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Contents

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Audrey J. Calomino

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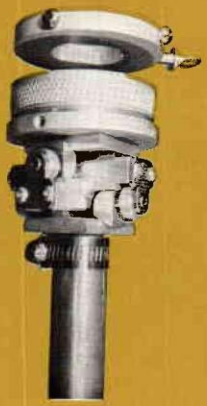

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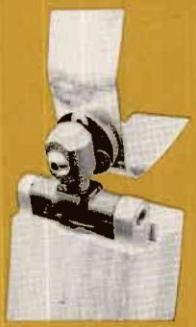

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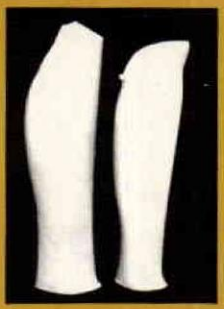

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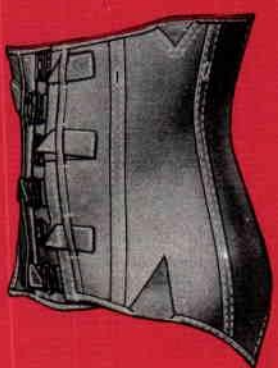

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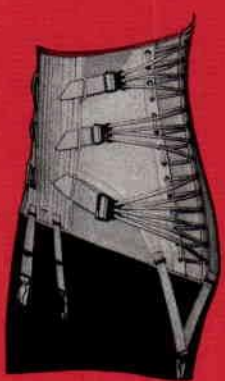

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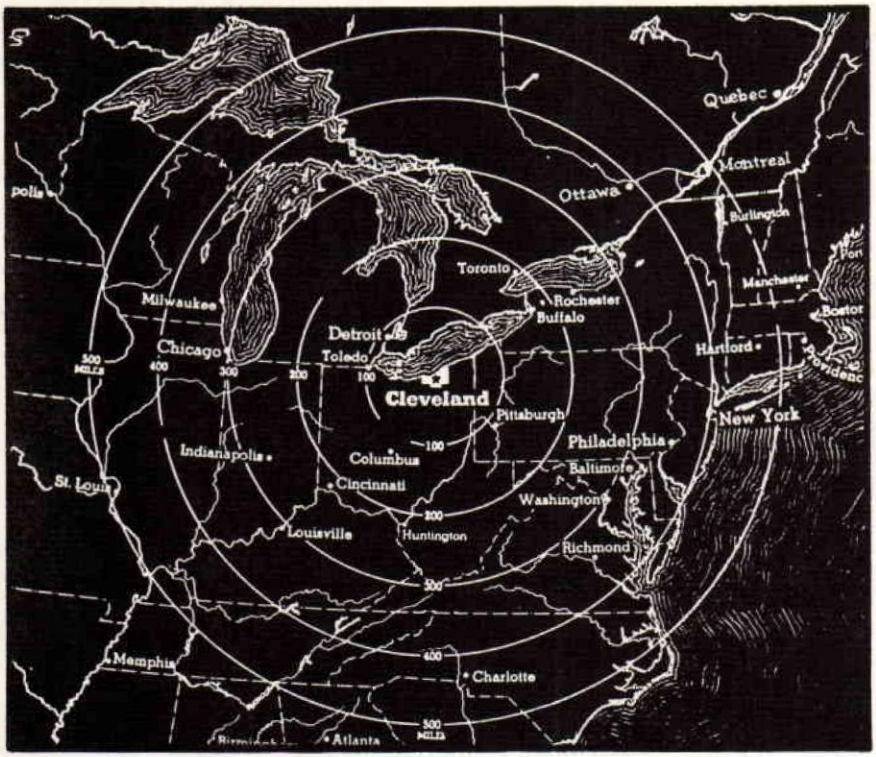

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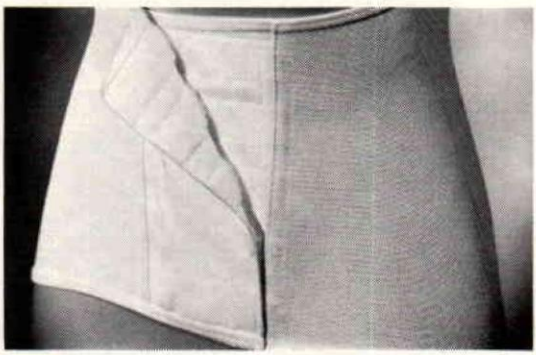

