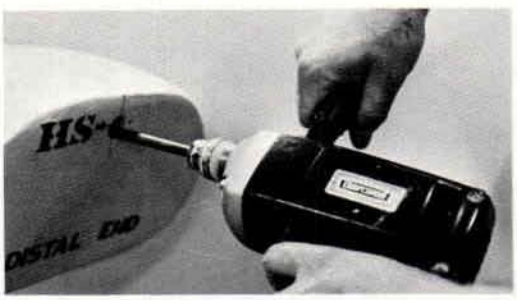


Fig. 3. The drill bit must be held level to posterior surface. It must not deviate from mid-line when drilling shaft. H.S. — horizontal shaft.

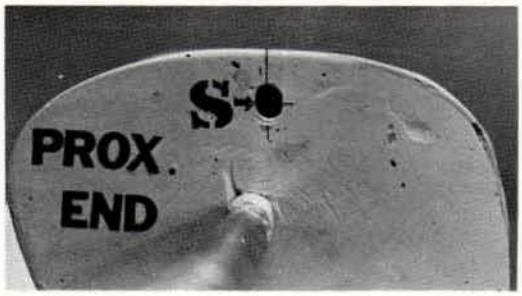


Fig. 4. If the shaft of the drill is not long enough to reach the proximal end a hole to meet it is drilled.

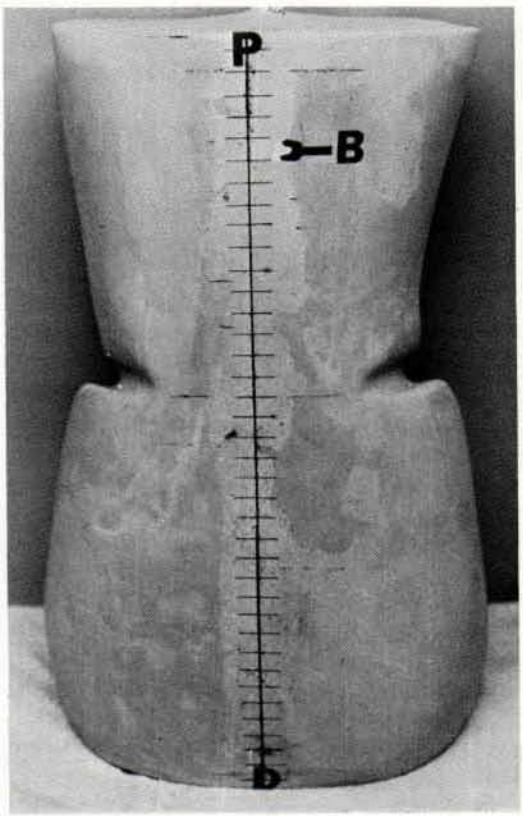


Fig. 5. Surface holes are drilled approximately ½ inch apart to direct the flow of vacuum air evenly from around model when the plastic is draped and suction is applied.

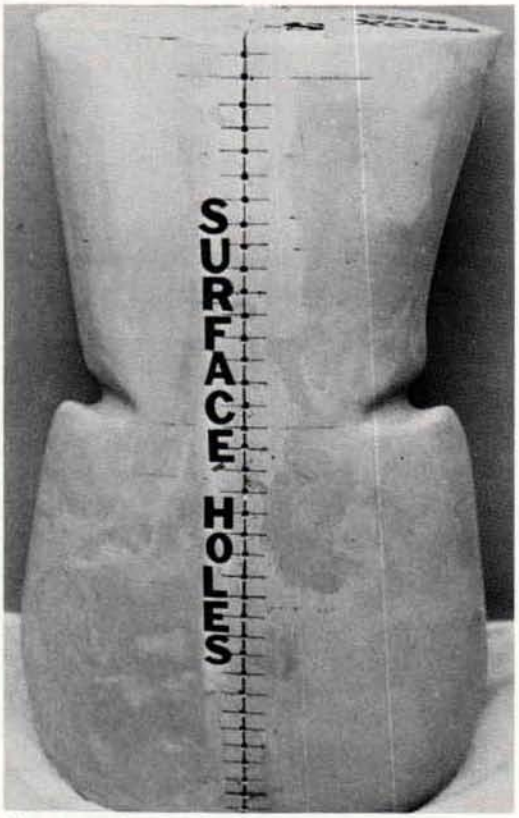


Fig. 6. Surface holes are used for evacuation of air from around the model, and for alignment of the posterior seam when draping plastic on model.

The Pelite is heated at 265 deg F about one minute or until moldable. It is then stretched and wrapped with Ace bandage to conform to the model (Figs. 7 and 8). When the Pelite is cool, one side of the interface is stapled as close as possible along the surface holes (Fig. 9). Excess material is cut off, and the procedure is repeated on the opposite side (Fig. 10).

The polyethelene may be formed directly over the Pelite liner in which case the two materials are bonded to each other. However, I prefer to place a layer of cotton stockinet (Fig. 11) over the liner-covered model to prevent bonding because this arrangement permits the insertion of pads between the liner and shell if needed and finishing is easier when the two materials are separate. Proximal and distal end caps fabricated of Plastizote and about one inch larger in diameter than the proximal and distal ends are put into place and the proximal Plastizote cap is heated in the center with a heat gun and pulled over the end of the pipe to form a nipple (Fig. 12). A small "X" is cut into the top of the

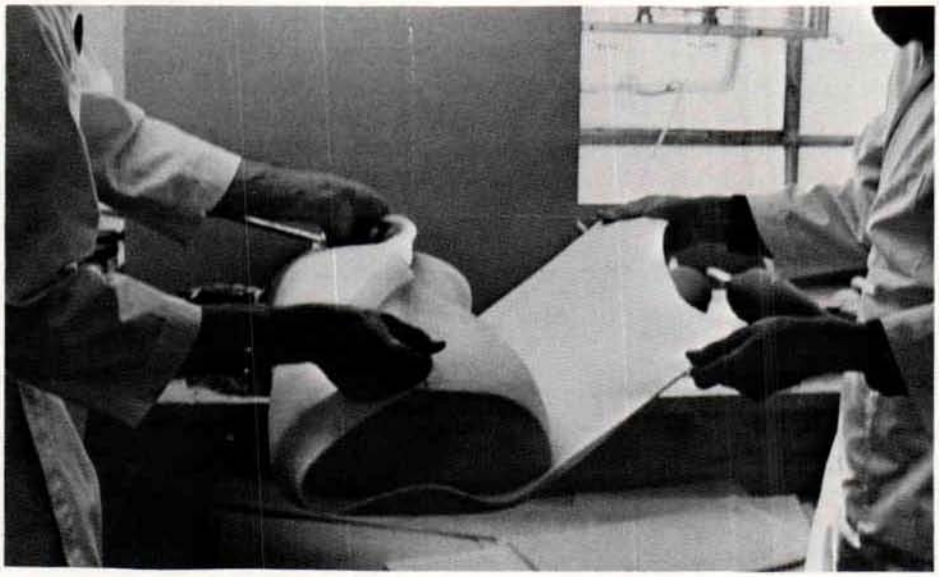


Fig. 7. The Pelite interface is heated, then stretched over the model.

Fig. 8. Ace bandage is used to hold Pelite in place.

nipple and pulled down, exposing the pipe.

The proximal cap is sprayed with a foam type of upholsterer's contact cement and attached to the model. The nipple opening is taped securely with electrical tape at the base of the pipe forming an air-tight connection. The distal cap is then placed on the model and an "X" marked on the Plastizote indicating the location of the horizontal shaft hole (Fig. 13). The "X" area is again heated to form a nipple and cut as before. The vacuum supply hose is placed into the distal end cap nipple and taped securely. It should extend about ½ inch beyond the inside of the nipple so that it may be inserted

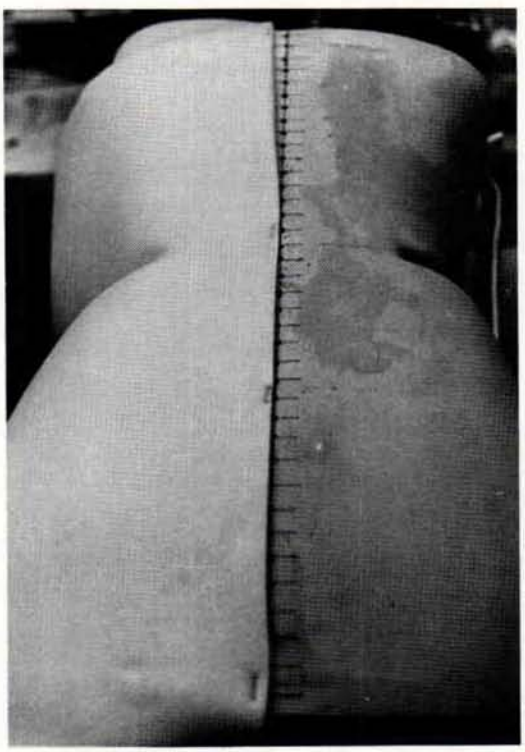


Fig. 9. When the Pelite is cool one edge is stapled as close as possible along the surface holes.

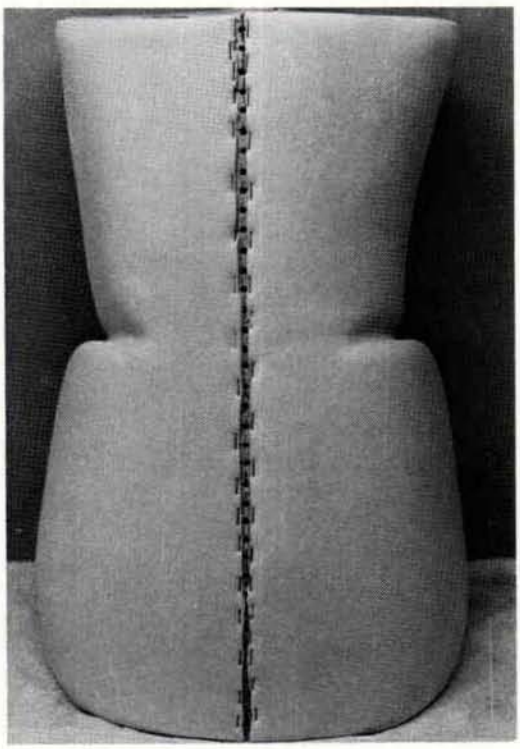


Fig. 10. Excess Pelite is cut off and the edge is stapled along the surface holes.

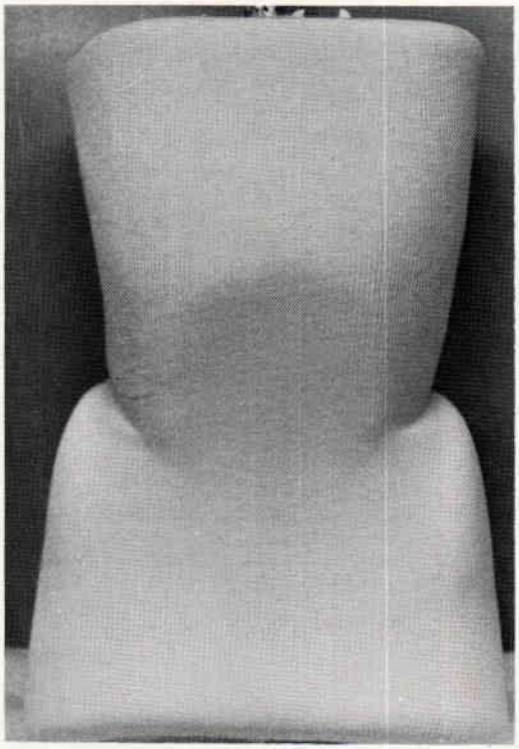


Fig. 11. Cotton stockinet is used to provide a non-adhering interface between Pelite and plastic sheet.

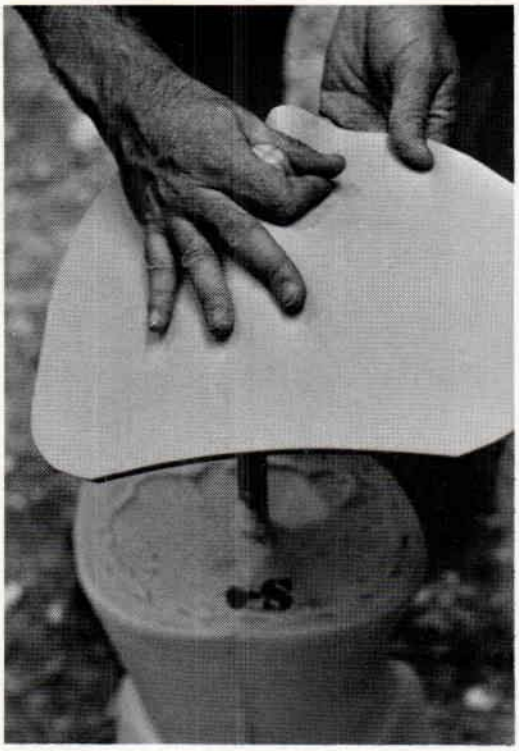


Fig. 12. The polyethylene foam Plastizote end cap is heated and a nipple is formed to be used to secure end cap to pipe.

Fig. 13. Locating distal horizontal shaft to form nipple.

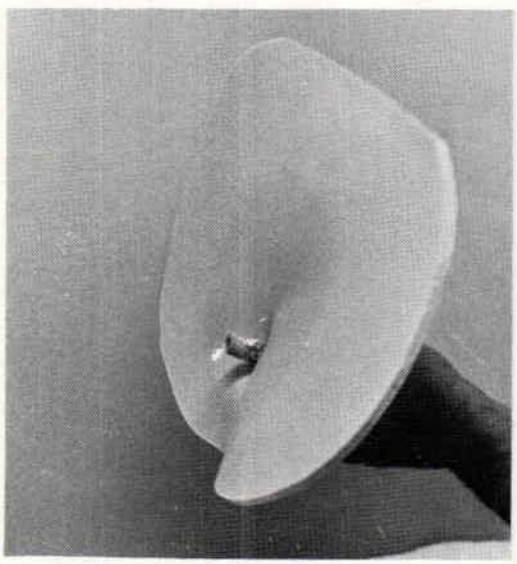


Fig. 14. The vacuum supply hose is inserted in the distal end cap nipple and taped securely.

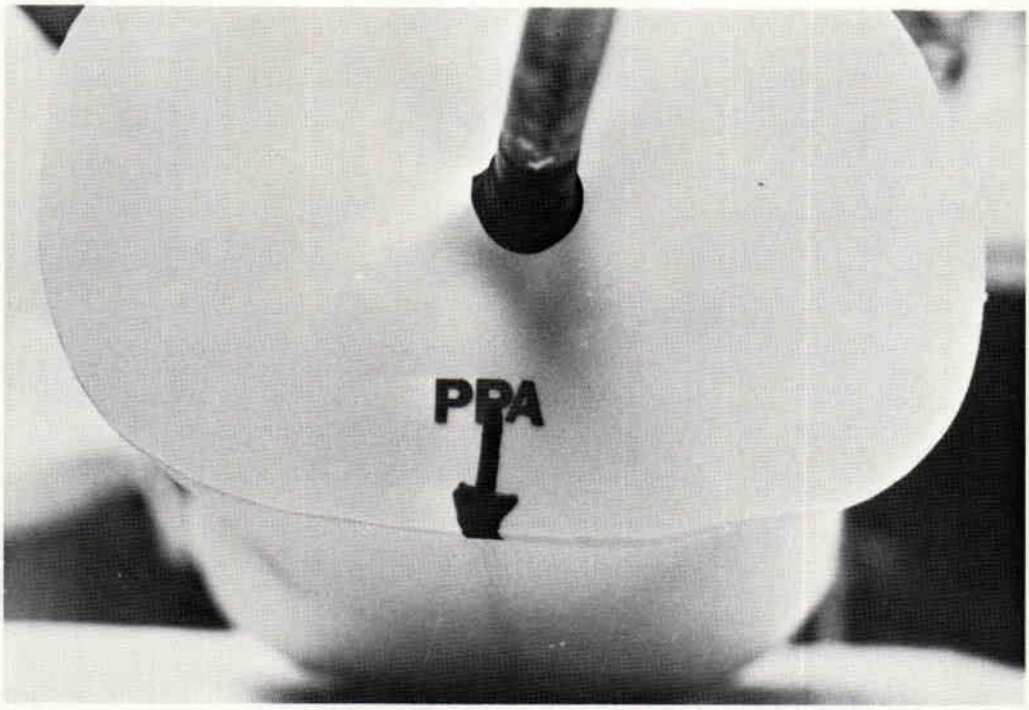


Fig. 15. P.P.A. (posterior proximal arrow) points to surface holes and is used for alignment of plastic when molding.

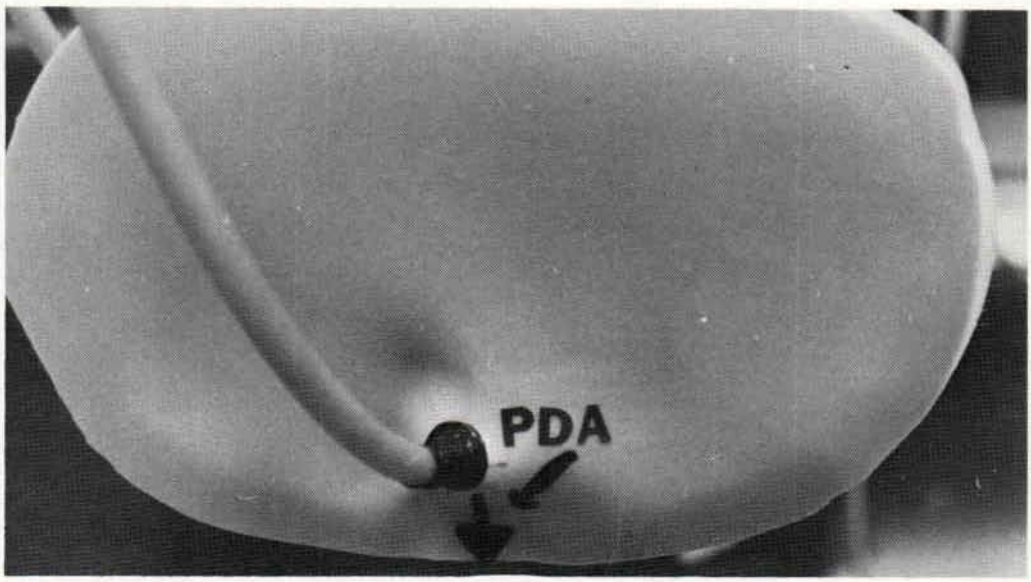


Fig. 16. P.D.A. (posterior distal arrow) points to surface holes and is used for alignment of plastic when drape molding.

into the horizontal air shaft when the cap is cemented to the model as before (Fig. 14). After the Plastizote end caps are cemented in place they are trimmed about the periphery to about ¼ in. from the stockinet to insure a good contact surface between plastic and the end caps so the vacuum can draw the air around the model.

The openings of the longitudinal hole are located and marked on the proximal (Fig. 15) and distal (Fig. 16) end caps with an arrow. The anterior surface of the model is bisected and the location is marked on the Plastizote end caps, proximal and distal (Fig. 17). The cotton stockinet is then sprayed with a Silicone parting agent or is powdered so that plastic will not adhere to the Pelite or stockinet.

IT IS VERY IMPORTANT that the end caps are kept clean to insure proper adherence of the plastic. The end caps are cleaned with acetone and the model is now ready for the vacuum-forming phase.

The thermoplastic I like to use is 5 mm. (3/16 inch), low density polyethelene. I prefer the low density polyethylene for its combination of physical strength characteristics. Polyethylene has exceptional resistance to chemicals and a fair drawing ratio (2.5:1). An orthosis fabricated from low density polyethylene is easier for a patient to don and will not fatigue and crack from flexure of the orthosis when it is donned.

To determine the size of the material for draping, two measurements are needed. The largest diameter of the model, plus 7.5 cm. (3 in.) is the circumferential width. The length of the model plus 3.75 cm. (1-½ in.) will give you the total length of the material.

The plastic is placed on a bench and the circumferential width of the model is divided in half; markers are placed proximally and distally on the plastic (Fig. 18). The "alignment marks" insure the proper alighment of the plastic to the proximal and distal marks on the model during the draping phase of the vacuum-forming procedure.

It is best that the oven be preheated to 265-270 deg F (125 to 130 C.) before insertion of the plastic. The moldability of the plastic varies according to the type of oven used and the heating time involved. For example, it will take approximately 35 to 40 minutes at 265-270 deg F for moldable condition to be reached in a non-circulating gas oven while a Grieye's electric circulating oven

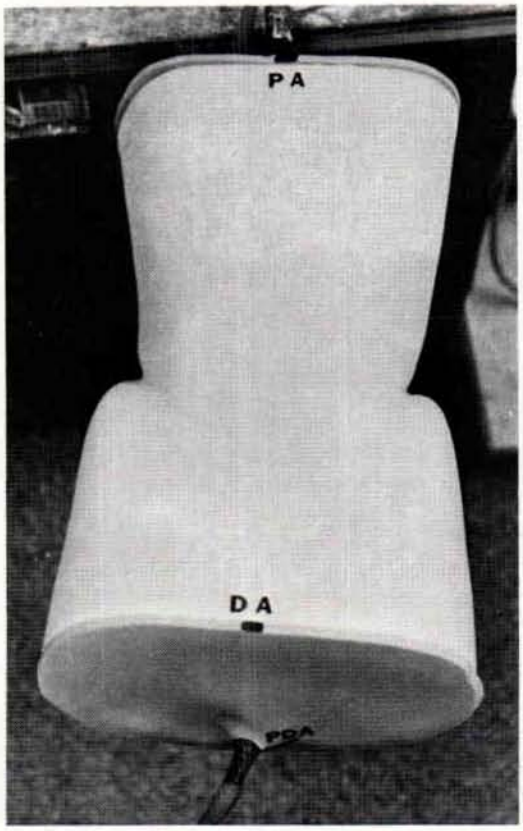


Fig. 17. Proximal anterior alignment mark and distal anterior alignment mark on end caps.

will require 15 to 20 minutes for the same amount of material. This time is based on a piece of plastic 35 in. x 22 in. x 3/16 in.

The plastic is heated at a low temperature to prevent surface pooling and shringkage caused by higher temperatures. Lower temperatures actually expand the material from 1.5 cm. (½ inch) to 2.5 cm. (1 inch), in length and width. Obviously, at the lower temperature the material retains its solidity and is easier to handle when being removed from the oven for draping.