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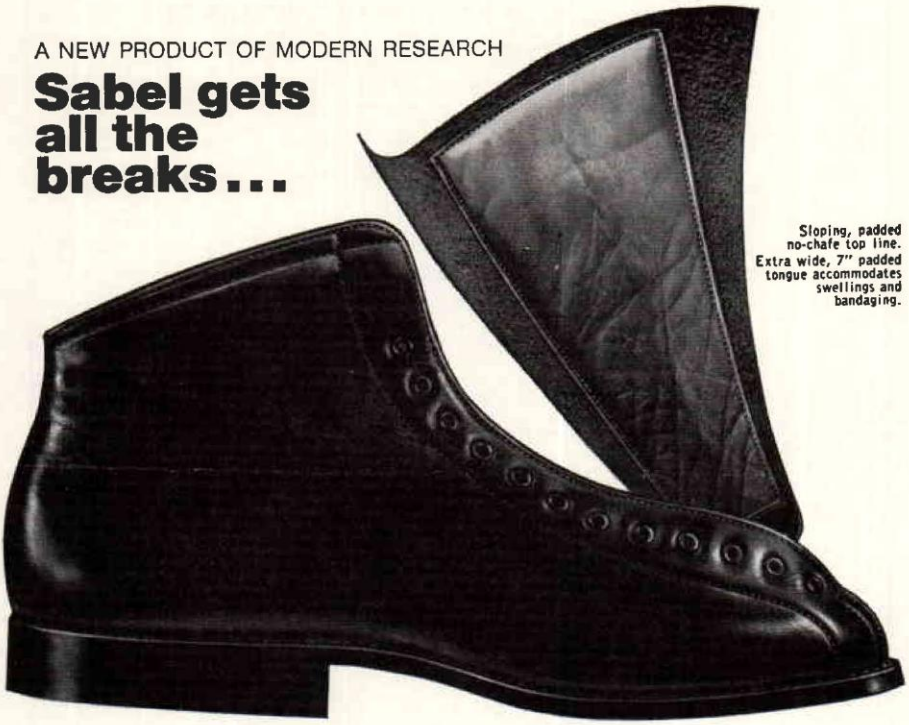

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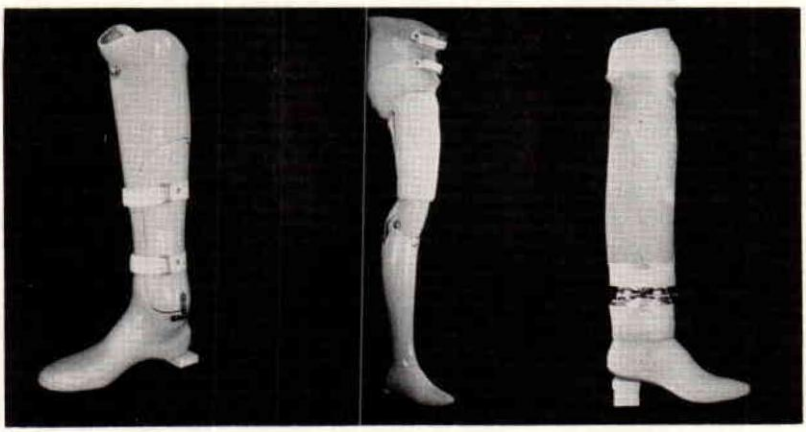