The plastic is now placed in the oven; 15 to 20 minutes for a circulating oven, or 35 to 40 minutes for a non-circulating oven. When the plastic reaches the stage of moldability it becomes transparent throughout. The vacuum pump is turned on and set at 20 to 28 inches of mercury vacuum. The heating tray is taken from the oven and the heated plastic removed by two people grasping the corners of either end. The plastic is lifted from the tray and held over the model. It is then lowered to the model, the alignment marks on the plastic coinciding with the proximal and distal alignment marks on the model (Fig. 19). The ends of the plastic are released and permitted to hang; the corners are taken proximally and brought together at the proximal posterior (alignment arrow). The plastic is pressed to the end cap, making sure the polyethylene adheres to the Plastizote

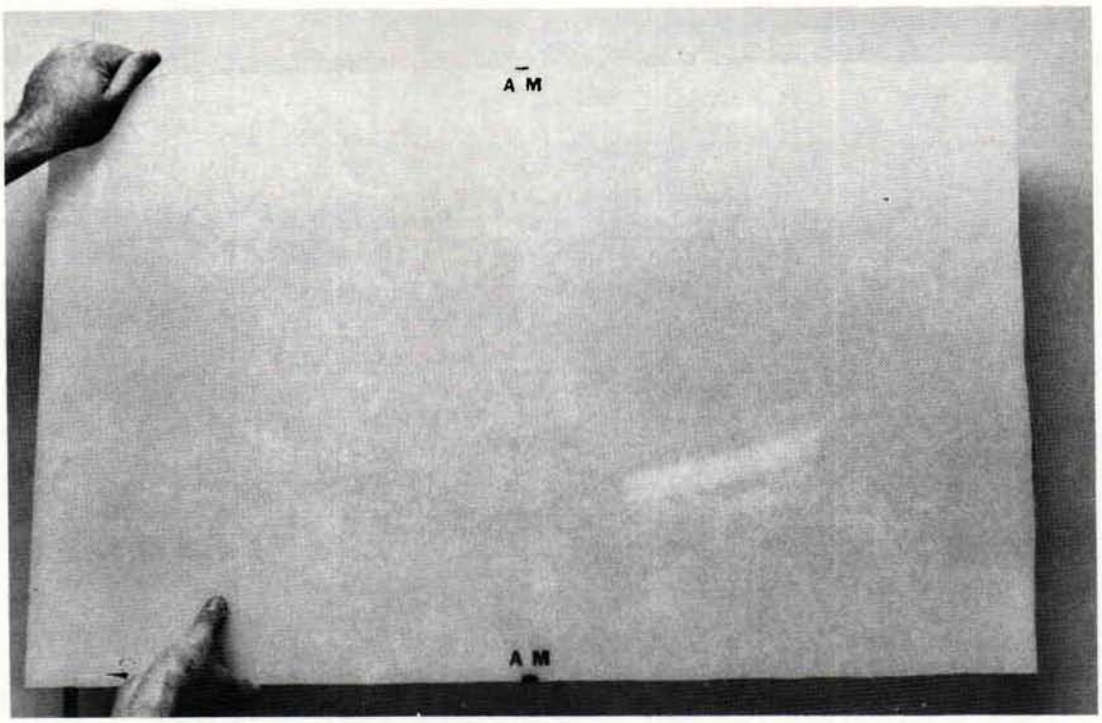


Fig. 18. A.M. (alignment mark). These alignment marks will coincide with proximal and distal alignment marks on end caps when plastic is draped onto model./ This also will allow equal amount of material to fall to each side; thus reducing the amount of stretch needed to bring ends of plastic to midline and maintaining a uniform thickness throughout.

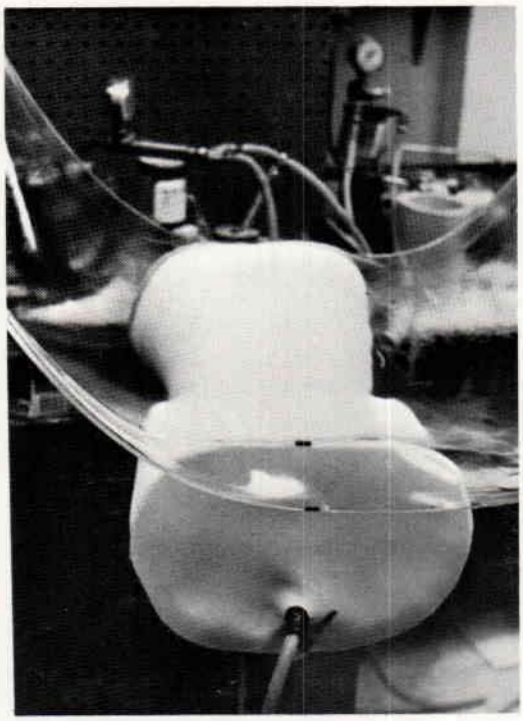


Fig. 19. Heated plastic is aligned over model.

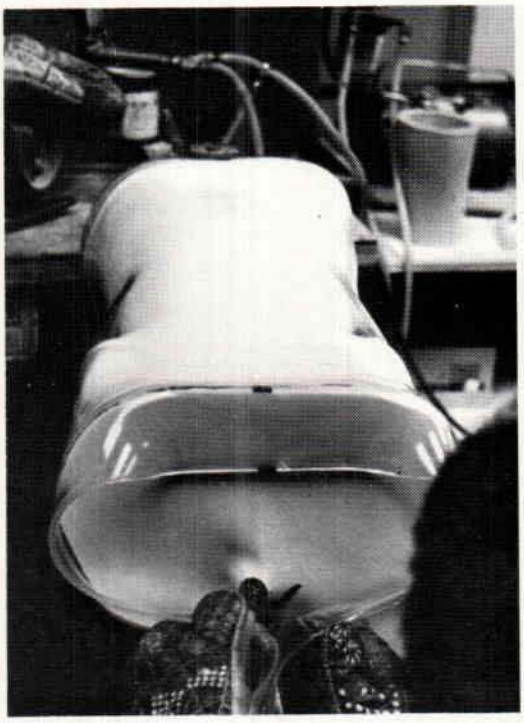


Fig. 21. The heated plastic is molded over the distal end cap.

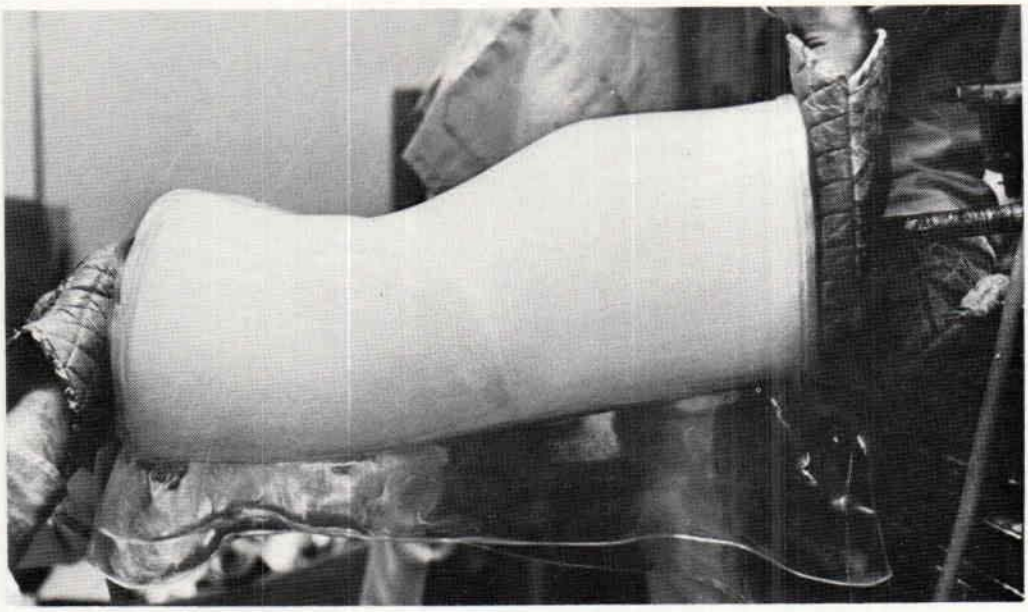


Fig. 20. The heated plastic is molded over the proximal end cap.

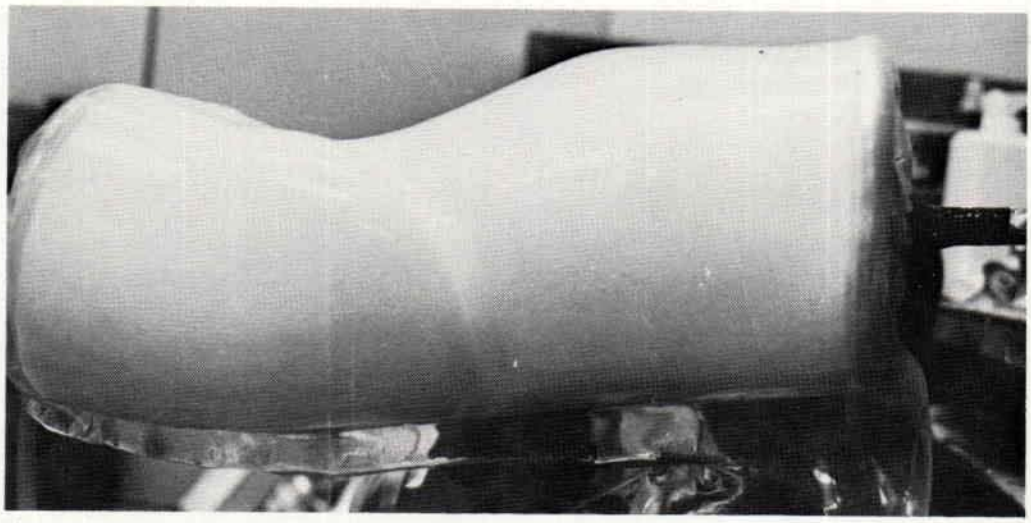


Fig. 22. The heated plastic is pressed together along the surface holes and the air is withdrawn.

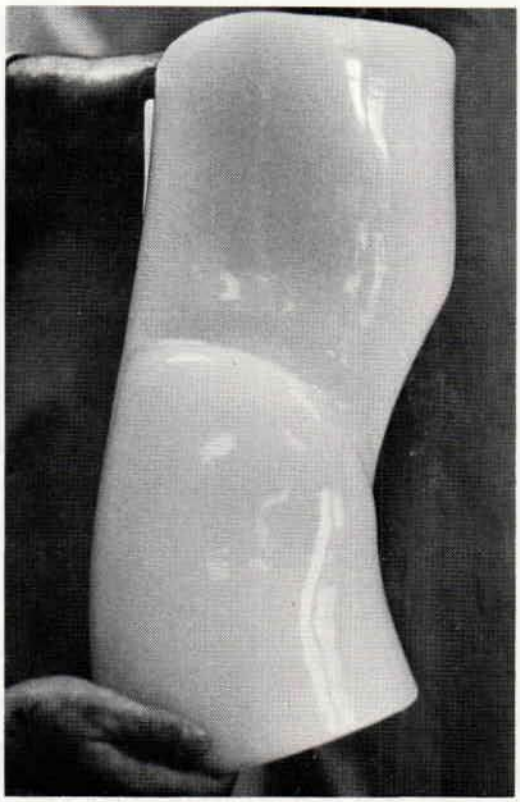


Fig. 23. Lateral view of orthosis just after removal from model.

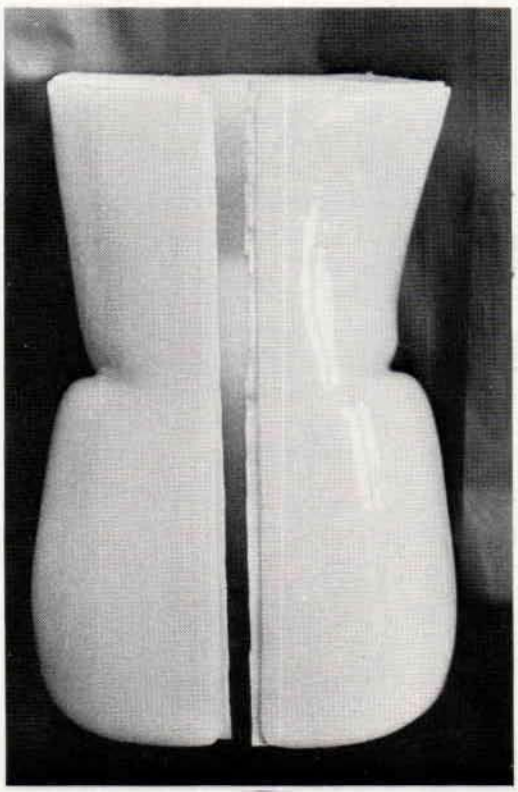


Fig. 24. Posterior view of orthosis just after removal from model.

(Fig. 20). This is repeated on the distal posterior area (Fig. 21). When the ends of the plastic are properly aligned and the plastic is pressed circumferentially to the end caps, the plastic along the surface holes is pressed together and the vacuum process begins evacuating the air from around the model, forming the plastic to the model (Fig. 22).

The vacuum pump remains on until the plastic is cool and once again opaque. The plastic is then trimmed from the model when it has been completely cooled as shown in Figures 23, 24, and 25.

Summary

This paper presents a simple method of drape vacuum forming of T.L.S.O. and L.S.O. Using this procedure an orthosis can be fabricated for the difficult, non-standard patient.

Here at the Rehabilitation Engineering Center of Children's Hospital at Stanford, we have fabricated over 100 T.L.S.O. and L.S.O.'s, using this procedure.

The longitudinal shaft and surface holes that are used for suction and alignment can be placed anteriorly, lateral or posterior, depending on where opening is needed in the orthosis. Finally, this is not the answer to all vacuum-forming procedures, but just one that may help manage the unusual needs of some of our patients.

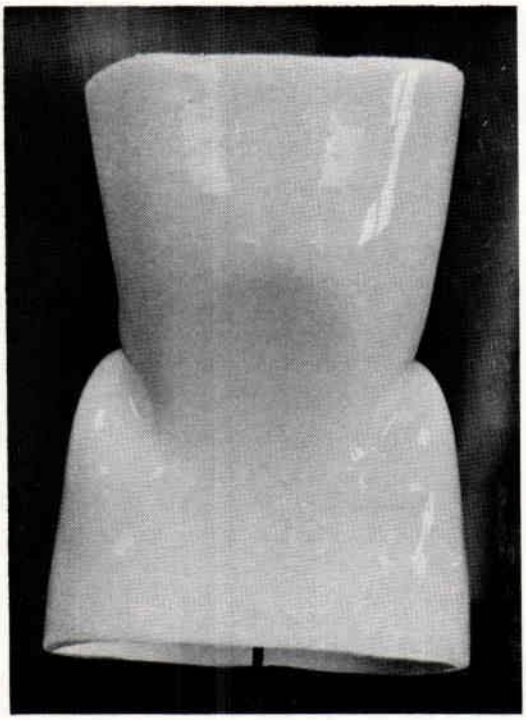


Fig. 25. Anterior view of orthosis just after removal from model.

Footnotes

[1]Head of Orthotics, Rehabilitation Engineering Center, Children's Hospital at Stanford, 520 Willow Road, Palo Alto, California 94304.

References

1. Artamonov, Alex. Orthotic-Prosthetic Developments, *Ortho-Pros,* Fall 1971.
2. Artamonov, Alex. Vacuumforming of Sheet Plastics, *Ortho-Pros,* Spring 1973.
3. Artamonov, Alex. Vacuumforming Techniques and Materials in Prosthetics and Orthotics, *Inter-Clinic Information Bulletin,* July 1972.
4. Wilson, A. Bennett. Vacuumforming of Plastics in Prosthetics and Orthotics, *Orthotics and Prosthetics,* March 1974.

Orthotics and Prosthetics, Vol. 33, No. 2, pp. 31-44, June 1979

The Genucentric Knee Orthosis—A New Concept

ROBERT FOSTER, B.S.[1]
JOHN MILANI, B.S., CPO[2]

The Genucentric Knee Orthosis[3] (Fig. 1) offers a unique polycentric (Genucentric) joint as an alternative to single axis or conventional polycentric joints for patients with mediolateral instability or genu recurvatum. Con-

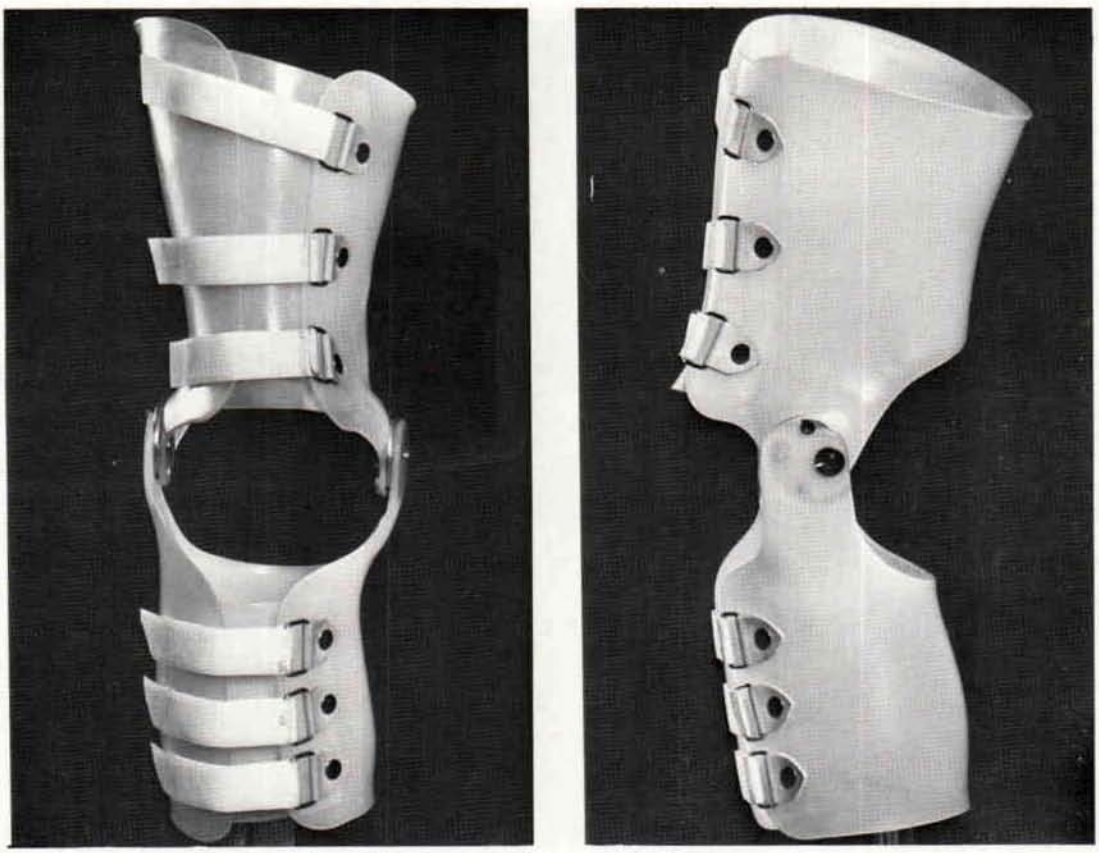


Fig. 1. Anterior and medical view of the Genucentric Knee Orthosis.

ceived by the authors and developed at the Veterans Administration Prosthetics Center (VAPC), this orthosis features lightweight construction, improved cosmesis, supracondylar-suprapatellar suspension, and a knee-tracking capability that eliminates pistoning and migration. The most distinct feature is the Genucentric joint (Figs. 2 and 3), with its ability to approximate its instantaneous center of rotation with the structurally sound and/or pathologically deranged knee. Clinical results thus far indicate that the intended goal of designing a polycentric joint to accommodate the anatomical knee, such as to eliminate completely the joint as a source of pistoning at the orthosis-limb interface, has been achieved.

The Genucentric Joint

A detailed description of the mechanical aspects of the Genucentric joint must begin with a discussion of the movements of the anatomical knee, since mimicking the anatomical knee is the desired result. Although considerable research has been devoted to the biomechanics of the knee joint, it is beyond the scope of this article to restate this research in full. We will, however, discuss briefly points found pertinent to the development of the Genucentric joint.

Kapandji (2) states that movement of the femoral condyles upon the tibial plateau is accomplished by a combination of rolling and sliding. A purely rolling motion requires a tibial plateau of approximately twice the width that actually exists to prevent dislocating the knee. A purely sliding motion would cause the femur to strike the posterior aspect of the tibial plateau, bringing flexion to a premature halt. The ratio of rolling to sliding varies throughout the flexion range. Beginning with rolling for the first 10 to 15 deg. for the

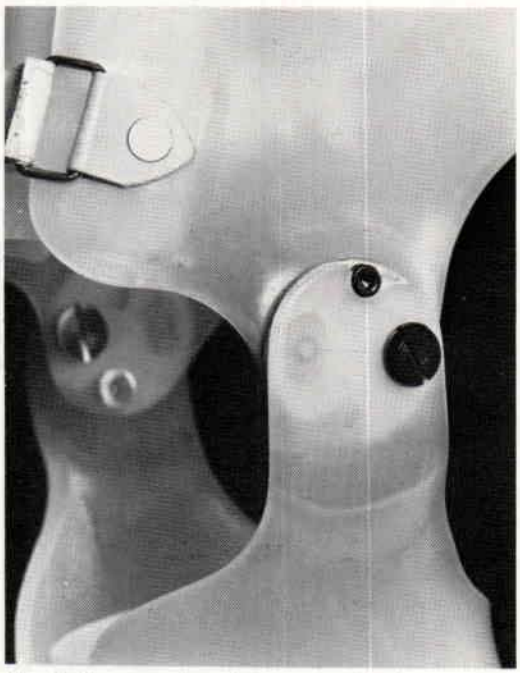


Fig. 2. Close-up view of Genucentric Joint.

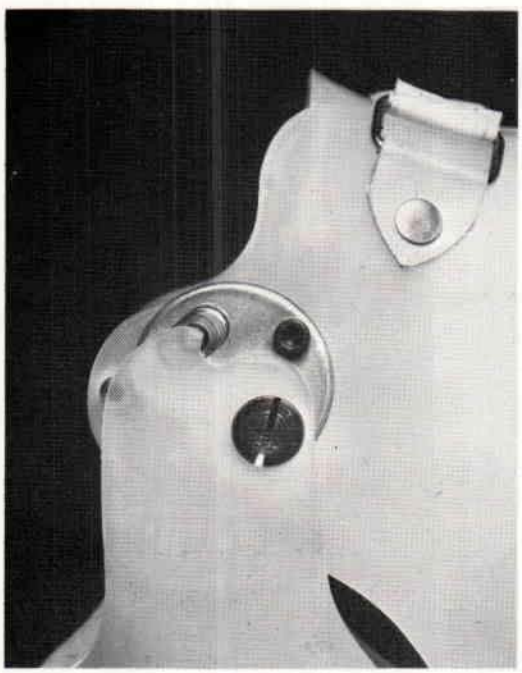


Fig. 3. Close-up view of Genucentric Joint fully flexed.

medial condyle, and 20 deg. for the lateral condyle, sliding becomes progressively more important until it becomes the only motion toward the end of the flexion range. The difference between the rolling-to-sliding ratio of the medial and lateral condyles explains why the lateral condyle covers a greater distance than the medial condyle, and accounts for the transverse rotation found at the knee joint.

The changing radius of curvature of the surface of the femoral condyles causes the instantaneous center of rotation of the knee to displace during flexion and extension. It is never displaced beyond a 2.3 cm circle about the lateral femoral condyle, unless severe structural derangement is present.

Frankel and Burstein (1) state that "It has been well-documented that normal motion (of the knee) involves a moving instant center of rotation. Therefore, it is unreasonable to expect that normal motion may be forced or created by the use of a well-fitted, single-hinged knee brace. If there is sufficient clearance or play between the elements of the brace and the leg, normal motion may be permitted providing the joint itself is capable of producing it by being displaced. However, if it is desirable to force normal motion with well-fitted braces or hinged casts, a knee which produces a moving instant center of rotation is necessary."

The inherent problem in using a single-axis joint to brace the multi-axis knee is that the single-axis joint tends to become displaced in its effort to follow the moving center-of-rotation of the anatomical knee. This movement is transmitted to the cuff sections and produces an angular change in the cuff sections that causes them to shift up and down along the limb (pistoning). Discomfort and slippage are the result.

Polycentric joints commonly used today utilize a moving center-or-rotation to reduce pistoning. However, they provide only one ideal path of instant centers and lack the flexibility needed to conform to individual variations found in healthy as well as pathologically deranged knees. By contrast, the slotted disk sandwiched between the thigh and calf sections permits the instant center of the Genucentric joint to move through a variety of paths, thereby allowing the joint to follow the path of the individual anatomical knee while providing the necessary support (Figs. 4 and 5). Plots of the instant center, using the methods outlined by Frankel and Burstein, show a concentrated locus of centers that lie within a 2.5 cm circle, indicating that the motions of the Genucentric joint can mimic the motions of the anatomical joint. Like the anatomical knee, the Genucentric joint has a sliding as well as a rolling component in its motion. Transverse rotation of the anatomical knee was not considered significant in the design of the Genucentric joint since this motion is adequately absorbed by the soft tissues between the skeletal members and the cuff sections.

Polypropylene is used in the construction of the Genucentric joint because it afforded the opportunity to make the joints continuous with an intimately fitting polypropylene calf and thigh cuffs (Fig. 5). This was accomplished during molding by extending the thigh piece below the knee center on the cast, terminating in a semicircle. The calf piece was extended as equal distance above the knee center and thigh piece, terminating in a similar manner. This provided a circle of overlapping plastic about the knee center within which to construct the joint. Sandwiched between the plastic cuff extensions are aluminum disks with two holes drilled in a horizontal plane. (See fabrication sequence below.) The holes provide the required

joint pivot points that are matched by a single hole in each of the plastic cuff extensions. Two stops (cap screws) are then added to each joint, one to the distal end of the thigh extension, the other to the proximal border of the aluminum disk, that are matched by slots in the adjacent structures. The stops keep the joints in proper alignment while donning and doffing the orthosis, and provide a halt to extension at full extension or at the desired degree of flexion.

This manner of construction offers significant advantages over conventional orthoses. The time consuming processes of bending, polishing, aligning, and riveting sidebars to cuffs are eliminated. And, by removing the bulky sidebars, a lighter-in-weight, more streamlined, and most cosmetically appealing appliance is produced.

Suspension is accomplished by a combined supracondylar-suprapatellar system in which tissue is compressed above the patella and the condyles. A built-in flare for the displaced tissue in the distal posterior section of the thigh cuff at the level of the suspension improves the effectiveness of the suspension and enhances comfort.

The Genucentric Knee Orthosis incorporates many improvements over the conventional knee orthosis while maintaining the basic biomechanical principles of the conventional orthosis. This orthosis, like the conventional orthosis, relies on a three-point pressure system to stabilize desired motions of the extremity while preventing undesired motions. Clinical results indicate that the Genucentric Knee Orthosis can be worn with significant improvements in comfort when compared to more common knee orthoses, with pistoning reduced to the point of becoming undetectable, and with migration eliminated.

Casting and Modification Procedures

1. Take standard measurements of limb. To utilize supracondylar suspen-

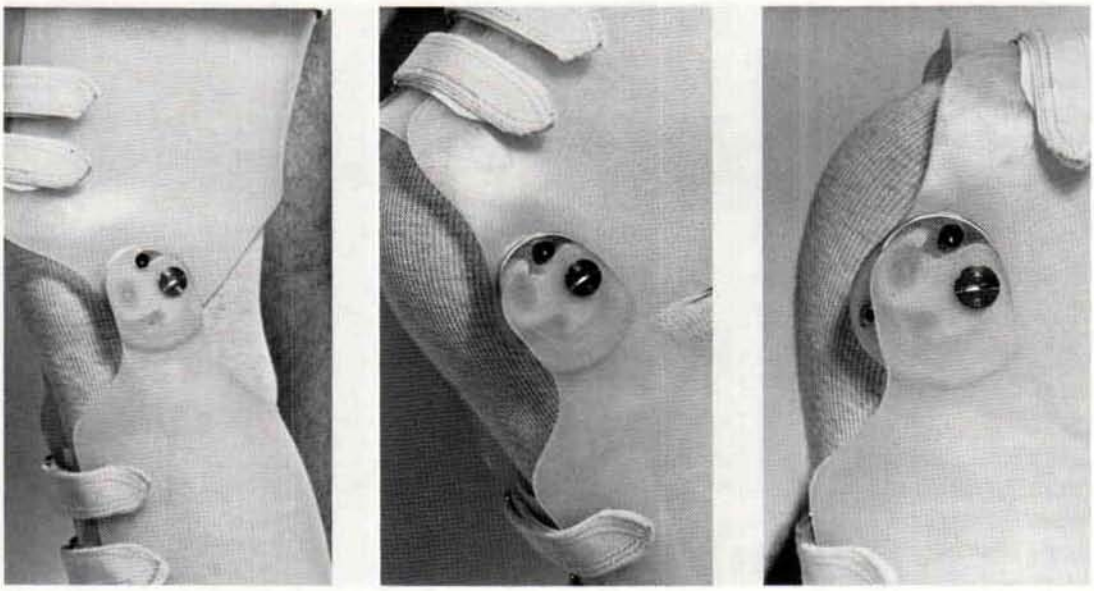


Fig. 4. As knee is flexed, it's instantaneous center of rotation is duplicated by the Genucentric Joint.

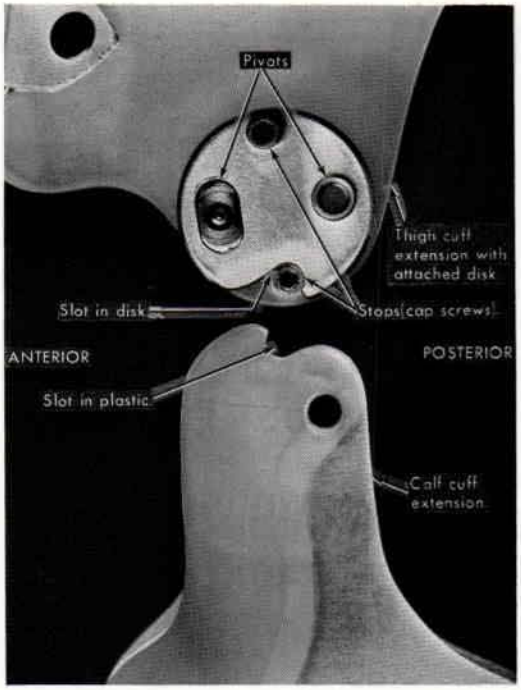


Fig. 5. Exploded view of the Genucentric Joint.

sion, take a tight mediolateral measurement above condyles.

2. Place Tubegauz on limb and secure from moving. Use latex tubing to help facilitate cast removal in the usual manner.

3. Mark the following anatomical landmarks with indelible pencil: patella, proximal borders of femoral condyles, knee center (determined by adding 18 mm (¾ in.) to the medial tibial plateau height), iliotibial band, head of fibula, tibial crest, and any pressure sensitive areas.

4. Cast limb with all defomities corrected as much as possible. To accentuate bony prominences, cast the knee in five deg. of flexion and with only partial weight-bearing while standing.

5. Use elastic plaster bandage to obtain a smooth cast. Start the wrap distally below mid-calf and extend proximally above mid-thigh. Compress areas immediately above condyles with palms of hands as plaster begins to set to accentuate suspension areas.

6. Once cast is set, draw a vertical reference line on anterior surface of cast. This line should be parallel to the mid-sagittal line.

7. Remove cast and prepare for pouring.

8. After plaster sets, use an awl to penetrate wrap on vertical reference line to transfer it to positive mold.

9. Remove wrap and smooth positive mold of all irregularities. Take care not to remove indelible marks, especially those indicating knee center.

10. Take M-L dimension above condyles down to within 3 mm of the measurement. Ensure that all circumferences are brought down to measurements and blended into the contours of the limb. Pressure sensitive areas are relieved with standard plaster buildups.

11. Because tissue is squeezed above the condyles and patella for suspension, it tends to bulge posteromedially and posterolaterally. To avoid flesh from being pinched by the edges of the orthosis, extend the modified cast in these areas (Fig. 6). The amount extended depends on the amount of subcutaneous tissue present. Cast should be extended 12 mm on slender patients, and 25 mm on heavyset patients.

12. The joints of the Genucentric Knee Orthosis are built as continuations of the cuff moldings (Fig. 6). Each cuff overlaps the other at knee-center level. Flat, circular build-ups on the cast are needed to create flat surfaces for joints. The build-ups should be 42 mm in diameter, parallel to both the mid-sagittal line and the line of progression, and build-ups should not increase the epicondyle M-L measurement. Extend the build-ups distally by 18 mm beyond circular portions of the joints, to allow offsets to be created in calf cuff and

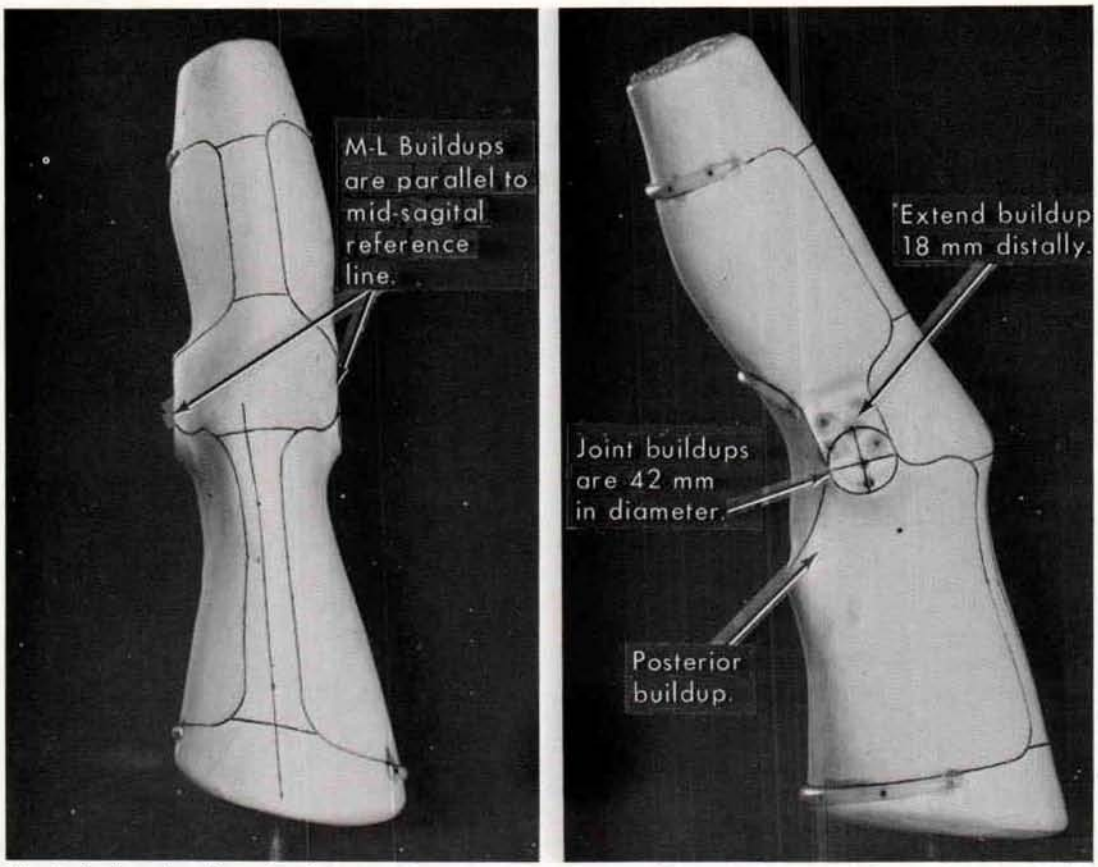


Fig. 6. A. Anterior view of positive model showing buildups parallel to the anterior reference line. B. Medial view of positive model showing joint buildups, flare extensions, and trim lines.

thereby allow the thigh cuff to flex to 135 deg.

13. Place trim lines and flares on cast. Mark each joint buildup with vertical and horizontal reference lines that will be used to align disks later.

Fabrication Procedures

Cast is prepared for both vacuum drape molding and standard hand molding without vacuum.

1. Use 5 mm-thick polypropylene to vacuum mold thigh cuff. Set vacuum to 15 psi.

2. After cooling, remove plastic from cast, trim it to trim lines, and place back on cast.

3. Tape a 3 mm-thick blank aluminum disk that is larger in diameter than proposed joint diameter, to knee-joint position on thigh cuff (Fig. 7A). Mold calf cuff over both thigh cuff extension and disk (Fig. 7B).

4. Remove calf cuff after cooling and trim to trim lines.

5. Hand-mold tongues on cast using 2 mm-thick low density polyethylene. Skive tongues where they fit under cuffs.

6. Attach reinforced Velcro straps, tongues, and 25 mm stainless steel loops reinforced with laminated Dacron tape, to cuffs.

7. Place completed cuffs on cast: 3 mm spaces parallel to both the mid-

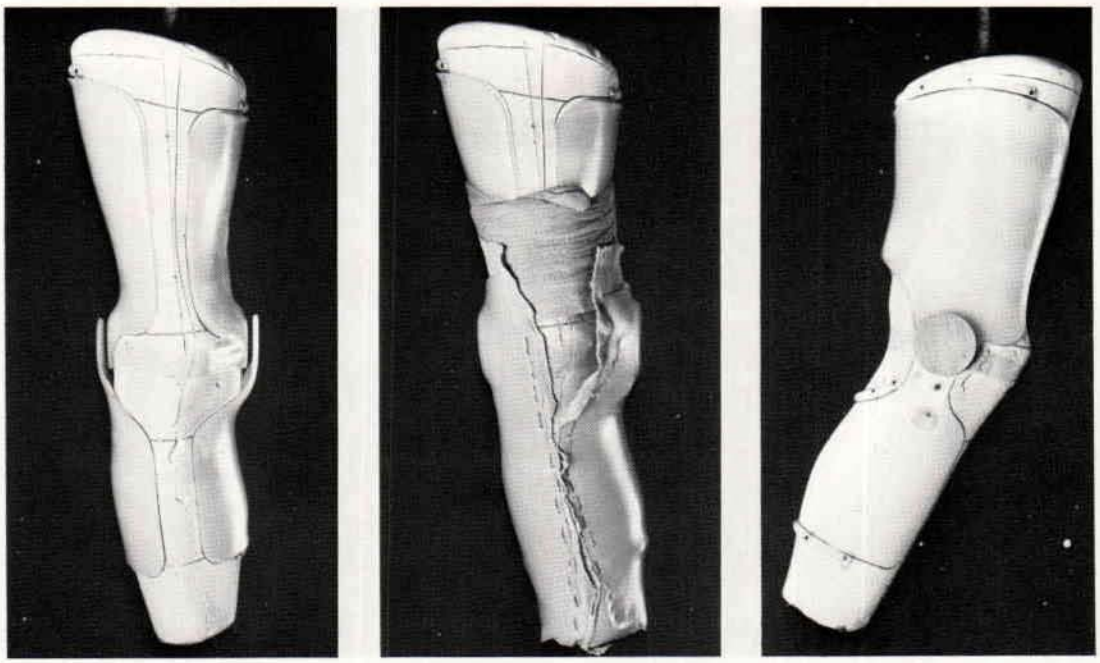


Fig. 7. A. Thigh cuff with blank aluminum disk on cast. B. Calf cuff molded over thigh cuff and blank disk. C. Both cuffs in position after trimming and polishing. Joint spaces for aluminum disks should be parallel in all planes.

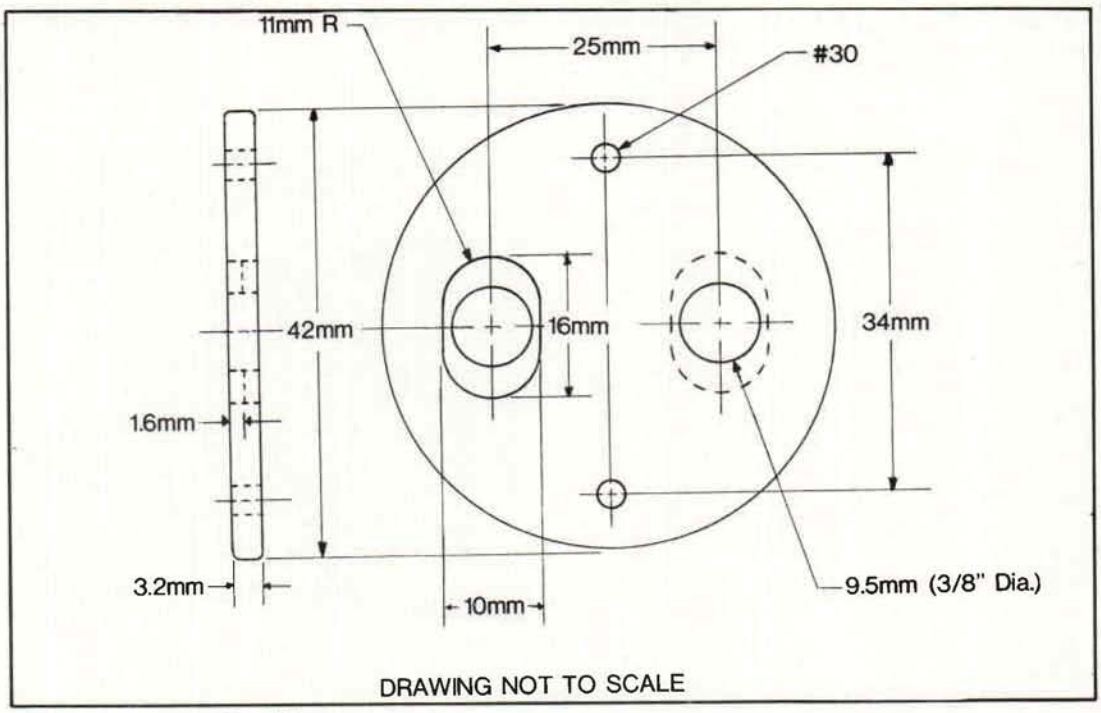


Fig. 8. Dimensions of the disk.

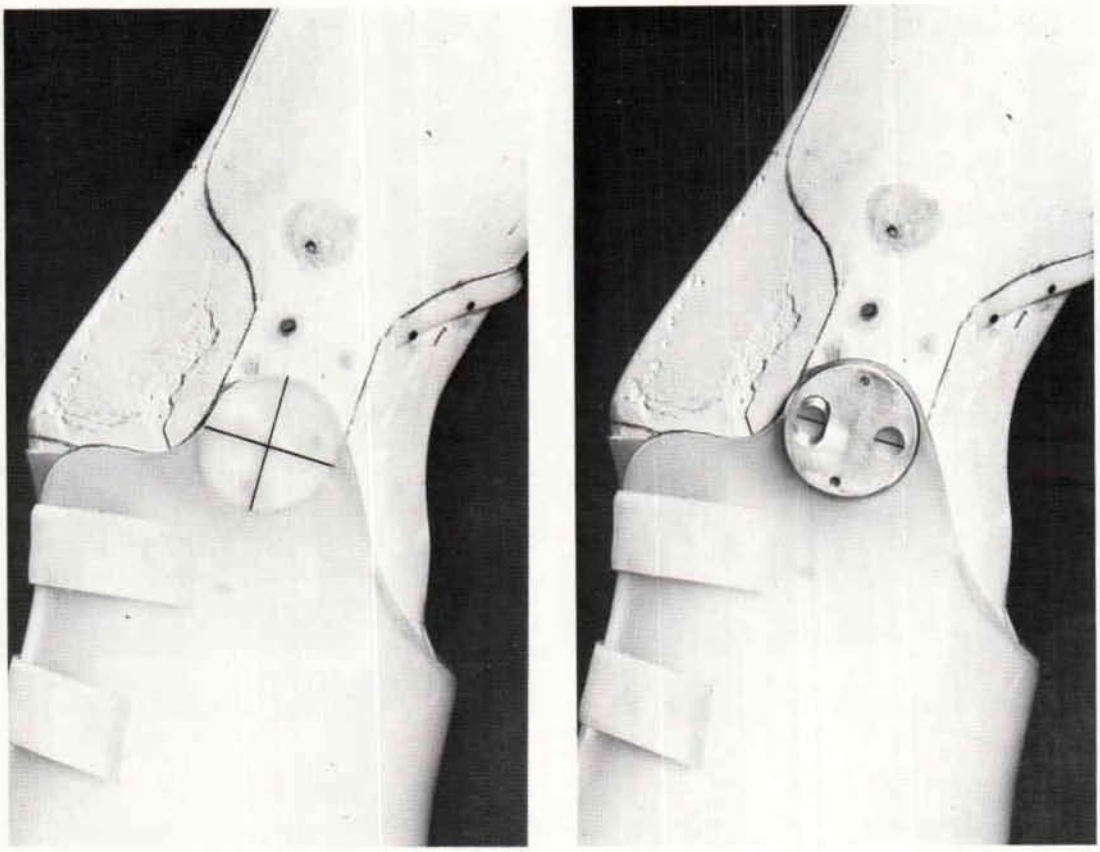


Fig. 9. A. Reference lines transferred from positive model to thigh cuff. B. Disks are positioned over reference lines. Anterior pivots and distal #30 holes in disks are marked and drilled through plastic.

sagittal line and the line of progression at joint surfaces should be observed (Fig. 7C).