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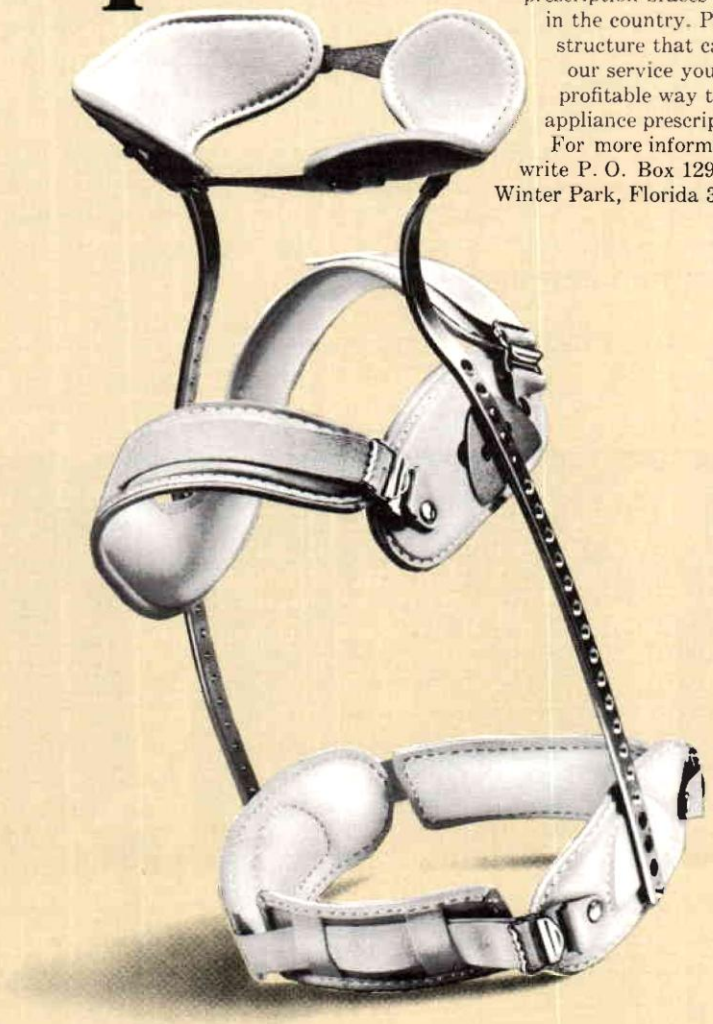

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Seventh Workshop Panel on Lower-Extremity Orthotics of the Subcommittee on Design and Development*

FOREWORD

The Subcommittee on Design and and Development of the Committee on Prosthetics Research and Development encouraged the planners of this workshop panel to go "all out" in an attempt to collect information on current developments in lower-extremity orthotics because the Subcommittee felt the emphasis should be given to work needed to improve the lot of patients who require braces. This workshop panel is considered to be only a start.

The panel meeting was unlike anything we have done before. We brought orthotists to Rancho Los Amigos Hospital to work rather than only to sit and think and talk. The first part of the workshop was a session in which 14 orthotists fitted patients with 19 different lower-extremity braces. Other persons were appointed as recorders of the fitting and fabrication procedures. From these people we expected not only descriptions of what they saw, but some expressions of judgment about the use and design of the appliances. We believe this scheme worked, as the summaries in this report will attest.

The patients who were fitted were analyzed by Drs. Clippinger and McCollough using the biotechnical analysis form explained in Appendix A. This permitted CPRD to

*Committee on Prosthetics Research and Development, Division of Engineering—National Research Council, National Academy of Sciences—National Academy of Engineering.

assist the American Academy of Orthopaedic Surgeons in the procedure for analyzing dysfunctions that might require bracing. Sample forms for some of the patients are shown in Appendix A.

After the fittings were completed, the patients wearing the experimental braces were presented before the entire panel and observers. This process was a review of the individual appliances, the design concepts, and the kinds of patients for whom the devices were primarily intended. It was difficult in each instance to provide exactly the kind of patient for whom the brace was designed, but indications and contraindications of each design were reviewed and questions raised.

During the third part of the panel meeting, the panelists discussed each brace. Although it is quite difficult to make decisions in large panel sessions, some decisions were made. What CPRD might do for each brace was of special significance to the Subcommittee on Design and Development at this point because many of these devices have been in laboratories for quite long periods of time. Needed was the review achieved at this meeting. Actions were recommended. (Appendices B and C were distributed for the information of the participants.)

It is hoped that it will not be too long before patients can benefit from the work that has gone into the development of these devices.

Originally we had intended to have the workshop panel explore only those devices intended for stabilization of the knee. However, the Subcommittee chose to expand the scope of the panel to include a number of below-knee braces intended for control of drop-foot because many of these seemed to be ready for advancement into either the CPRD evaluation program or into the educational program. With the summaries provided on the drop-foot braces in this report, we believe we have accomplished an objective. Most are relatively simple devices, and some possibly can be selected for local trial based on the information contained here. At the same time all might very well be studied by a bioengineering laboratory to delineate the differences among them, and thus help the educational program in offering prescription guidelines.