8. The spaces created are for two 3 mm-thick aluminum disks. Each disk will have two pivots and two stops (Fig. 5). Fabricate disks as shown in Fig. 8.

9. Remove calf cuff while maintaining thigh cuff in place on cast. The somewhat translucent plastic will permit reference lines previously drawn on cast to show at knee-joint area (Fig. 9A). Position disks so that holes line up with reference lines (Fig. 9B). The anterior pivot point of each disk should be marked and drilled through plastic with a 9 mm (3/8 in.) drill. Attach disks to thigh cuff using standard ankle joint bushings and screws.

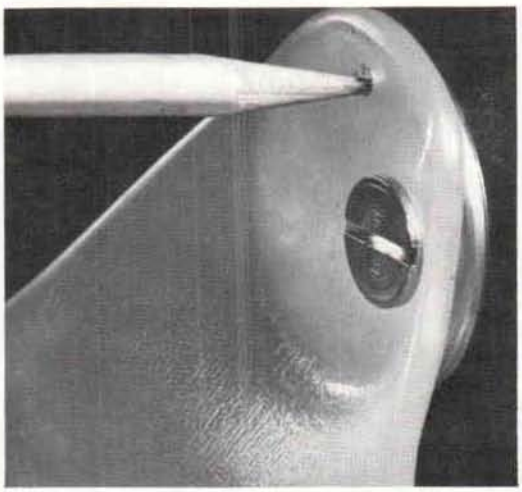


Fig. 10. Close-up of disk being rotated about anterior pivot. A pencil is used to scribe path that stop travels through.

Realign disks, mark, then drill lower #30 holes in plastic. Insert a pencil through plastic joint (Fig. 10) and scribe an arc on disks as they are rotated around anterior pivots. Remove disks and expand lower #30 holes by drilling in disks to 7 mm or 9/32 in. Using the scribed arcs as guides (Fig. 11A and B), cut slots into disks (Fig. 5) to permit 6 mm cap screw heads to run smoothly within slots. Enlarge #30 holes by drilling in plastic to #4 size holes so that post screws can be inserted into plastic. Place cap screws and post screws into plastic thigh cuff, then attach disks and rotate them. There should be no binding. Place thigh cuff back on cast.

10. Secure disks against cap screws with masking tape (Fig. 12A). Attach calf cuff to cast. Use holes in disks for reference marks since disks now obscure reference marks on cast (Fig. 12B). Mark posterior pivot points and upper #30 holes onto plastic calf cuff. Remove calf cuff and drill posterior pivots in same manner as anterior pivots. Drill upper #30 holes into plastic. Remove disks from thigh cuff and attach to calf cuff at posterior pivot points. Insert pencil through #30 holes in disks, rotate disks about posterior pivots, and scribe arcs onto plastic as previously done for thigh cuff in step 9 above. Enlarge #30 holes by drilling in plastic cuff to 10 mm or 5/16 in. Use arcs on plastic as guides to cut slots in plastic (Fig. 5) and thereby permit cap-screw heads to run freely within slots. Enlarge upper #30 holes by drilling in disks to #21 size holes and tap holes for 10-32 threaded cap screws.

11. Reassemble orthosis. No binding should be present and joints should be square in all planes.

12. The orthosis is now ready for fitting. No localized pain or skin pinching should occur. However, some initial discomfort over condyles may be experienced owing to snug fit for suspension. A piece of tubular stockinet may provide relief until patient becomes accustomed to orthosis (Fig. 4).

13. Since only minor alignment changes can be carried out on the orthosis, all steps should be followed carefully.

Clinical Experience

The Genucentric Knee Orthosis was delivered to patients with mediolateral instability and/or genu recurvatum of the knee. Following are reviews of four case studies of patients who have worn the device for sufficient periods of time to obtain meaningful results.

1. Patient B.C., a 24-year-old active male, an automobile body-and-fender man, sustained gunshot wounds of the left femur in 1970. Resulting deformities include: limited range-of-knee motion (15 to 100 deg.), genu varum of 22 degrees, and a one-inch shortening. The patient's major complaint was pain at the lateral aspect of the knee on standing, walking and squatting, which resulted in loss of time from work. B.C. was originally provided with a double bar KAFO with corrective pads. However, due to weight, bulk and overall extensive bracing, he refused to wear the device. An elastic hinged knee orthosis was then prescribed, but while the patient liked the weight and freedom of the orthosis, his condition worsened.

The clinic team, in April 1978, decided to provide B.C. with a Genucentric Knee Orthosis. After wearing this orthosis for five weeks, the patient was seen in the clinic for follow-up examination. He was able to walk and stand with less pain and his deformities were controlled. In addition, he found the orthosis to be lightweight, cosmetic and comfortable, and it provided sufficient freedom for his needs. During seven months of wearing this orthosis, the patient has experienced no problems concerning function or wear of components.

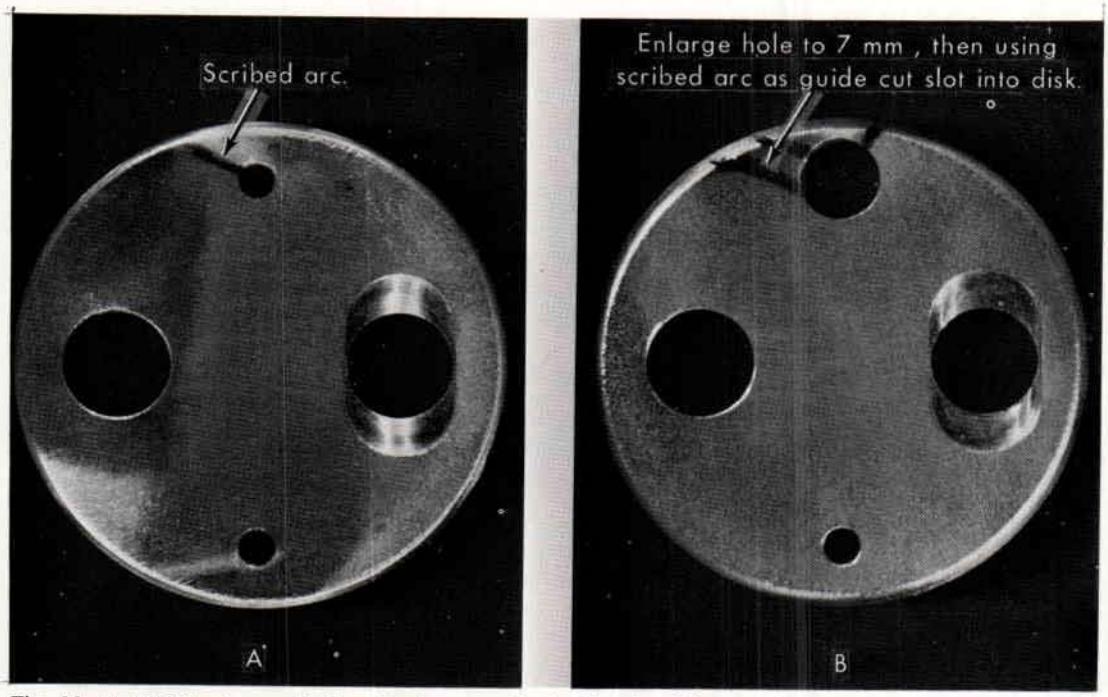


Fig. 11. A. Disk having scribed path of stop on it. B. Slots in disks permit cap screw heads to run freely within them.

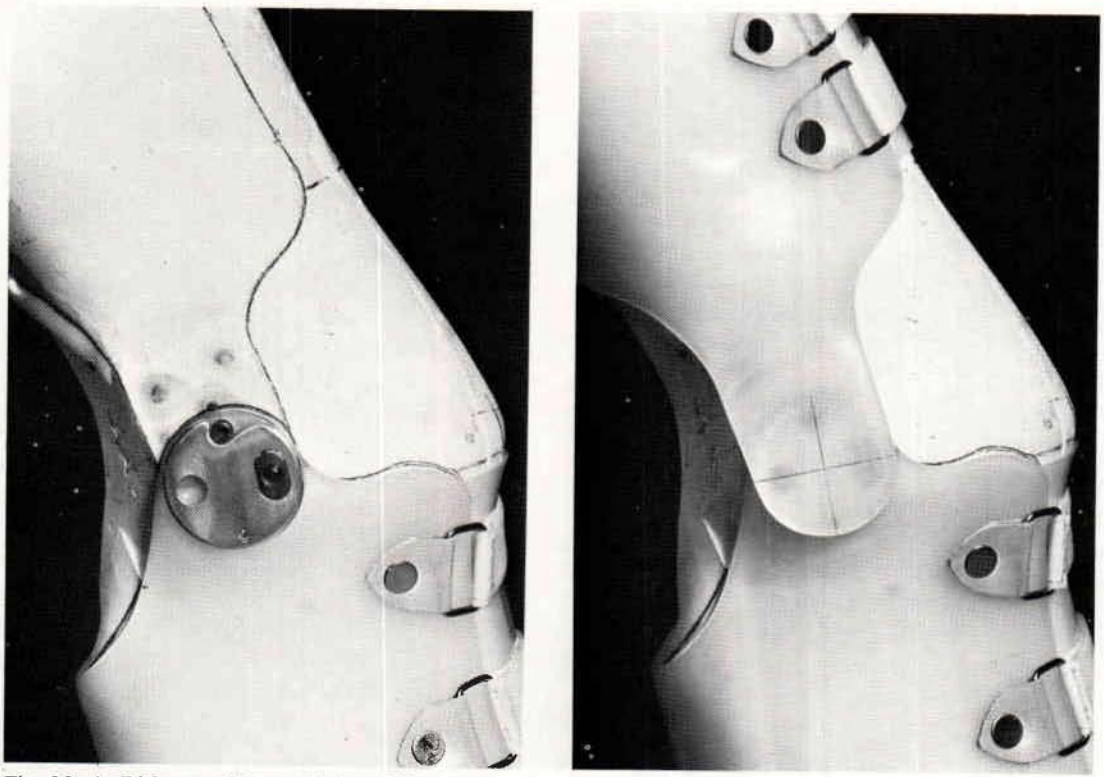


Fig. 12. A. Disk assembly on thigh cuff. B. Calf cuff positioned over disk. Posterior pivots and proximal #30 holes are marked and drilled through plastic.

2. Patient J.A. (Fig. 13), a middle-aged male, injured his right knee after falling from a truck in 1953. The resulting trauma created mild laxity in both the A-P and M-L planes. In addition, the patient has pain, atrophy and a moderate limp. Active range-of-knee motion is limited from 0 to 100 deg. due to severe pain and joint damage. Since the onset of this condition, the patient has worn various knee supports; the latest being an elastic knee orthosis with medial and lateral pads. Disabling pain, however, persisted.

The patient was provided with a Genucentric Knee Orthosis in May 1978, and was seen for a follow-up examination five weeks after the orthosis was delivered. Although J.A. still had pain, he no longer experienced the sharp pain he had with previous devices. Laxity in both A-P and M-L planes were well controlled; the patient found the orthosis to be lightweight and cosmetic, and it did not piston as previous devices had (Fig. 14).

3. Patient M.L. (Fig. 15), a 55-year-old male, suffered a head injury in 1945, secondary to shell fragment wounds, with resulting hemiplegia on his right side. He walks with a spastic equinovarus deformity of the right foot. His quadriceps are good and he is stable while standing and walking. M.L. was provided with a single bar AFO with 90-degree plantar stop and varus corrective strap. With the passage of time, stresses

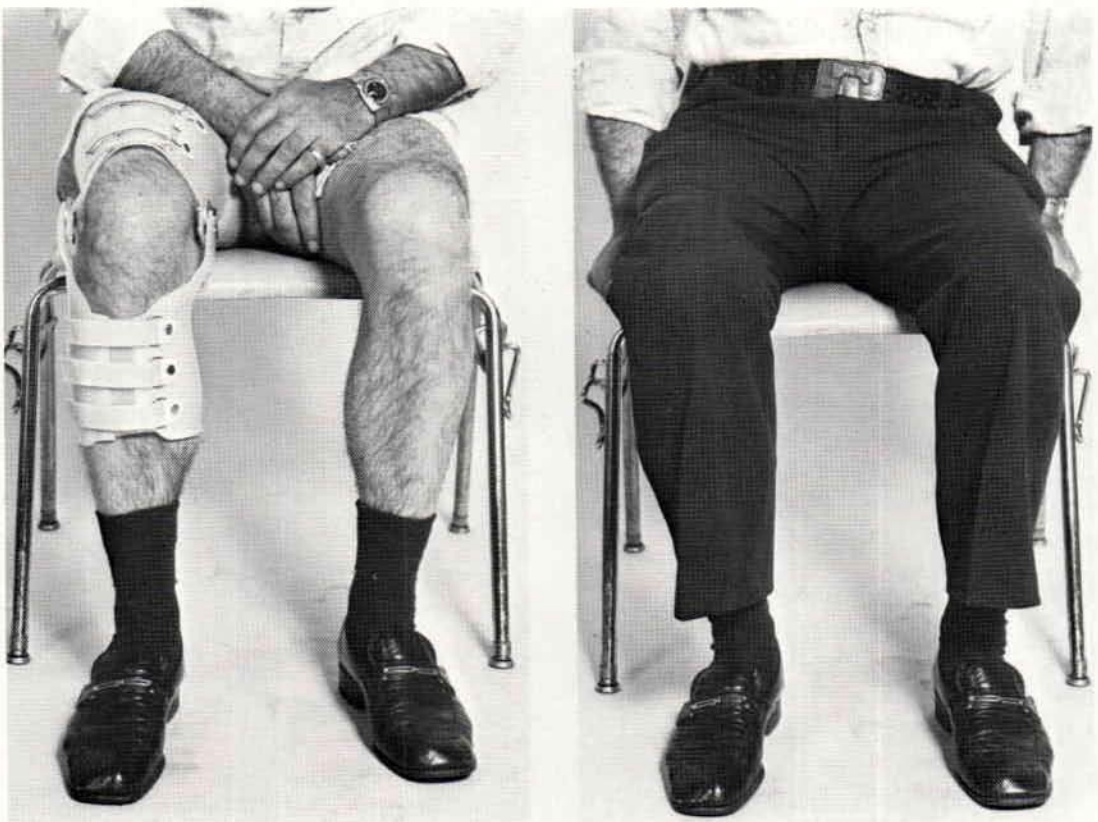


Fig. 13. Patient J.A. Normal knee motions are unrestricted even while he is seated, enhancing both comfort and cosmesis.

acting on the right knee caused posterior ligament stress, anterior knee compression, and excessive hyperextension, all resulting in pain and fatigue.

The clinic team, in April 1978, decided to provide M.L. with a KAFO utilizing a polypropylene shoe insert and a Genucentric Knee Joint. The orthosis was fitted, but due to upper extremity involvement and spastic equinovarus, the patient could not don the device independently. However, when assisted in donning the device, the patient functioned well with it on. The orthosis was modified by maintaining the knee section and replacing the shoe section with an aluminum medial upright, caliper stirrup with 90-degree plantar stop, and varus corrective strap. With these modifications, M.L. was able to don and doff the orthosis independently. Five weeks after delivery, a follow-up examination revealed that the patient was doing well; genu recurvatum was controlled, pain and fatigue were eliminated.

4. Patient G.H., a 44-year-old active male truck driver, injured his left knee when he fell from a ladder in 1956. Cartilage was removed from the medial aspect of the knee. G.H. has marked atrophy of the thigh, limited range-of-knee motion (15 to 90 deg.), pain, and some A-P instability. He was given a Jones knee cage, with drop locks for occasional use. The VAPC Knee Orthosis, prescribed in October 1974, was lighter in weight, provided good function, and had no locks. The patient was seen in May 1978 for a new orthosis because the VAPC Knee Orthosis was no longer serviceable.

The clinic team decided to use the Genucentric Knee Orthosis to eliminate pistoning. The patient found the new design to be lighter in weight, more cosmetic, and better in function than previous devices.

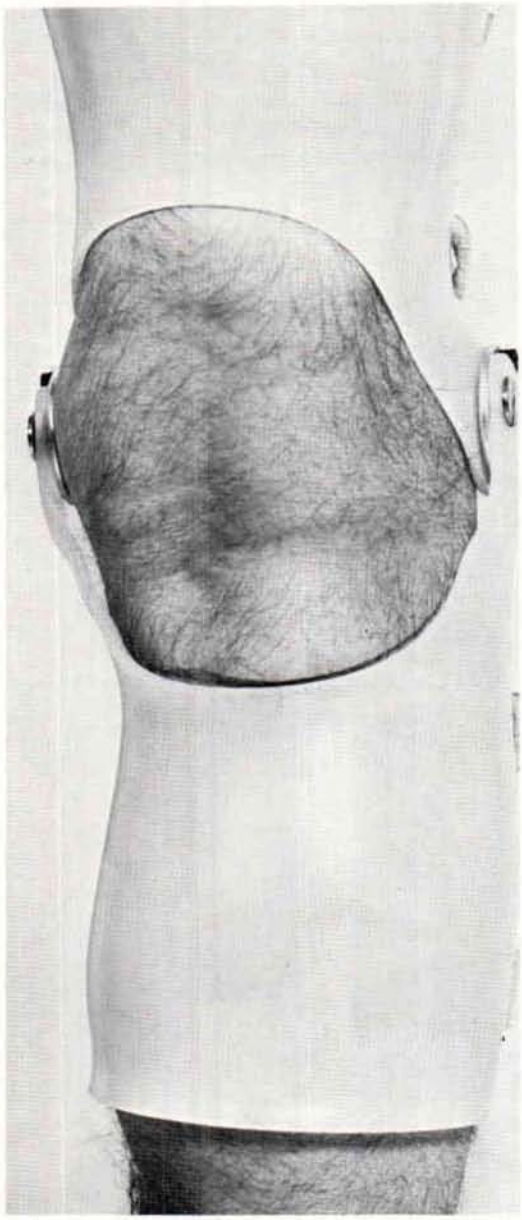


Fig. 14. Intimate fit can be obtained with Genucentric Knee Orthosis.

Fig. 15. Patient M.L. wearing plastic KAFO with Genucentric Knee unit. Cosmesis of this device is excellent.

Summary

The Genucentric Knee Orthosis employs a unique new joint to eliminate pistoning. This is due to the capability of the joint to duplicate the motion of the individual anatomical knee it controls. With pistoning eliminated, and with a firm foundation provided by its supracondylar-suprapatellar suspension system, migration of the orthosis becomes clinically undetectable, even after lengthy periods of active use. In addition, to further enhance patient comfort and acceptance of this unique rehabilitation approach, the orthosis is fabricated of lightweight plastic utilizing vacuum-forming and drape-molding techniques.

The Genucentric Knee Orthosis is presently being clinically tested on patients with various knee problems; four patients have thus far worn the device for sufficient periods of time to compile definitive results. In each case, the patient found the orthosis to be comfortable and non-restrictive to the desired motions of the limb. Neither wear nor mechanical failure have been observed, even though some of these patients are young and quite active.

Acknowledgments

The authors would like to express their appreciation to Kenneth LaBlanc, Senior Technical Specialist, and Max Nacht, Technical Writer, for their cooperation and assistance in preparing this article; to Michael Lamberti, Photographer, for his outstanding photographic work; and to Gary Fields, Technical Assistant to the Director of the VAPC, and Dr. Gustav Rubin, Clinic Chief, for their encouragement and interest.

Footnotes

[1]Orthotist, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, New York 10001

[2]Orthotist-Prosthetist, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, New York 10001

[3]The term "Genucentric" has been coined to distinguish our unique polycentric joint from the polycentric joint now in common use.

References

(1) Frankel, Victor H., and Burstein, Albert H., *Orthopaedic Biomechanics,* (Philadelphia: Lea and Febiger, 1970), pp. 118-144

(2) Kapandji, I.A., *The Physiology of the Joints,* Vol. Two, (Edinburgh-London-New York: Churchill Livingstone, 1970), pp. 86-91

(3) Smidt, Gary L., "Biomechanical Analysis of Knee Flexion and Extension," *Journal of Biomechanics,* Vol. 6, (Great Britain-New York: Pergamon Press, January 1973), pp. 79-91

Orthotics and Prosthetics, Vol. 33, No. 2, pp. 45-53, June 1979

Evaluation of an Ultralight Below-Knee Prosthesis[1]

BRIAN REED, R.P.T.[2]
A. BENNETT WILSON, JR.[2]
CHARLES PRITHAM, C.P.O.[2]

This is a report on experience gained since publication of the article by Wilson and Stills (1) in the March 1976 issue of "Orthotics and Prosthetics" on ultralight prostheses for below-knee amputees made by vacuum-forming sheet polypropylene (Fig. 1). The design resulted in a prosthesis that weighs one-third of the more conventional PTB prosthesis, with essentially the same function, depending upon the treatment of the sole and heel. In addition to offering the possibility of a decrease in energy requirements, suspension problems might be reduced. In the article it was stated that the Rehabilitation Engineering Center would welcome other groups to participate in the development of this concept.

With partial support from the Veterans Administration work on this project was continued and although the original aim of the project was to provide a better prosthesis for the geriatric patient, it was found that the active patient also appreciated advantages offered by the new design. By March 1976 a draft of a manual was sufficiently complete so that it was practical to invite prosthetists from each of the Rehabilitation Engineering Centers, the Veterans Administration Prosthetics Center, and several privately practicing prosthetists to Northwestern University to become acquainted with the technique so that it could be applied in their own setting and provide information useful in making the technique as practical as possible.

With the help of the participants the original fabrication technique was modified to use hand draping of the polypropylene to mold the shank to provide more uniform wall thickness and an anterior seam. An alternate method of fabricating the foot was also introduced (Fig. 2). During the fall of 1976 a fabrication manual (2) was prepared and submitted to the VA with the suggestion that the ultralight below-knee prosthesis be evaluated nationwide through the VA outpatient amputee clinics.

Instead of acting upon this suggestion, the VA requested a proposal from us for the conduct of clinical trials through the Philadelphia Regional Office Amputee Clinic. The proposal was accepted by the VA, and the program was initiated in January 1978.

Method

Seven Philadelphia-area prosthetic firms agreed to participate in the study. The prosthesis design selected was the one using the rigid toe section since it was the lightest of the two designs. The prosthetists were instructed in the fabrication

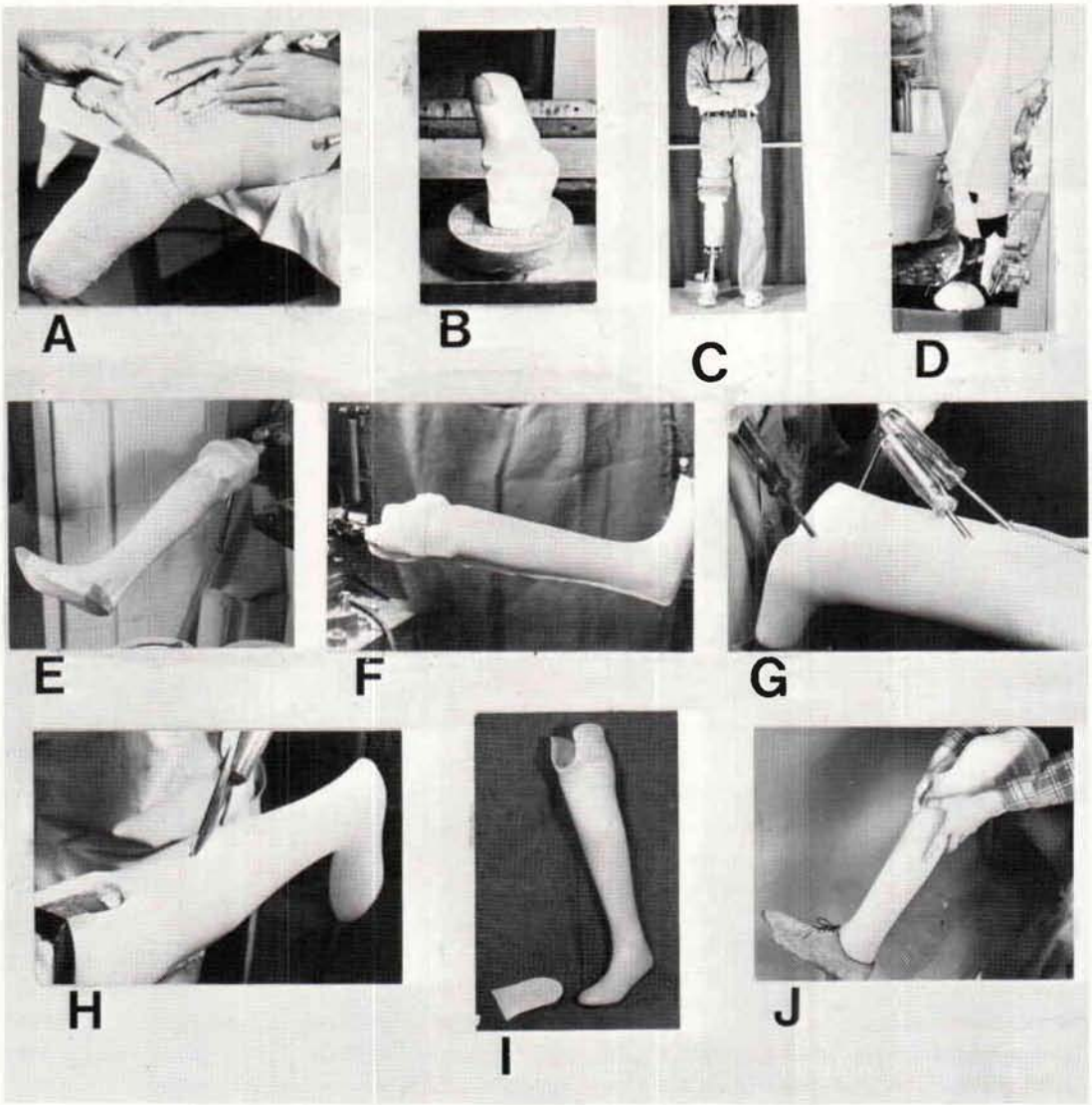


Fig. 1. Steps in fabrication of ultralight below-knee prosthesis from sheet thermoplastic.

and fitting of the ultralight prosthesis in a twelve-hour course at the Rehabilitation Engineering Center of Moss Rehabilitation Hospital in January 1978. The prosthetists then fitted amputees from the VA Regional Office Amputee Clinics, and from their own private practices who were referred to the study from two other local clinics. Amputees who were receiving their first definitive prosthesis as well as amputees who already were successful PTB users were included in the study. Data were collected by means of questionnaires (Appendices A and B). For the former PTB users, one questionnaire was administered before fitting and another one was administered two weeks after a "satisfactory"

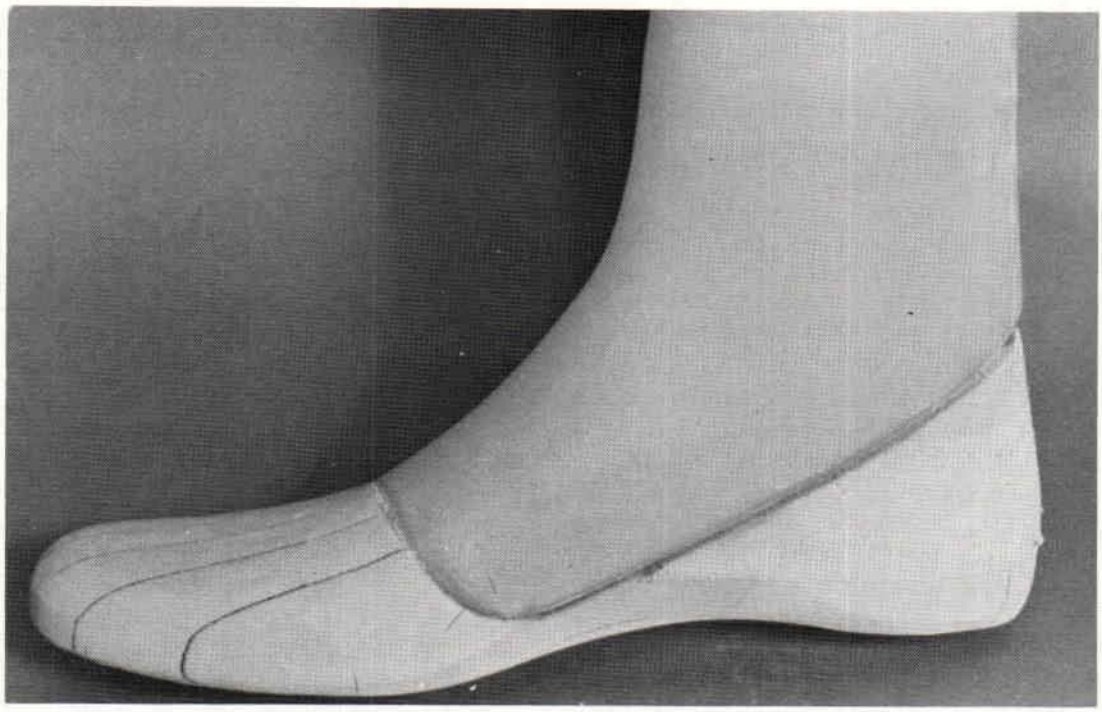


Fig. 2. The foot-and-ankle section of an ultralight below-knee prosthesis when the full function of a SACH foot is desired.

fit was obtained. A "satisfactory" fit was one which was agreeable to both the patient and prosthetist. In addition, an unannounced followup was done one month after the final fitting in order to determine if the subjects were still using the ultralight prosthesis or if they had gone back to their conventional prosthesis. At this time the subjects were also asked whether they liked the lightness of the prosthesis, other factors aside. The prosthetists were given a questionnaire (Appendix C) after all patients had been fitted in order to assess fabrication and fitting problems and the applicability of the device as a first definitive prosthesis versus a PTB replacement. Data in this respect were not collected on the new amputees since they had no prosthetic experience on which to base a comparison.

To date (January 1979), the sample consists of thirty-six patients who have been fitted with the ultralight prosthesis. Of that number, four are receiving it as their first definitive prosthesis. Of the remaining thirty-two patients, complete data have been obtained on fourteen. All but one are male. One patient died during the course of the study from an unrelated cause.

Results

The patient data are presented in Figure 3. The responses of one patient, H.G., need to be considered in light of the fact that shortly after receiving the prosthesis he moved out of state. He then had a structural failure of the foot of the prosthesis which altered its cosmesis, fit, and alignment. He indicated that this was the reason for his unfavorable response to several of the questions. Those responses are circled. He was unable to return to Philadelphia to be fitted

with another ultralight prosthesis.

The following general conslusions can be drawn from this preliminary data:

1. Although wearing time and walking distance do not appear to increase when the lighter prosthesis is used the overwhelming majority of the subjects felt that the lighter prosthesis requires less energy to walk with than a conventional prosthesis.
2. Opinions were mixed regarding which prosthesis is easiest to control and which one was the most comfortable to walk on. In both cases, however, the majority favored the experimental prosthesis.
3. The majority of the subjects felt that conventional prostheses are more cosmetically acceptable than the ultralight (polypropylene) model.
4. For the most part, either there was no difference in ease of donning and doffing, or else the lighter prosthesis was slightly superior in this area.
5. The overall preference was overwhelming for the ultralight prosthesis. The two who preferred their conventional prosthesis both liked the lightness of the experimental prosthesis, but they were very dissatisfied with the foot action.
6. There were six incidences of structural failure. Three were fractures of the polypropylene at the toe area of the foot. Two other cases involved crushing of the internal keel foot. The other failure was a subluxation of the socket within the shank. The first two problems were corrected by using an external keel foot. The socket problem was solved by using a heavier guage polypropylene and meticulous welding at the brim. It may be noted that structural failures occurred with both of the bilateral amputees. Structural failure also occurred most frequently in patients who subjected the prosthesis to extreme stress, as would be expected.
7. All but three subjects were using the ultralight prosthesis at follow-up. Of the three who did not, two gave their reasons as dissatisfaction with the "fit" that they had as a result of the rigid foot. The third subject (H.G.) was not wearing his prosthesis because the crushed foot precluded its use.
8. The subjects were unanimous in their approval of the lightness of the prosthesis.
9. Half of the patients commented that they disliked the rigid foot of the prosthesis, and there were some interesting comments about the light weight of the prosthesis. Two subjects (L.B. and J.C.) commented that the lighter weight noticeably reduced pistoning of the stump in the socket. Two others (A.W. and H.G.) stated that they had found the leg useful for work in and around water. A.W. also Commented that his stump was in better condition than it had ever been before. R.S. felt that the lightweight legs were superior to his conventional ones in every way except durability. Data from the prosthetists's questionnaires has not been compiled yet since some subjects are still undergoing fitting modifications. From informal communication, however, the principal complaints of the prosthetists are: (a) that the ultralight prosthesis is difficult to modify once it is made; (b) structural failures, especially at the foot, pose a problem.

Discussion

The preliminary data seem to indicate that the concept of an extremely

Subject	Age	Stump Length (L) (R)	Sex	Stress on Prosthesis: Extreme	Moderate	Minimal	Wearing Time: Increased	Decreased	No change	Walking Time: Increased	Decreased	No change	Least Energy Required: Light weight prosthesis	Previous prosthesis	So difference	Easiest Control: Light weight prosthesis	Previous prosthesis	No difference	Most Comfortable: Light weight prosthesis	Previous prosthesis	No difference	Most Acceptable Cosmesis: Light weight prosthesis	Previous prosthesis	No difference	Easiest Donning and Doffing: Light weight prosthesis	Previous prosthesis	No difference	Overall Preference: Light weight prosthesis	Previous prosthesis	So difference	Structural Failure: Yes	No	Prosthesis used at follow-up: Light weight	Other	Do you like the lightness?: Yes	No	Specific Complaints
E.W.	49	5¼	M		X				X			X			X		X				X					X			X			X	X	X	X	X	Dislikes rigid foot
C.H.	68	3½	M		X		X				X		X					X	X			X					X				X	X	X	X	X	
J.D.	40	7½	M		X				X	X			X			X			X					X	X			X			X	X	X	X	X	Dislikes rigid foot
G.F.	50	4	M	X					X			X	X			X			X					X			X	X			X		X	X	X	Dissatisfied with fit (new limb being made)
H.S.	30	4 8½	M	X				X				X	X			X			X			X			X			X			X			X	X	
L.B.	54	7½ 7½	M	X					X			X	X					X			X			X			X			X			X	X	Dissatisfied with fit (rigid foot)
A.W.	53		M	X					X			X	X			X			X			X			X			X			X		X		X	
H.S.	53	5½	M		X				X			X	X			X			X			X			X			X			X		X		X	
J.C.	23	5½	M	X					X			X	X				X				X	X			X			X				X	X		X	Dislikes rigid foot
H.G.	31	11	M	X				X		X			X					X		X			X			X			X			X		X	Poor fit after major structural failure
F.S.	31	3½	M	X				X				X		X		X				X			X		X			X			X		X		X	Dissatisfied with fit (rigid foot)
A.J.	60	5½	M		X				X			X			X		X			X		X				X			X			X		X		X	Dislikes rigid foot
A.R.	71	4½	F			X			X		X		X			X			X			X			X			X			X		X		X	
A.B.	64	7	M		X				X			X	X				X		X					X	X			X			X		X		X	Dislikes rigid foot
				TOTALS			1	3	10	2	1	11	11	1	2	7	4	3	8	4	2	3	8	3	5	1	8	12	2		6	8	10	3	14	

Fig. 3. Chart showing interim results of clinical trials of ultralight below-knee prosthesis.

light below-knee prosthesis is valid. The model used for this study seems to be inferior to conventional below-knee prostheses only in the areas of adjustability, durability, and, in some cases, function of the foot. Half of the patients sampled complained about action provided by the rigid foot. Most frequently the complaint was that heel-strike was jarring, and that it was hard to walk up inclines because of difficulty in "rolling over" the foot. The complaints about the rigid foot may be simply a matter of "getting used to it," especially after being used to a SACH foot. Nevertheless, the rigidity of the foot as well as its structural weakness can probably be solved by the incorporation of an external keel foot, a possibility now being considered by the REC. It is estimated that an external keel foot would add about 8 oz. to the prosthesis. Regarding cosmesis, the REC is now investigating the use of prosthetic skins that have been developed elsewhere. The current model is probably best used with patients who do not subject the prosthesis to extreme stress. It is of potential benefit to amputees of all ages, but it may be particularly indicated for patients with cardio-vascular impairments.

A final report on this project will be issued toward the end of 1979. Meanwhile a new fabrication manual will be published, and it is hoped that the American Academy of Orthotists and Prosthetists will undertake a nationwide clinical evaluation of this technique on behalf of the Veterans Administration.

The authors wish to express the sincerest of appreciation for the cooperation and assistance provided by Dr. Howard Zeidman, Chief, Prosthetics Clinic Team, VARO, Philadelphia, Edward Vargo, Prosthetics Representative, VARO, and the following prosthetists:

Joseph Botkin, J.E. Hanger of Philadelphia
Frank N. Cocco, Cocco Brothers
Virgil Faulkner and Amin K. Hajj, INA O&P Research Laboratory, University of Pennsylvania Hospital
Harry J. Lawall, Harry Lawall and Son
Harry J. Lawall, Jr., Harry Lawall and Son
Frank J. Malone, Jr., Frank Malone and Son, Inc.
Edward F. Moran, Cocco Brothers
Blondell Smith, Nu-Way Limb and Brace, Inc.
Thomas Sulima, Modern Limb and Brace Co.
John Swoyer, Modern Limb and Brace Co.
Charles Wright, J.E. Hanger of Philadelphia
Without their unselfish help and open minds this study could not have been carried out.

Literature Cited

1. Wilson, A. Bennett, Jr., and Melvin Stills, Ultralight prostheses for below-knee amputees, *Orthotics and Prosthetics* 30:1, 43-47, March 1976.
2. Wilson, A. Bennett, Jr., Charles Pritham, and Melvin Stills, Manual for an ultralight below-knee prosthesis, Rehabilitation Engineering Center, Moss Rehabilitation Hospital-Temple University-Drexel University (1977).

[1]This work was carried out with fiscal support from the Veterans Administration under Contract V101(134)P-576.

[2]Rehabilitation Engineering Center, Moss Rehabilitation Hospital-Temple University-Drexel Hospital, Philadelphia, Pa. 19141.

APPENDIX A

Questionnaire I – (For amputees who have previously used a definitive prosthesis)

Name: _____ Date: _____

1. How many hours a day do you wear your present prosthesis?
   a. 0-4 hours
   b. 4-8 hours
   c. 8-12 hours
   d. more than 12 hours

2. Are you presently satisfied with your prosthesis?
   a. Yes
   b. No

3. If not, why?
   a. because of the way it fits
   b. because of the way it looks
   c. because it's worn out
   d. other – please explain

4. How far can you walk on your prosthesis without resting?
   a. up to ½ block
   b. ½ block to 1 block
   c. 1 to 2 blocks
   d. more than 2 blocks

5. How long have you had your current prosthesis?

6. How do you like the fit of your prosthesis?
   a. excellent
   b. good
   c. fair
   d. poor

APPENDIX B

Questionnaire II—(For amputees who have previously used a definitive prosthesis)

Name:_____ Date: _____

Instructions: Please answer the following questions as objectively as possible.

1. How many hours a day do you wear the light-weight prosthesis?
   a. 0-4 hours
   b. 4-8 hours
   c. 8-12 hours
   d. more than 12 hours

2. How far can you walk on the light-weight prosthesis without resting?
   a. up to ½ block
   b. ½ block to 1 block
   c. 1 to 2 blocks
   d. more than 2 blocks

3. How do you like the fit of your light-weight prosthesis?
   a. excellent
   b. good
   c. fair
   d. poor

4. Overall, which prosthesis do you prefer?
   a. the light-weight one
   b. your original one (the one you used before entering this study)
   c. no preference

5. Which of the two prostheses do you feel requires less energy to walk with?
   a. the light-weight one
   b. your original one
   c. they both require the same amount of energy

6. Which prosthesis is easier to control when you are walking on it?
   a. the light-weight one
   b. your original one
   c. there is no difference

7. Which of the two prostheses do you feel is more comfortable to walk on?
   a. the light-weight one
   b. your original one
   c. there is no difference

8. In your opinion, which prosthesis looks better?
   a. the light-weight looks better than your original prosthesis
   b. the original prosthesis looks better than the light-weight one
   c. there is no difference

9. Which one is easier to put on and take off?
   a. the light-weight one
   b. your original one
   c. there is no difference

10. If you have found any particular advantages or disadvantages of the light-weight prosthesis as compared to your original one, please describe them here.

APPENDIX C

Questionnaire III – (for prosthetists)

Name: _____ Date: _____

Instructions: Based on your professional experience, and your recent exposure to the light-weight BK prosthesis, please answer the following questions as objectively as possible.

1. Which type of prosthesis is easier to fabricate?
   a. light-weight
   b. conventional
   c. no difference
2. Which type of prosthesis is easier to fit as a first definitive prosthesis (new amputee)?
   a. light-weight
   b. conventional
   c. no difference
3. Which type of prosthesis is easier to fit to an amputee who is already experienced at walking on a prosthesis?
   a. light-weight
   b. conventional
   c. no difference
4. Do you feel that the ultra light-weight prosthesis is a feasible device for your private clinical practice?
   a. Yes
   b. No
5. Do your feel that there are any particular age groups that the light-weight prosthesis is especially appopriate or inappropriate for? Please explain.
6. Do you feel that there are causes of amputation which are especially appropriate or inappropriate to use the light-weight prosthesis? (i.e., traumatic, vascular, etc.) Please explain.
7. Do you feel that the ultra light-weight prosthesis is most useful as:
   a. a first definitive prosthesis
   b. a replacement prosthesis (replacement for a conventional prosthesis)
   c. both
   d. neither
8. What specific difficulties have you encountered in fabricating the ultra light-weight prosthesis?
9. What specific difficulties have you encountered in fitting the ultra light-weight prosthesis?
10. Please give any additional comments that you feel are relevant to the feasibility of the ultra light-weight prosthesis.
11. What method have you used for forming the foot of the ultra light-weight prosthesis?
    a. by vaccu-forming an old sach foot
    b. by vaccu-forming a plaster foot
12. Have you used a flexible forefoot or a rigid forefoot on the ultra light-weight prosthesis?
    a. flexible
    b. rigid
13. What type of suspension system have you used for the light-weight prostheses you have made?

Orthotics and Prosthetics, Vol. 33, No. 2, pp. 54-62

Individual Engineering-Orthopedic Care for Patients Suffering From Infantile Cerebral Palsy[1]

R. VOLKERT[2]

A special consulting hour for patients was set up within the scope of collaboration between the Orthopedic Clinic of the University of Mainz and the Children's Neurological Center of the state of Rhineland-Palatinate. Emphasis is placed on conservative care of children suffering from cerebral and behavioral disorders.

The purpose of engineering-orthopedics in this case is to modify proven designs to meet particular individual needs and to apply new techniques in dealing with the multi-faceted problems presented.

It must be understood that, basically, the cerebral-palsy child is a brain-damaged child. The damage is in the first central motor neuron, the disorder affecting predominantly the control mechanisms of motion. The resultant neuromuscular malfunctioning takes the form of various pathological symptoms, but provides only a partial indication of the overall damage; or ought to be considered as such. Roughly speaking, a distinction is made between hemiplegia, diplegia, and tetraplegia. Disordered coordination of motion (ataxia) and also involuntary non-controlled motion (Athetosis) are frequently noted in this respect.

Because of these pathologically symptomatic conditions, the patients are predestined for special care involving modern therapeutic gymnastic methods. Correction of neuromuscular dysregulation and improper posture can be achieved in an autonomous manner. Supplementing and functionally improving steps may also be introduced and realized with directed attention-absorbing therapeutic techniques. The work by this pair of professional groups (KG and BT) must be given priority over technical orthopedic measures. A fairly good support of the therapeutic measures is provided by commercially available orthoses. However, the desired goals cannot always be achieved in individual care by using fairly heavy (conventional) orthoses. This is especially the case because fairly heavy appliances, in many instances, enhance the propensity for spasticity because of their rigid, mechanical construction, and because the patient cannot tolerate the loads exerted. The orthoses to be used, therefore, must be so designed that they complement existing residual functions with a modicum of equipment and that they correct pathological dysregulation and improper postures by means of moderate loads of pressure.

They must not hamper existing func-

tions, and simultaneously they must lead to functional improvements by exploiting given static-dynamic conditions.

An earlier report by this author (1) discussed provision of orthoses in dealing with neuromuscular malposture in the region of the upper limbs. The present report extends these considerations to the lower limbs.

The following ought to be the goals in the presence of pathological functioning and malposturing of the lower limb in brain-damaged children:

1. Light to Moderate Dysregulation:
   - compensate for inadequate static attitudes;
   - correction of pathological pattern of motion;
   - suppression of pathological behavior of motion to pave the way to proper movements.
2. Serious and Most Severe Failures and Manifold Handicaps:
   - achievement of standing;
   - provision of devices for correction of existing improper rest positions of the limbs;
   - technical orthopedic measures to ease care and prevention of contractures.