Although the meeting became hectic at times, particularly when 14 orthotists had to fit 19 braces in one shop, we think much was accomplished. The chart shown in the report provides a functional analysis of each brace in a concise and conveyable form which in itself provides some guidelines for prescription. As a matter of fact, this analysis of each brace keys in quite adequately with the analysis of disability developed by AAOS. (It should be noted that this same form of analysis is already being used in some clinics for prescribing conventional braces.)

Some of the panelists might have felt frustrated while experiencing the very difficult task we had at this meeting, but the Subcommittee on Design and Development will be pleased with the resulting compilation of data about these braces under development. The Subcommittee on Evaluation of CPRD can now make plans for appropriate

clinical studies of some of these items.

Perhaps of special significance is the principle of the NYU Insert Brace. Although limited here to a below-knee brace, the concept of a plastic-laminate shoe insert can be applied to nearly all lower-extremity braces. It is now well to consider the possibility that conventional shoe attachments in many cases can be replaced by the more functional and cosmetic shoe insert. We hope that the Subcommittee on Evaluation will consider this very significant possibility in improving lower-extremity bracing. The use of synthetics, particularly thermoplastics in below-knee braces such as the IRM Spiral BK Brace, may have significant impacts on bracing today. Moreover, although not novel by any means, the whole concept of single-bar bracing can be further promulgated by the information contained in this report.

The Subcommittee on Design and Development wishes to thank its Panel Chairman, Roy Snelson, and the entire staff at Rancho Los Amigos Hospital for accommodating this unique workshop; we especially appreciate the use of the Rancho patients and the help of James Blomer in the laboratory. We think an outstanding job was done by all; the Subcommittee, on behalf of CPRD, is profoundly grateful.

ANTHONY STAROS

Chairman, Subcommittee on Design and Development

Orthotic Analysis of Patients

Fabrication of Braces

Group Session For Presentation of Braces

1. SUMMARY OF EACH BRACE

A. *UC-BL Shoe Insert* (Fig. 1)

1. Purpose

Developed to control the foot in the shoe when fitting a leg brace, its purpose is to hold the foot in position of function in the shoe.

2. Description

The shoe insert is a polyester plastic shell which is contoured to the foot. The insert accomplishes its purpose by stabilizing the foot in alignment position. It can be used with or without a brace attached to it.

3. Prescription

It is indicated for correction of nonrigid varus or valgus deformities of the subtalar joint, for painful subtalar joint motion secondary to arthritic changes, and for inflammation of the plantar fascia.

It is contraindicated where fixed bony deformities exist.

4. Fabrication

Reference (a) covers the fabrication of the shoe insert in detail. The general procedure is that a plaster cast is taken of the foot in weight-bearing, alignment position and the shell is laminated over the plaster model.

5. References

a. Henderson, W. H., and J. W. Campbell, *UC-BL Shoe Insert: Casting and Fabrication,* Bulletin of Prosthetics Research, *10*:11:215-235, Spring 1969.

b. Inman, V. T., *UC-BL Dual-Axis Ankle-Control System and UC-BL Shoe Insert: Biomechanical Considerations,* Bulletin of Prosthetics Research, *10*:11:130-145, Spring 1969.

c. Mereday, C., C. M. E. Dolan, and R. Lusskin, *Evaluation of the UC-BL Shoe Insert in "Flexible" Pes Planus,* New York University, September 1969.

B. *UC-BL Dual-Axis Ankle Brace* (Fig. 2)

1. Purpose

To duplicate and control the combined motions of the ankle and subtalar joints, thereby providing improvement in function and comfort over single-axis ankle braces.

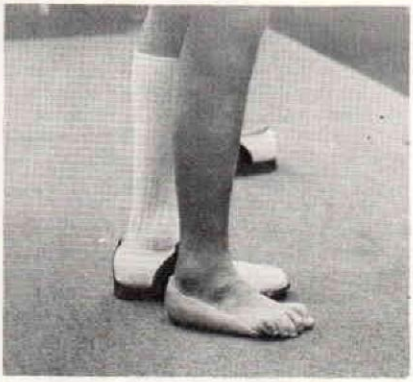


Fig. 1
UC-BL Shoe Insert.