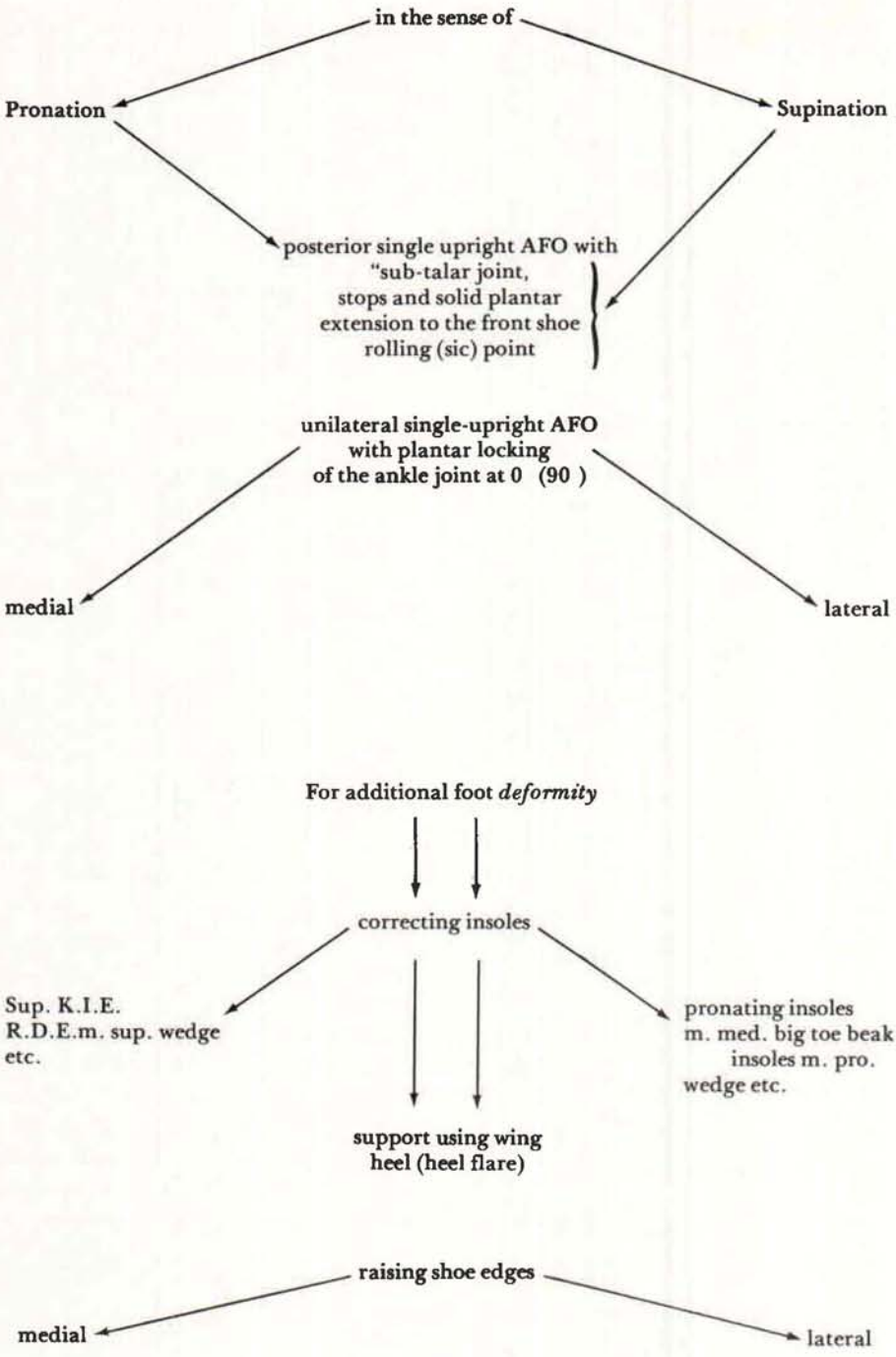
Treatment programs corresponding to these goals were drawn up (Fig. 1) for the most frequent problems found in the

1) Treatment scheme for slight, spastic foot deformities with orthoses
   - 1.1 Defective foot positions with regular arches present.
   - 1.2 Defective foot positions with clearly pathological feet.

2) Treatment scheme for severe defective foot position and foot attitude for the lower limb with orthopedic engineering techniques
   - 2.1 Functional defective attitude in the sense of easily and well compensated equinus
   - 2.2 Still correctable equinus in combination with defective foot attitude
   - 2.3 Difficult-to-correct equinus with marked foot deformity and defective attitude to the lower limb
   - 2.4 Mild calcaneous, dorsiflexion
   - 2.5 Calcaneous with severe foot deformity and defective lower-extremity attitude.

3) Treatment scheme for spastic foot defective position, attitude and rotational aberrations of the lower limb using orthopedic engineering techniques.
   - 3.1 Slight rotational deviations
   - 3.2 Rotational deviation with foot deformity
   - 3.3 Rotational deviation with severe foot deformity and defective attitude of the lower limb

Fig. 1. Treatment scheme for lower-limb for spastic foot deformities.



SUPPLEMENT: functional straps for knee-hip stretching assistance

Fig. 2. Excerpt from the treatment scheme for the still-to-be compensated equine foot.

lower limbs. In conformity with the dysfunctions listed, the individually required technical-orthopedic procedures can then be applied in a rational manner, as shown by the diagram of Figure 2.

Whereas slightly pathological foot positions can be well corrected by means of shoe accessories or special insoles, it is the functional equine foot with flexion contractures of the knee and hip joints which is the greatest problem. The forefoot lever can be extended as shown in Figure 3 so that the body weight automatically corrects the pointed foot by applying a slight pressure so that, in turn, the lower limb straightens.

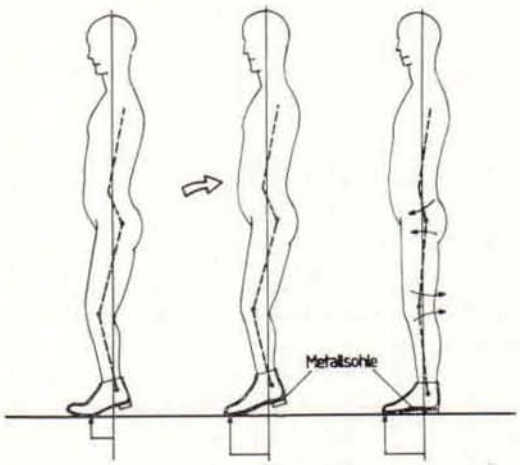


Fig. 3. Statically determined body-straightening.

As regards the spastic equine foot without foot pathology, the body resting-point can be moved forward (Fig. 3) and thus the forefoot lever can be extended in a problem-free manner by means of a simple metal insole in the shoe and by corresponding pads proximal and posterior to the calcaneous, with an additional shoe-tongue cushion (Fig. 4). The purpose of the latter is to fix the foot in the shoe.

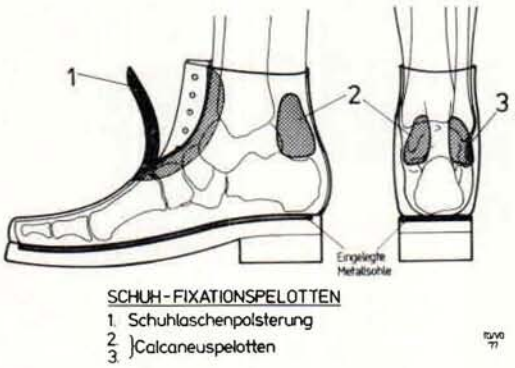


Fig. 4. Schematic of metal insoles arrangement of fixing pads.

Treating the equine foot when appreciable supination is present (frequently seen in hemiplegia) (Fig. 5) is substantially more difficult.

In this case it is found that supination can be quite well corrected by providing a pivoting posterior single-upright AFO with adjustable "subtalar" joint, whereby also the equine foot is very well corrected. As seen in Figure 6, the prosthetic bar first assumes the function of correcting the supination by pivoting the foot into the lower-leg axis, the foot being brought into the right-angle position to the lower leg in the second stage by a back-swing of the dorsal lower-leg brace part (Fig. 7). A lateral projection of the rail fastening mechanism passes in plantar manner to the base articulation of the little toes and thereby prevents the elasticity of the shoe from following the wrong positional tendency of the foot (Fig. 8). This technique makes it possible without the use of expensive equipment to achieve foot-position correction which contributes extensively to sure-footed standing and walking of the patient (Fig. 9).

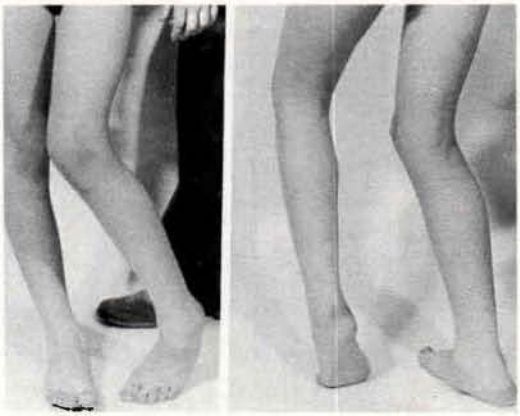


Fig. 5. Patient with left-side plastic hemiplegia in typical attitude.

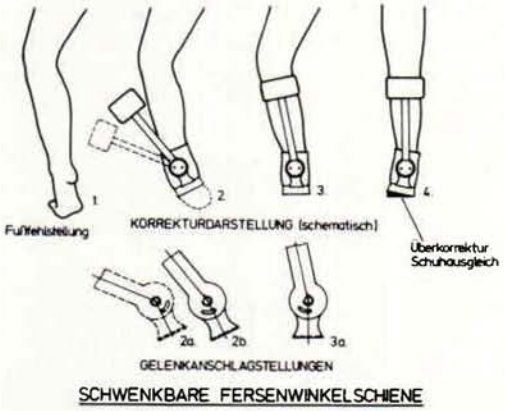


Fig. 6. Diagram of posterior single upright ankle-foot orthosis with adjustable "sub-talar" joint for correcting supinated foot. Posterior view.

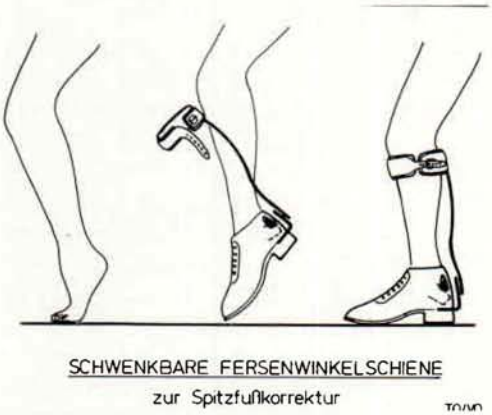


Fig. 7. Lateral view of posterior single upright orthosis with "subtalar" joint showing correction of plantar-flexion contracture.

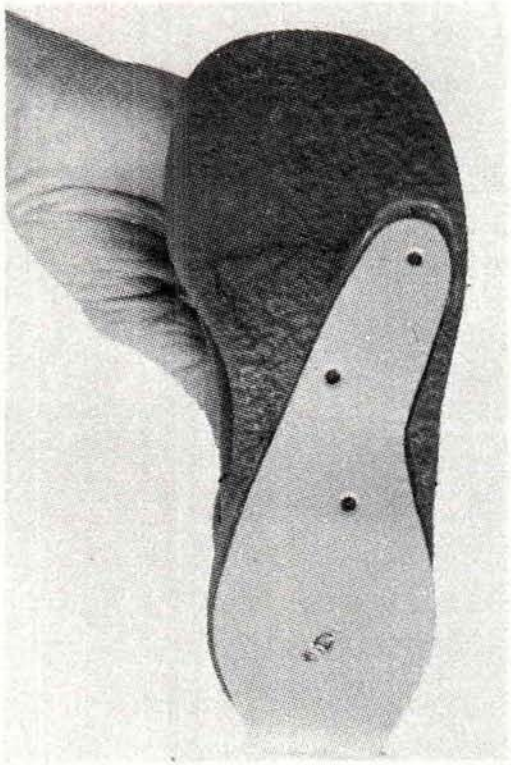


Fig. 8. Plantar view of shoe attachment bar and shoe showing lateral extension.

The spastic equine foot in combination with severe deformity in the sense of the extensively contracting buckled flat foot (valgus), as well as the varus foot in sickle form, can be well corrected by means of a shoe insert and a lateral single upright orthosis (GOCHT's inside and outside lever brace). The corrective forces which are provided can be distributed over a larger, optimally shaped surface so as to be very easily tolerated by the patient (Fig. 10). The advantage of the single bar orthosis in this sort of treatment is that the foot can be brought gradually into the optimal corrective position in successive stages.

The movable and partly blocked ankle joint permits all the activities which oppose the deformity, and these accessories therefore entail only a limited inactivation opposing the pathology. The long

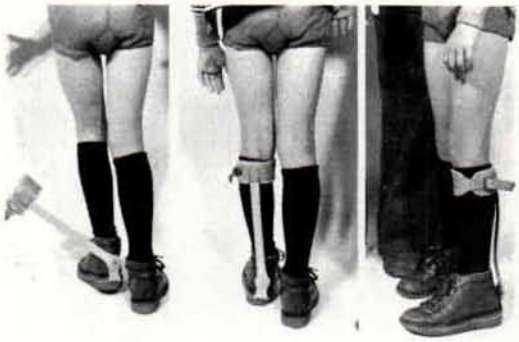


Fig. 9. Patients with posterior single upright AFO with "sub-talar" joint.

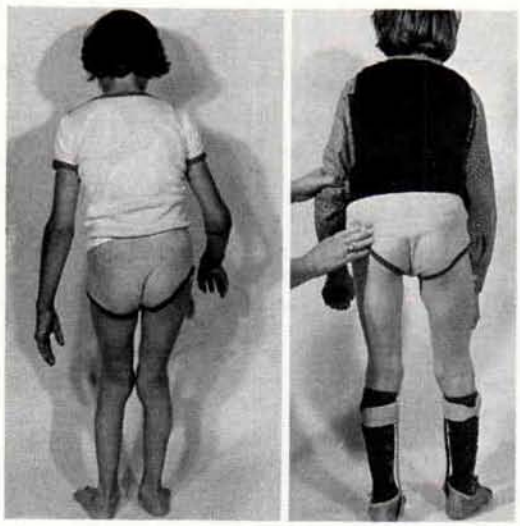


Fig. 10. Patient with appreciably spastic valgus flat feet
a) without orthosis
b) straightening by a Gochy inside lever brace with walking shoe (medial single upright AFO with shoe insert sandal)

metal sole under the shoe insert, the stop in the ankle joint, and the firm front strap below the knee joint are known techniques to offset forward the body's center of gravity and further to provide a mechanically static support to achieve lifting of knee and hip (Fig. 11). This propensity to stretching the knee and hip articulations may be enhanced by using a functional bandage (strap) as shown in Figure 12.

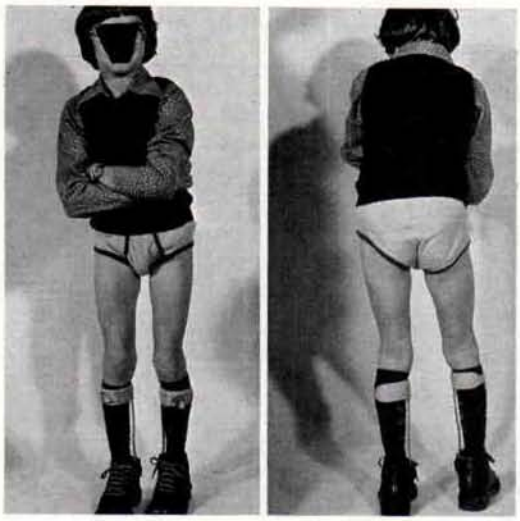


Fig. 11. Same patient following technical orthopedic care with Gocht inside lever braces with medial single upright AFO with shoe insert sandals in ready-made shoes.

Multiply handicapped patients (Fig. 13) can achieve, postsurgically, good ability to stand and walk in the conventional sense by means of individually designed devices that increase their radius of action (Fig. 14).

Technical orthopedic measures for children most severely affected physically and mentally will only be meaningful if correction of posture and prevention of contractures (Fig. 15) are achieved.

disturbed children, technical orthopedic accessories of the most varied kinds are used to prevent pathological behavior patterns. By suppressing such deviant behaviorism, the handicapped child can gain access to treatment in psychology, special pedagogy, and behavioral science. The equipment required to such ends are illustrated by two cases.

The disturbed behavior of the first patient, a female, took the form of permanent onanism. An individually made chastity belt (Fig. 16) interrupted this aberrant behavior and simultaneously

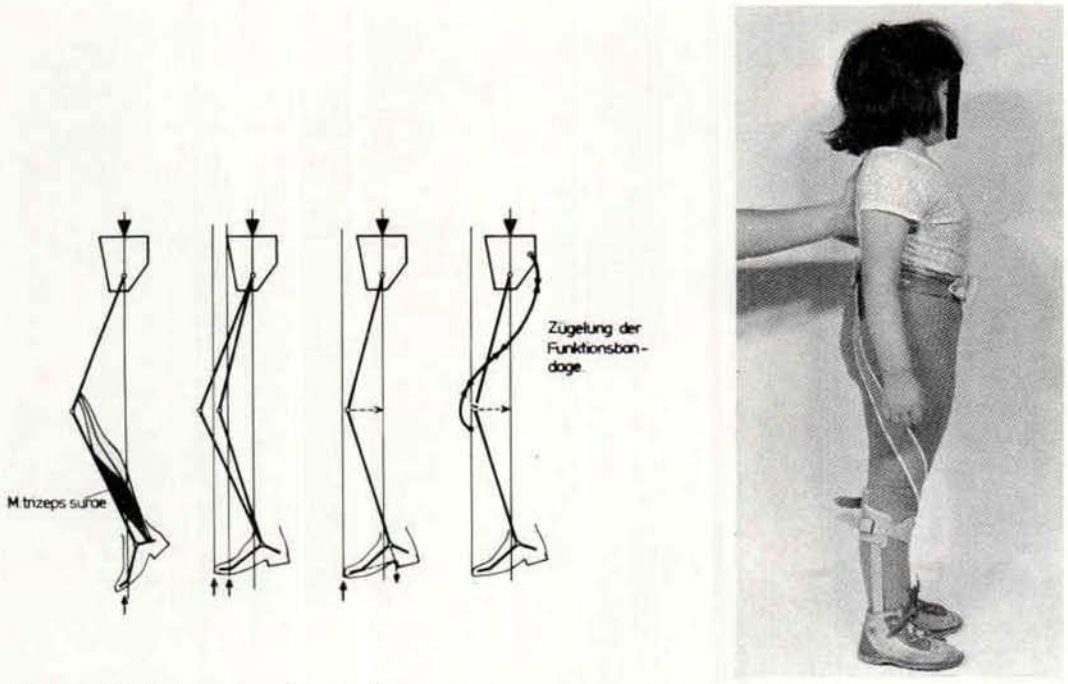


Fig. 12. a and b: Schematic and actual representation of support for knee and hip stretching by functional straps.

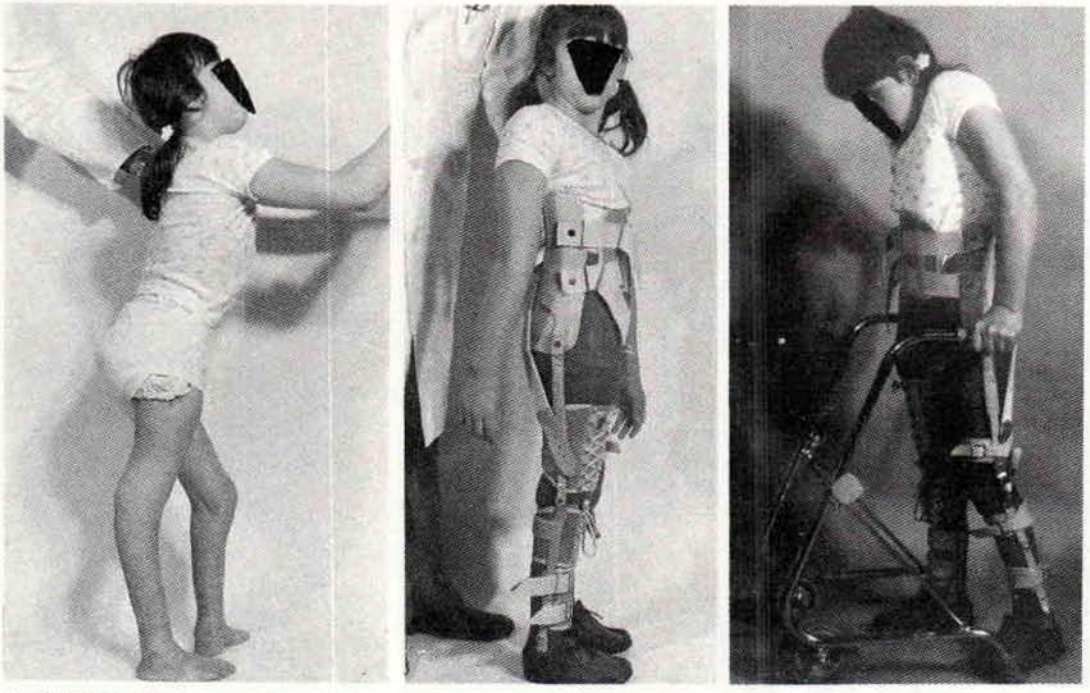


Fig. 13 & 14. Multiply handicapped patient with appreciable restrictions on knee and hip functions. The same patient equipped with engineering orthopedic means.

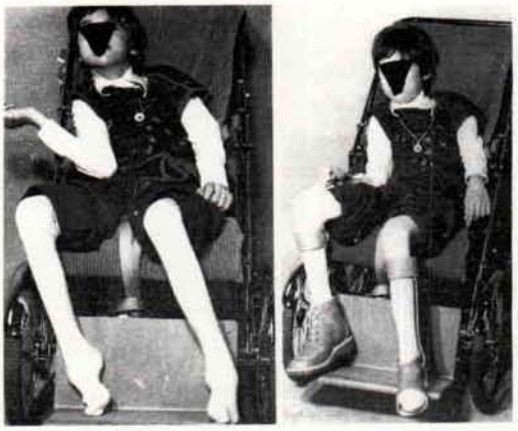


Fig. 15. Patient with defective attitude of lower extremity in wheelchair, without and with correcting means.

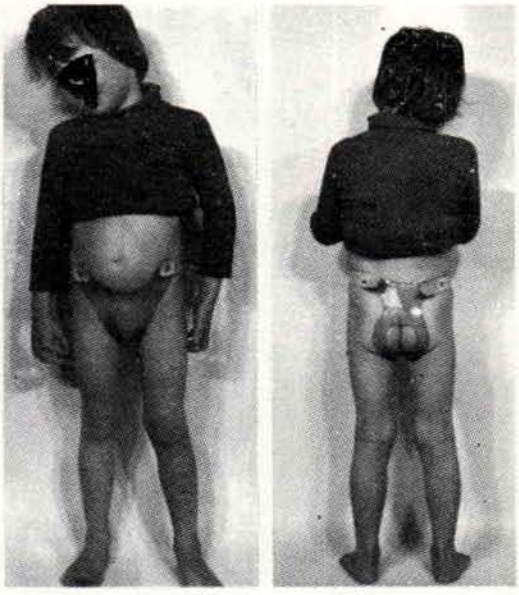


Fig. 16. Female patient with chastity belt in various views.

allowed introduction of specific therapeutic procedures.

Technical orthopedic devices may also be indicated for patients whose aberrant behavior takes the form of self-aggression. Frequently substantial injuries occur, the patients using their own body parts to such ends most of the time. Figure 17 illustrates a boy who first injured his face and head with his hands. After being prevented from doing so, he used his head to abuse his shoulders. To prevent this as well, Plastazote foam devices covering the endangered shoulder

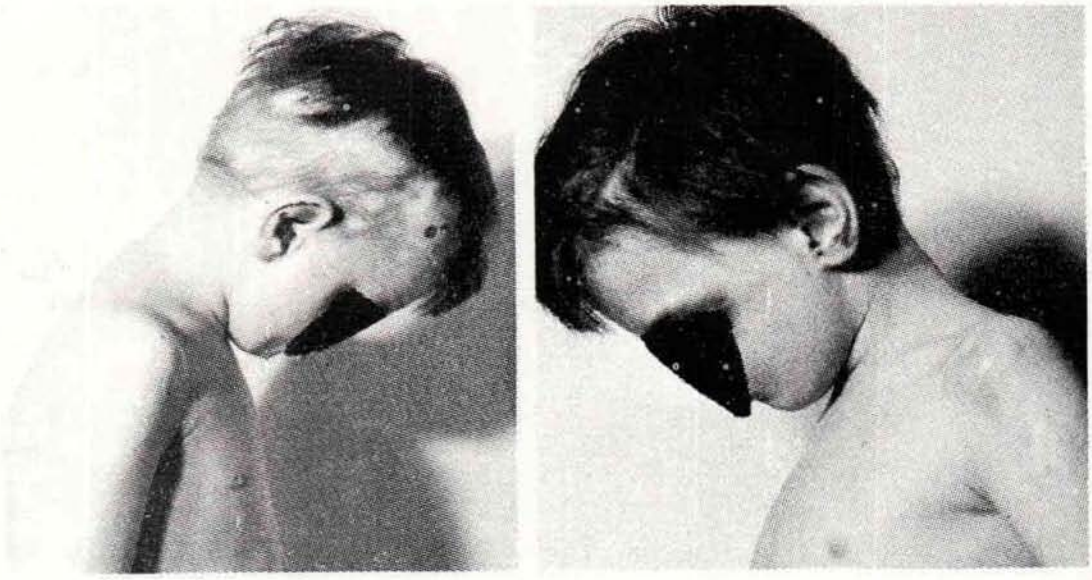


Fig. 17. Injuries of an auto-aggressive patient.

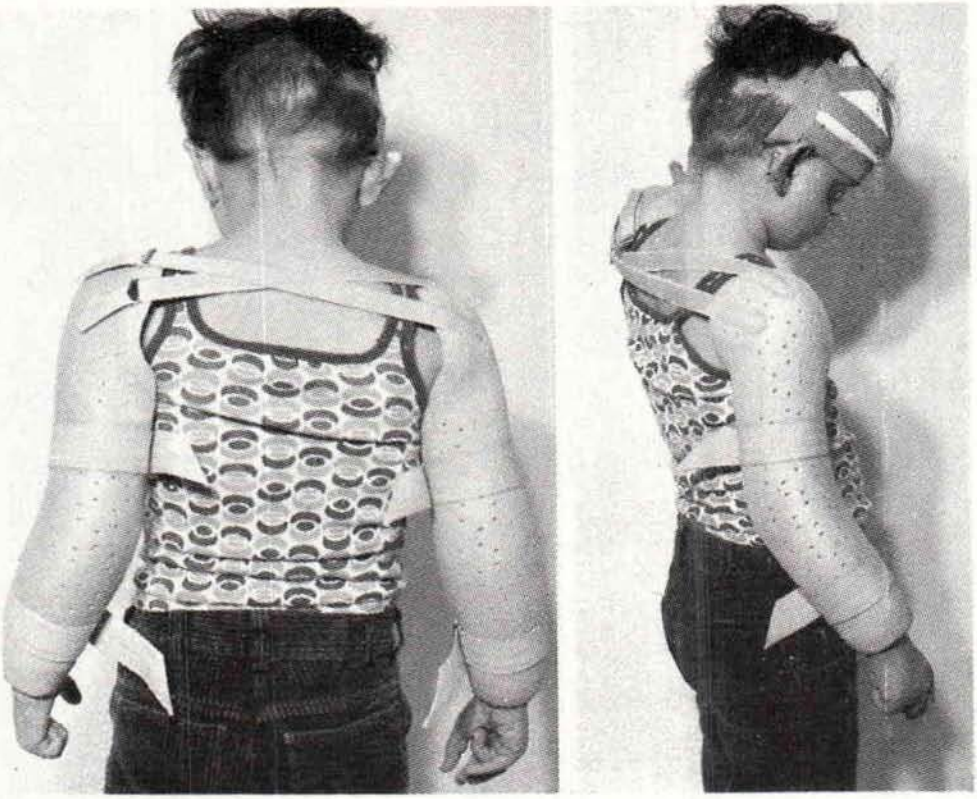


Fig. 18. Technical orthopedics with Plastazote arm splints.

parts were formed and fitted to the patient. The elastic material and the relatively loose back connection (Fig. 18) allows considerable freedom of motion for all sorts of activities without permitting self-injury.

Besides being protected, the patient was also expected to be becalmed so he could be treated with appropriate psychotherapy.

The treatment discussed herein should provide an overview of technical orthopedic measures which have been found practical within the scope of the special care of children suffering from cerebral palsy and behavioral disorders.

In conclusion, I wish to thank here my collaborators for their support, without which the care and treatment described above could not have been implemented.

Literature Cited

(1) R. Volkert and W. Schoen, "Individuelle orthopaedisch-technische Hilfsmittel zur Funktionsverbesserung der behinderten Hand, ORTHOPAEDIE-TECHNIK 29, (1978) 13-16.

---

[1]Report given at the yearly meeting of the Federal Association of Engineering Orthopedics, 25-26 May 1978, at Trier. Originally published in Orthopadie Technik 11/1978. Translated and published here by permission.

[2]Director, Department of Orthopedic Engineering, Mainz Orthopedic University Clinics, Langenbeckstrasse 1, 6500 Mainz, W. Germany.

Orthotics and Prosthetics, Vol. 33, No. 2, pp. 63-66, June 1979

Technical Note

Three-Stage Impression Technique For The Upper Arm

A three-stage technique has been developed for accurate impressions of the arm for above-elbow prostheses. It has been used successfully in our laboratory for approximately two years, and experience indicates it can produce an accurate impression which requires little, if any, modification of the axilla border. The technique also is useful in orthotics.

The technique consists of a "stage" impression similar to the Fillauer method (1) for below-knee prostheses, in conjunction with a wire-reinforced latex tubing similar to that used by Thranhardt (2) for the diagonal posterior trim of below-knee prostheses. By combining these two methods the prosthetist-orthotist can give more time to the molding procedure.

The impression technique for an above-elbow prosthesis is illustrated in Figures 1 through 5. (For orthoses the technique must be altered to facilitate removal of the plaster from an intact limb. This is most easily accomplished by using plaster splints, instead of the plaster bandage shown in Figure 4, as with the Michigan technique (3) for ankle-foot-orthoses.) The limb is covered with Tubegauz® or stockinet and all skeletal landmarks are outlined (Fig. 1). Latex tubing reinforced with malleable wire is contoured to the axilla while the limb is in a flexed position and extended against resistance (Fig. 2) in order to accentuate the pectoral and latissimus tendons to

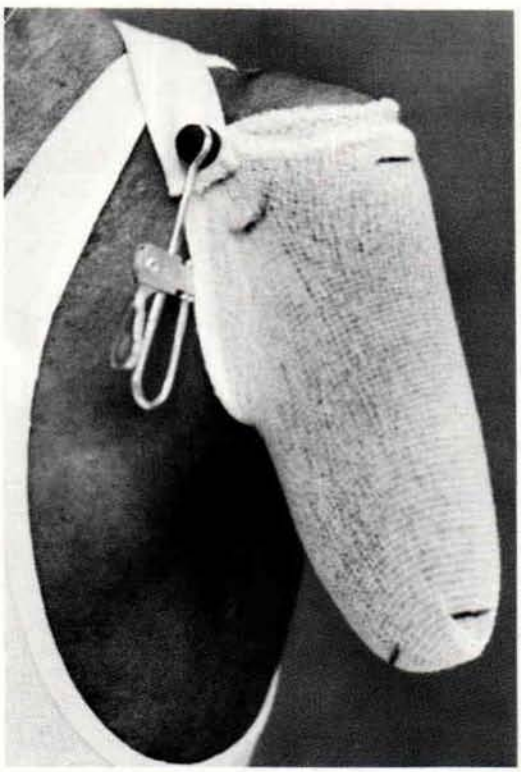


Fig. 1. Limb is prepared in the usual manner.

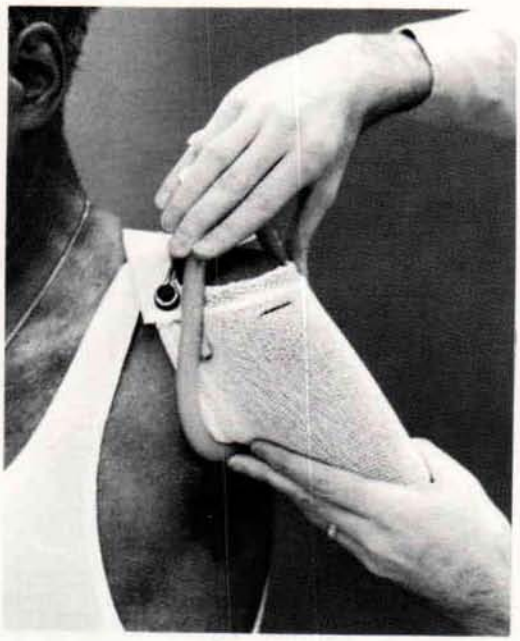


Fig. 2. Wire-reinforced latex tubing is contoured to the axilla.

their fullest. The medial border (anterior and posterior) of the socket can also be established with this tubing. Plaster-of-Paris splints, six layers thick, are used to cover the axillary portion of the tubing and encapsulate the end of the limb to permit accurate control of socket length. After the splints have hardened, the limb is covered distally from the axilla level with an elastic plaster bandage reinforced with regular plaster (Fig. 4). When this portion has set, the proximal impression is taken with splints nine layers thick (Fig. 5). At this time both hands are free to concentrate on molding the anterior and posterior wings in the deltoid area. Because the tubing requires minimal space in the axilla area, there is less chance of lateral gapping of the prosthesis resulting from too much shoulder abduction during the impression procedure.

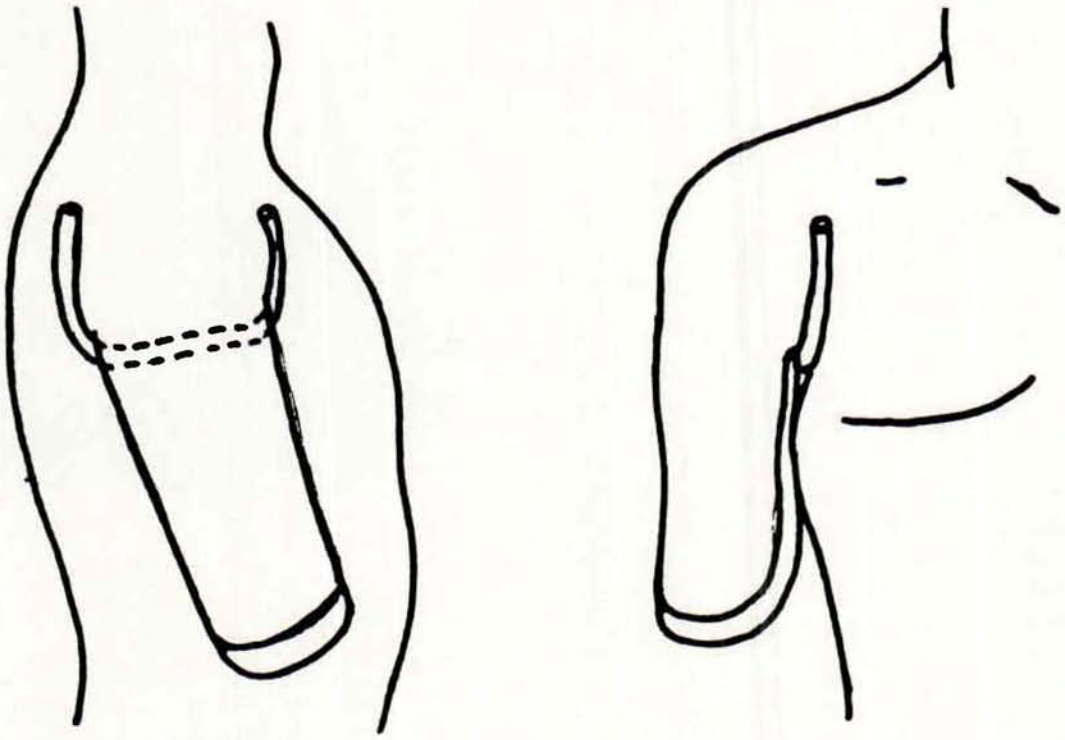


Fig. 3. Six layers of plaster splints form axilla border and "cap" distal end.

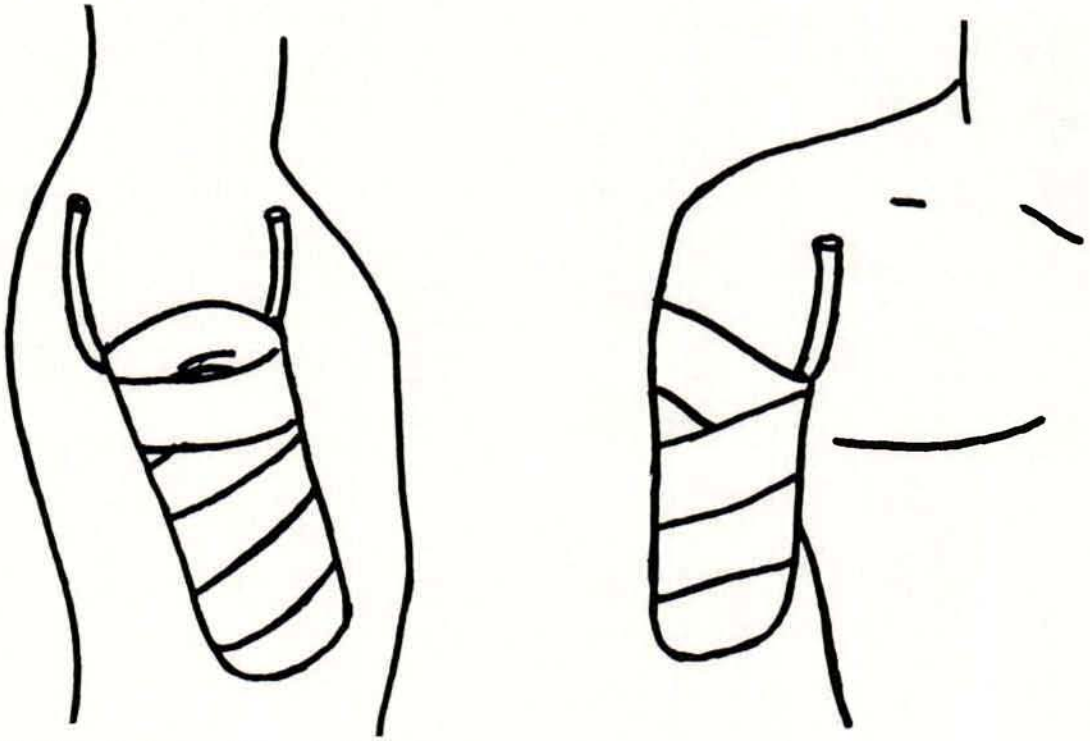


Fig. 4. Elastic plaster, reinforced with regular plaster, encases the distal limb.

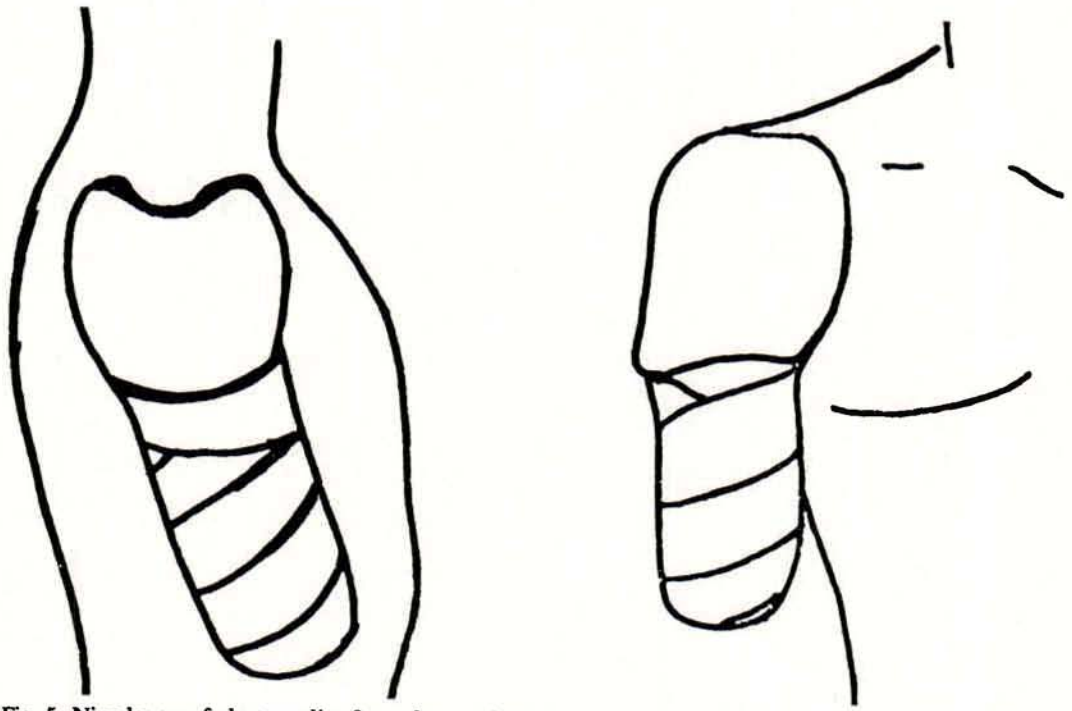


Fig. 5. Nine layers of plaster splint form the proximal section.

The impression technique described here produces an accurate model of the limb which requires little or no modification of the axilla area. The method also permits an accurate overall impression because the prosthetist-orthotist has good control during all aspects of the impression procedure. An orthosis or prosthesis can then be fitted to the patient with less chance of discomfort that is the case with more conventional methods.

This work was supported by Veterans Administration Contract V101(134) P326.

Literature Cited

(1) Fillauer, Carlton, *A patellar-tendon-bearing socket with a detachable medial brim,* Orthotics and Prosthetics, 25:4, pp. 26-34, Dec. 1971.

(2) Thranhardt, Ted, *Personal communication,* March 1976. J.E. Hanger, Inc. of Florida, Orlando, Florida.

(3) Tyo, J.H. and R.P. Koch, *Procedures for obtaining casts for ankle-foot orthoses,* Orthotics and Prosthetics, 32:2, pp. 12-20, June 1978.

Terry J. Supan, C.P.O.
Chief Research Prosthetist-Orthotist
Prosthetics Research Laboratory
Department of Orthopaedic Surgery
Northwestern University Medical School
345 E. Superior Street
Chicago, Illinois 60611

New Publications

Muscles Alive, J.V. Basmajian, 4th Edition, Williams and Wilkins, 495 pp. 176 illustrations.

The progress made in electromyography has been so rapid and the demand for "Muscles Alive" so great that it was necessary for Dr. Basmajian to prepare this fourth edition only four years after the third edition was issued. As most readers know the previous editions have been excellently organized, well documented, and beautifully produced. The fourth edition carries on the tradition.

Amputations and Prostheses, Miroslaw Vitali, Kingsley P. Robinson, Brian G. Andrews, and Edward E. Harris, Baillere Tindall, London (available in the U.S. through Macmillan Publishing Co.), 241 pp. 167 illustrations, $27.50.

The authors of this authoritative volume are four well known orthopaedic surgeons all of whom have been connected closely for a number of years with the Limb Fitting Service of British Ministry of Health. It is therefore not surprising that the emphasis is more on surgery and medical care than it is on prostheses. The philosophy set forth is quite similar to that expressed by leaders in prosthetics in the United States. The text is clear and to the point. The illustrations are well chosen.

It is an excellent reference book and no collection of material on limb prosthetics will be complete without this well presented book.

Error:

The March '79 O & P Journal had the following two mistakes. Please take note and make the appropriate corrections for your records.

- Figure 18 located on p. 49 should be switched with Figure 1 on p. 53 and vice versa.
- The correct spelling of the authors of the article entitled "An Effective Orthotic Design for Controlling the Unstable Subtalar Joint" are J. Martin Carlson, M.S., C.O. and Gene Berglund.

We regret any inconvenience caused by these two errors.

Also please note: Due to production problems, the June '79 O&P Journal has arrived late. We again regret any inconvenience created by this delay.

CLASSIFIED ADVERTISEMENTS

Member—First 35 words - $24.00 (minimum). Additional words $1.00 each. Non-member—First 35 words - $36.00 (minimum). Additional words $1.50 each. (a word consists of 5 characters). Mail Addressed to National Office forwarded unopened at no charge. Classified Advertisements are to be paid in advance; checks should be made payable to AOPA. Send to: Editor, AOPA Almanac, 1444 N St., N.W. Washington, D.C. 20005. No classified ads will be taken by phone.