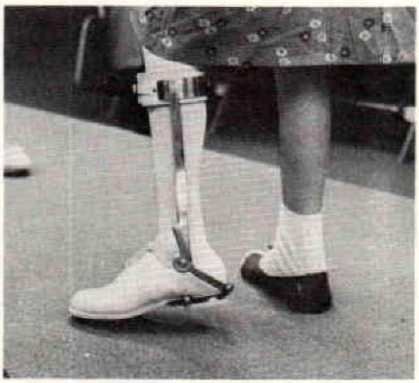


Fig. 2
UC-BL Dual-Axis Ankle Brace.

2. Description

The dual-axis ankle brace has two mechanical joints—the lower of which attaches to the shoe—with one metal upright which attaches to a calf band. It accomplishes its purpose by alignment of the mechanical joints to the anatomical ankle and subtalar joints and by using rubber-band spring assist.

3. Prescription

It is indicated for flaccid paralysis of the plantar flexors, dorsiflexors, inverters and/or everters of the foot.

It is contraindicated where pain exists due to increased ankle or subtalar joint motions or where there are rigid deformities of the ankle or subtalar joints. Also, in its present configuration, it cannot be used where weight-bearing is necessary. (A weight-bearing design is under development.)

4. Fabrication

Reference (a) covers the fabrication of the dual-axis ankle brace in detail. The general procedure is to take a plaster cast of the foot and lower leg and very carefully align the mechanical joints to the cast, which is positioned in the shoe. The joints are then attached to the shoe, the calf band is positioned on the cast, and the upright bent and connected to the joints and the calf band.

5. References

a. Campbell, J. W., W. H. Henderson, and D. E. Patrick, *UC-BL Dual Axis Ankle-Control System: Casting, Alignment, Fabrication and Fitting,* Bulletin of Prosthetics Research, *10:*11:184-235, Spring 1969.

b. Inman, V. T., *UC-BL Dual-Axis Ankle-Control System and UC-BL Shoe Insert: Biomechanical Considerations,* Bulletin of Prosthetics Research, *10:*11:130-145, Spring 1969.

c. Lamoreux, L. W., *UC-BL Dual-Axis Ankle-Control System: Engineering Design,* Bulletin of Prosthetics Research, *10*:11:146-183, Spring 1969.

C. NYU Insert Brace (Fig. 3)

1. Purpose

It combines the advantages of the UC-BL Shoe Insert with the conventional short-leg brace to stabilize the foot in the shoe while providing ankle joint motion control. In addition, it improves cosmesis and allows easy interchange of

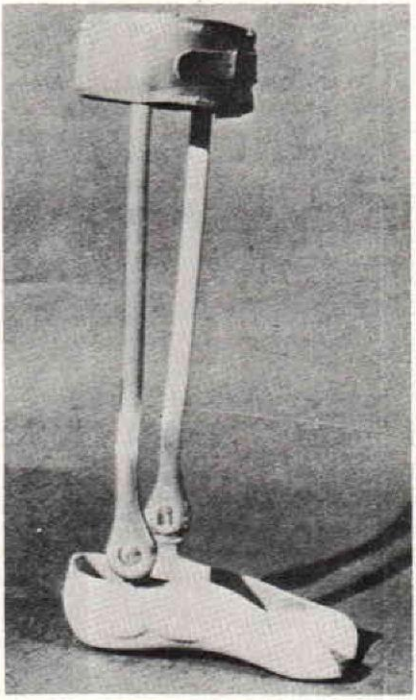


Fig. 3
NYU Insert Brace.

Fig. 4
AMBRL Two-Rod Drop-Foot Brace.

shoes, since the insert brace fits inside the shoe and is not connected to it.

2. Description

The insert brace is a conventional short-leg brace with the metal stirrup laminated into a shoe insert. The shoe insert provides foot alignment in the shoe, the standard ankle joint provides A-P control of the ankle, and the double uprights with calf band provide M-L stability of the ankle. The patient may need a slightly larger shoe with this brace because of the thickness of the insert and stirrup.

3. Prescription

It is indicated for flaccid or mildly spastic paralysis of the ankle joint musculature and for nonrigid varus or valgus deformities of the foot.

It is contraindicated where severe spasticity or fixed varus or valgus deformity of the foot exists.

4. Fabrication

A plaster cast is taken of the foot according to UC-BL procedures for the shoe insert. The ankle joint is aligned on the plaster model, and the stirrup is laminated into the plastic shell over the model. The ankle joints and metal uprights with a calf band are attached to the stirrup.

5. Reference

Dolan, C. M. E., C. Mereday, and G. Hartmann, *Evaluation of NYU Insert Brace,* New York University, July 1969.