ORTHOTIST, PROSTHETIST, O-Technicians, P-Technicians—Immediate Openings, Excellent Benefits, Competitive Salaries. Chicago/Chicago Suburbs. Resumes Kept in Confidence. AOPA Box 5794. 1444 N St. N.W. Washington, D.C. 20005.

CERTIFIED ORTHOTIST (+ CERT. PROS. TECHN.)—desires situation. 7 yrs exp., specialty in Spinal, sports med, burns., Full clinical + Fabrication exp. Resume and references on request. Contact David A. Guest, 11015-96 St., Edmonton, Alta, Canada T5H-2K7.

IMMEDIATE NEED—Certified Prosthetist-Lab Work and clinic a progressive modern facility, excellent benefits, send resume listing experience. Salary negotiable. Wagner Prosthetics Inc. 202N 23rd. P.O. Box 274. St. Louis, MO. 314-436-0996

CERTIFICATION ELIGIBLE—B.S. degree from U. of Wash. program. One year experience. Seeking position in Northwest. Send reply to: Personal, 2704 Atlanta Dr. Silver Spring, MD. 20906

PROSTHETIC INSTRUCTOR — UNIQUE OPPORTUNITY—Assist with design and implementation of personalized training program for Prosthetic Practitioners. 916 Vocational Technical Institute is extending its career ladder offerings to provide short term/certificate training in Prosthetics. Competent, creative CPO or CP needed to help develop this midwestern training program. Call or send resume: Ken Chagnon, (612) 770-2351, Ext. 256, 916 Vo-Tech Institute, 3300 Century Ave. N., White Bear Lake, MN 55110. (Metro St. Paul/Minneapolis area)

C.O. AND/OR C.P.—Benefits include health and dental insurance, life insurance, retirement plan, paid vacation and all major holidays. Salary open. Replies confidential E.H. Rowley Company, Inc., 11330 Woodward Ave., Detroit, MI 48202

ORTHOTIC ASSISTANT OR TECHNICIAN—Experienced Orthotist wanted who is qualified to fabricate and fit all types Orthotic appliances. Paid Life, Health, and Vacation, salary negotiable. Please send resume and references to R. E. Lebold, Salem Orthopedic & Prosthetic Inc., 675 12th St. SE, Salem, Oregon 97301

CERTIFIED PROSTHETIST—Beautiful S.E. mountain resort area has immediate opening for experienced C.P. Excellent working conditions and benefit package. Send resume to: AOPA Box 5793, 1444 N Street N.W., Washington, D.C. 20005. All inquiries confidential.

CERTIFIED ORTHOTIST OR CPO—Established firm, paid vacation, health insurance, retirement plan, salary plus bonus, two hours from Yellowstone Park and Jackson, Wyoming. We have lady fitter and Orthotic technician. Send resume to Medical Mart Orthotics and Prosthetics Division, P.O. Box 2467, Idaho Falls, Idaho 83401. 1-208-523-0402 Seth Jenkins.

CERTIFIED PROSTHETIST—Well established firm in lovely New Jersey seaside community needs a prosthetist with wide experience. Send resume and salary requirements. All inquiries confidential. Reply AOPA, Box 6792, 144 N Street, N.W. Washington, D.C. 20000

CERTIFIED PROSTHETIST-ORTHOTIST—position available for a progressive practitioner seeking Management position with an established firm. Salary commensurate with experience. Excellent benefits and incentive plans. Replies confidential. Please send resume to: Daniel L. Shamp, C.P.O., Shamp Prosthetic Center, 3090 Wadsworth Road, Norton, Ohio 44203

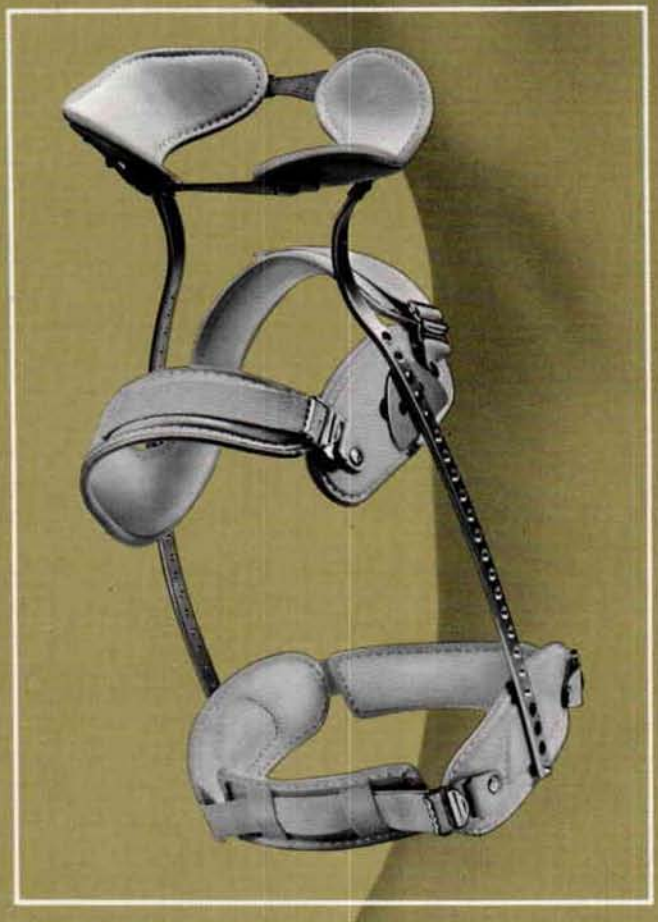
ORTHOTIC TECHNICIAN—Opportunity to work in a dynamic university setting with exposure to a wide variety of orthotic appliances. Requires one year of experience or training in an orthotic/prosthetic program. Duties will include fabrication of polypropylene CTLSO, TLSO's and lower limb orthoses. Excellent benefits. Apply to Employment Office, 126 Eleanor Taylor Bldg, 39th & Rainbow Blvd, Kansas City, Kansas 66103, University of Kansas Medical Center, College of Health Sciences and Hospital - an equal opportunity employer

ORTHOTIST/PROSTHETIST—Certified or board eligible. Location San Juan, Puerto Rico. Spanish speaking not necessary. Salary dependent on experience. Travel expenses reimbursed for interview. Excellent opportunity for advancement with growing company. Patient contacts include office, shop and hospitals. Send resume to AOPA, Box 2791, 1444 N Street, N.W., Washington, D.C. 20005.

CERTIFIED ORTHOTIST OR BOARD ELIGIBLE—Position open in well established midwest facility. Twenty-five years in same location. Will consider partnership to honest reliable person. All replies are held in confidence. Send response to AOPA, Box 5791, 1444 N Street, N.W., Washington, D.C. 20005

DIRECTOR OF PROSTHETICS AND ORTHOTICS NEEDED—for a major Center for the Development and Service of artificial limbs. Applicant should be Board certified in both Prosthetics and Orthotics; and member, Academy of Orthotists and Prosthetists. Should have considerable background in facility management. Prior experience in teaching and prosthetics and orthotics research will be highly desirable. Salary and benefits negotiable. Send resume: F.W. Clippinger, M.D., Professor, Orthopaedic Surgery, Box 3935, Duke University Medical Center, Durham, N.C. 27710 (An Equal Opportunity/Affirmative Action Employer)

CERTIFIED PROSTHETIST AND CERTIFIED ORTHOTIST—Excellent professional opportunities to work in a teaching Medical Center with a dynamic and growing rehabilitation program for children and adults. Strong growth potential. Suburban type living within 2½ hours of Washington, D.C. Send resume and salary requirements to: Personnel Department, University of Virginia, Charlottesville, VA 22903 - Affirmative Action/Equal Opportunity Employer.



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

FOR FIT *and* COMFORT

SHOES FOR EVERY NEED!

COLORS: Black, White, Beige, Blue and Green Gluv, Brown and Toupe Thorobred

OUR FAMOUS

Rover

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

Sizes: 5 - 12 in varying widths, leather uppers.

AND POPULAR

Rings

COLORS: Black, Camel, Bone, White Blue and Red

Please Send For Our In Stock Catalog.

Drew Shoes

DREW SHOE COMPANY
252 Quarry Road
Lancaster, Ohio 43130
(614) 653-4271

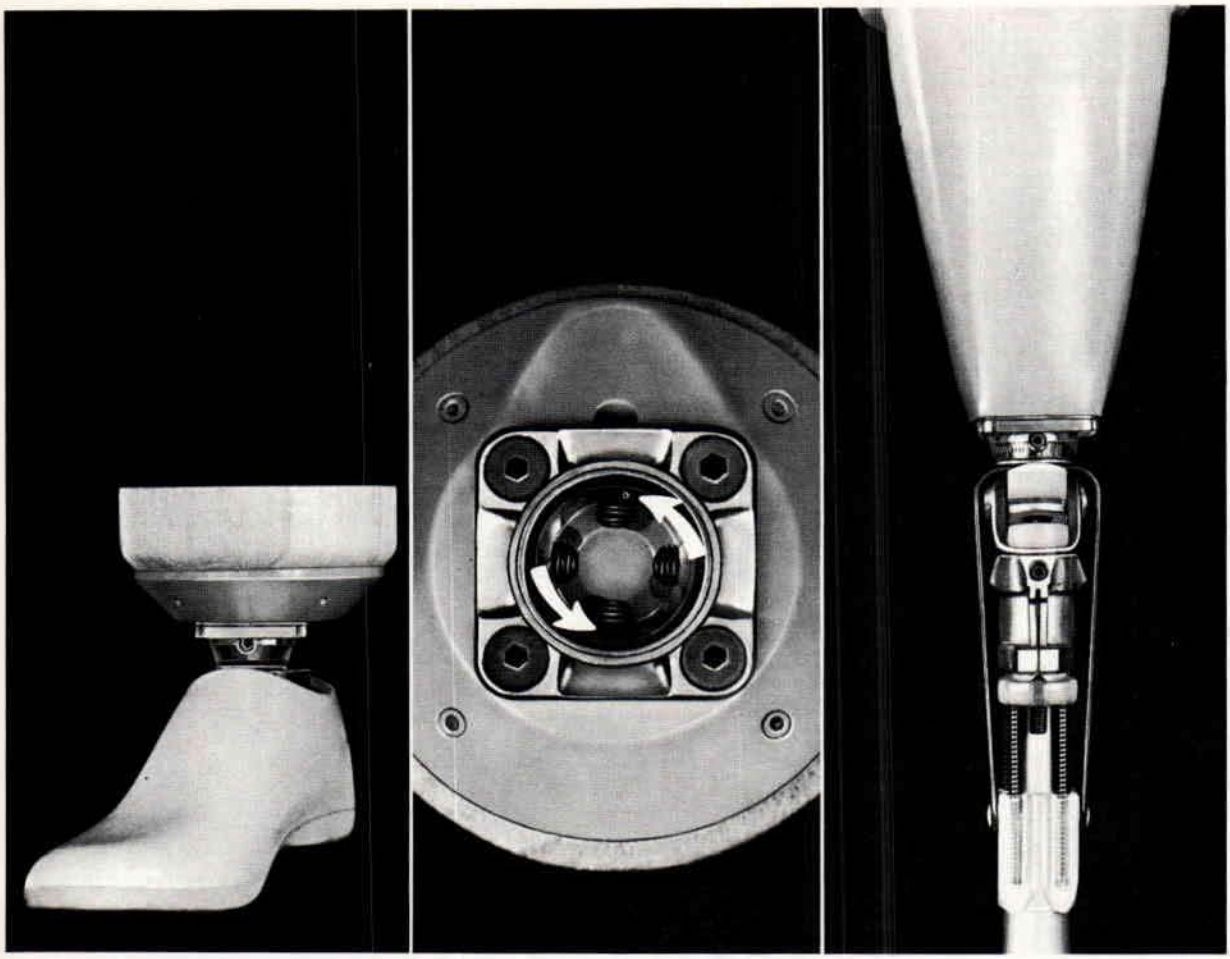
A Public Service of this magazine & The Advertising Council Ad Council

Last year millions upon millions

counted on us.

We're counting on you.

Red Cross. The Good Neighbor.



A new adjustable rotation adapter for the OTTO BOCK lower extremity Modular System

The need for a simple socket rotation adjustment in medium or long B/K and A/K amputation cases led us to develop the new 4R37 base plate adapter.

By loosening the four attachment screws, the socket can be rotated through a total range of 40° (20° internal and 20° external).

This new product is a tremendous aid to the Prosthetist in achieving optimum dynamic alignment for the Patient.

Otto Bock
ORTHOPEDIC INDUSTRY INC.
UNITED STATES OF AMERICA
610 Indiana Avenue North
Minneapolis · Minnesota 55422

CERVICAL ORTHOSES

Knit-Rite Catalog Pages 61, 62, 63

POLYURETHENE SOFT CERVICAL COLLAR

PLASTAZOTE CERVICAL COLLAR

FOAM COLLAR/HALTER

THOMAS ADJUSTABLE PLASTIC COLLAR

ADJUSTABLE FLEXION COLLAR

WIRE FRAME CERVICAL COLLAR
With Pad Type Back—Three Sizes
With Posterior Plate—Three Sizes

ADJUSTABLE PLASTIC COLLAR

SIDE OPENING COLLAR

ADJUSTABLE CERVICAL COLLAR

SINGLE POST CERVICAL BRACES

STANDARD FOUR POST

FOUR POST CERVICAL BRACE
With Ball and Socket Adjustment

ALL METAL CERVICAL BRACE

CERVICAL-DORSO BRACE

S.O.M.I.

16 STYLES
57 SIZES

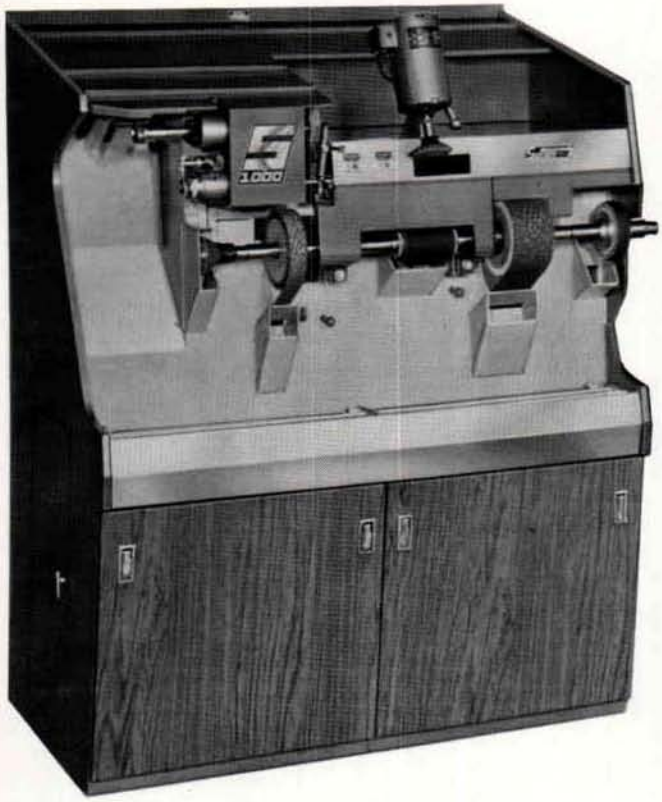
KNIT-RITE®

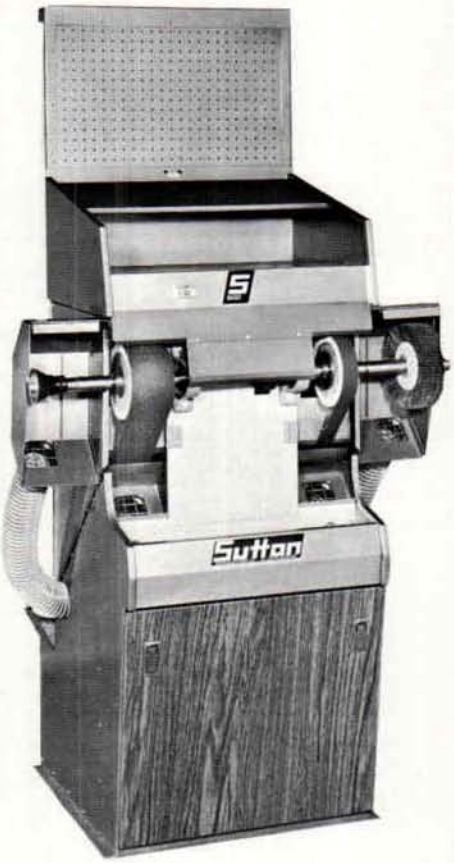
Distributed by KNIT-RITE, INC.

2020 Grand, P.O. Box 208, Kansas City, Missouri 64141
Call TOLL FREE 1-800-821-3094 / MISSOURI COLLECT 816-221-0206

September, 1978

2 Great New Machines To Enhance The Skills Of The Orthotic Professional





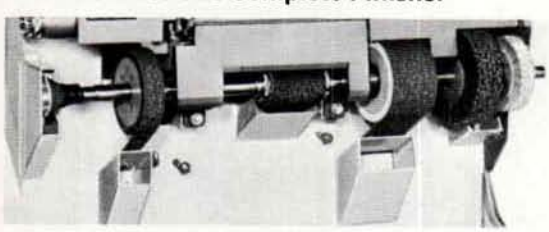
S1000

The S1000 has two ultra-high speed 60" quick change belts, the new Quik-Adjust sole trimmer that lets you dial any size edge iron to a #36 while the machine is running, and a fully ducted dust control system that is so efficient it doesn't even need a bag shaker. The S1000 fits into a 50-inch space and comes with a heel breaster, 1-9/16" wide belt, a 4½" bottom sander, a 4" belt, and a drum sander. Alternate shaft configurations available.

S500

This compact sander fits in a 40" space and may be ordered with any combination of two 4" or 1-9/16" belts. Belts are a full five feet long for maximum cutting speed. Steel brush for right end of shaft, heel breaster for left end, with all dust areas fully ported to highly efficient dust control system. Swingaway access doors for fast belt changes.

This Shaft For The Complete Finisher



Order your S1000 to accept the combination brush-burnisher wheels. Mounted with bayonet fittings, the brown or black wheels snap on the right end of the shaft quickly, eliminate the need for a separate brush-burnisher unit. Dozens of other fittings to fit shaft end.

Sutton *Shoe Machinery Co.*
3500 Scarlet Oak Boulevard • St. Louis, MO 63122

Toll free: (800) 325-3542; In Mo. dial (314) 225-5255.

[ ] Send complete information on the S1000
[ ] Send information on the S500

Name _____

Firm _____

Address _____

City, State, Zip _____

Telephone _____

AN INVITATION TO JOIN THE I.S.P.O.*

The International Society for Prosthetics and Orthotics was formed in Copenhagen, Denmark in 1970 to promote high quality prosthetics and orthotics care throughout the world for people with neuromuscular and skeletal disabilities primarily by conducting congresses, seminars, and evaluation programs, publishing appropriate reports, and acting as a source of information.

To date there are 62 National Member Societies and approximately 1600 members.

Benefits from membership in the Society:

1. Receipt of the journal "Prosthetics and Orthotics International." Published three times per year, "Prosthetics and Orthotics" is the only professional journal in prosthetics and orthotics that is truly international. It provides a forum for interdisciplinary interchange of information and ideas concerning research, development, evaluation, clinical application, and education in prosthetics, orthotics and related areas. A sample copy can be obtained by contacting A. Bennett Wilson, Jr., Moss Rehabilitation Hospital, 12th Street and Tabor Road, Philadelphia, Pa. 19141. (Libraries and non-members may subscribe to "Prosthetics and Orthotics International" for $20.00 per year.)

2. Reduced registration fee at I.S.P.O. sponsored programs. A World Congress is held at different sites every three years; international seminars on special topics are held for practitioners and others from time to time.

A copy of the constitution of the Society is also available from Mr. Wilson. An application for membership can be found on the reverse side of this page. The membership fee is $30.00 per year, $5.00 of which is retained by the U.S. Committee.

A. Bennett Wilson, jr.

A. Bennett Wilson, Jr.
Chairman, U.S. National Committee

***The International Society of Prosthetics and Orthotics**

INTERNATIONAL SOCIETY FOR PROSTHETICS AND ORTHOTICS

APPLICATION FOR ELECTION TO MEMBERSHIP

I herewith apply for admission to the International Society for Prosthetics and Orthotics.

FIRST NAME(S): _____ (IN BLOCK LETTERS, PLEASE)

SURNAME: _____ (IN BLOCK LETTERS, PLEASE)

NATIVE LANGUAGE: _____

DATE OF BIRTH: _____

SECOND LANGUAGE: _____

ADDRESS: _____

_____ COUNTRY: _____ (IN BLOCK LETTERS, PLEASE)

PROFESSION:

( ) Physician or Surgeon
( ) Engineer
( ) Prosthetist or Orthotist
( ) P-O Technician
( ) Therapist
( ) Other (please detail)

PRESENT POSITION: _____

INSTITUTION/FIRM: _____

LENGTH OF SERVICE: _____

RESPONSIBILITY: _____

_____

_____

QUALIFICATIONS/DEGREES: _____

_____

_____

_____

MEMBERSHIP OF OTHER PROFESSIONAL SOCIETIES: _____

_____

SIGNATURE: _____ DATE: _____

Please make checks payable to U.S. National Committee, ISPO

MAIL ADDRESS: Howard R. Thranhardt, Acting Secretary-Treasurer, ISPO, U.S. National Member Society, 87 Cunningham Drive, New Smyrna Beach, Florida 32069

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.

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** _____

Jobst® Post-Op Air Boot® Provides Continuity of Kinesthetic Sense of Gait and Balance

An Immediate Post-Op Prosthesis Following Below-Knee Amputation.

®Reg. U.S. Pat. Off.

PATIENT BENEFITS

- Continuity of kinesthetic sense of gait and balance
- Decrease of pain—increase of comfort
- Rapid Healing
- Quicker stump maturation
- Earlier prosthesis fitting

MEDICAL ADVANTAGES

- Rigid Dressing
- Easy application and removal—allows viewing of healing wound
- Air Pressure Control Unit easily attached to inflate correct pressure, and removed for ambulation
- Comfortable—avoidance of flexion contractures
- Decrease and control edema
- Hemostasis
- Clinically Proven Effective

AVOIDS THESE COMMON PROBLEMS

- Uneven pressure when applying elastic bandages
- Faulty position of knee
- Proximal constriction of socket and uneven pressure over condyles

Model No. 28-01 with Inflating System

JOBST®

Jobst Institute, Inc.
Box 653
Toledo, Ohio 43694, U.S.A.

Please send full information on Jobst Post-Op Air-Boot

Name_____

Address _____

City _____

State _____ Zip _____

American Orthotic and Prosthetic Association
1444 N Street, N.W.
Washington, D.C. 20005