D. AMBRL Two-Rod Drop-Foot Brace (Fig. 4)

1. Purpose

It provides a positioning force to hold the foot in a neutral or slightly dorsiflexed position during swing phase of gait and provides mild resistance to inversion or eversion of the ankle joint.

2. Description

Two round fiber glass-epoxy rods are mounted on the shoe and extend to pockets in the calf band. The rods are slightly flexible and are aligned to provide dorsiflexion assist. The amount of spring force can be varied by the diameter and alignment of the rods.

3. Prescription

It is indicated for drop-foot with mild M-L ankle instability or for mild spasticity.

It is contraindicated where marked M-L ankle instability or

marked spasticity exists. A trial brace can be temporarily clamped to the patient's shoe to aid in prescription; see reference (c).

4. Fabrication

Reference (f) covers the fabrication of the AMBRL Two-Rod Drop-Foot Brace in detail. All parts of the brace can be prefabricated—the metal shoe plate, metal shoe adaptors, rods, and calf band. The shoe plate is installed in the heel of the shoe and the adaptors with rods are attached to the plate. The rods are then cut to length and inserted into the calf band.

5. References

a. *Evaluation: AMBRL Fiberglass-Epoxy Drop-Foot Brace,* Bulletin of Prosthetics Research, *10*:9: 153-155, Spring 1968.

b. Hancock, R. P., and J. W. Hodge, *Structural Analysis and Evaluation of USAMBRL Plastic Drop-Foot Brace Adaptor,* USAMBRL Technical Report 6913, September 1969.

c. Hill, J. T., and A. L. Fenwick, *A Clamp-On Fitting Brace for Use in Prescribing the Fiberglass-Epoxy Drop-Foot Brace,* USAMBRL Technical Report 6809, September 1968.

d. Hill, J. T., and A. L. Fenwick, *A Fiberglass-Epoxy Drop-Foot Brace,* Orthotics and Prosthetics, *22*:3:1-8, September 1968.

e. Hill, J. T., and A. L. Fenwick, *Fiberglass-Epoxy Drop-Foot Brace,* USAMBRL Technical Report 6801, January 1968.

f. Hill, J. T., and R. W. Stube, *An Improved Manufacturing Technique for the USAMBRL Fiberglass-Epoxy Drop-Foot Brace,* USAMBRL Technical Report 6910, July 1969.

g. Hill, J. T., and R. W. Stube, *The USAMBRL Fiberglass Drop-Foot Brace,* Prosthetics International, *3*:9:25-28, 1969.

E. VAPC Drop-Foot Brace
(Fig. 5)

1. Purpose

This brace provides the same function as the AMBRL Posterior-Bar Drop-Foot Brace explained below.

2. Description

It is similar to the AMBRL brace below except that it has a clip which fits on the counter of the shoe instead of an insert in the heel, allowing it to be clipped on any stiff-counter shoes without special attachment.

3. Prescription

The indications and contrain-

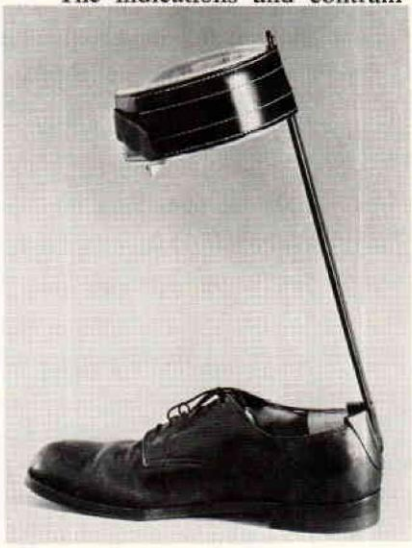


Fig. 5
VAPC Drop-Foot Brace.

dications for use are the same as for the AMBRL brace. It has not yet been determined if this brace can be used permanently as well as a trial device for aid in prescription.

4. Fabrication

The posterior strap and calf band are made in similar manner to the AMBRL brace. The clip, which is still in development, is presently made of sheet metal stamped out and bent to shape. With the current design, large and continuous forces cannot be exerted on the clip because it will damage the counter of the shoe.

5. References

None.

F. AMBRL Posterior-Bar Drop-Foot Brace (Fig. 6)

1. Purpose

It provides a positioning force to hold the foot in a neutral or slightly dorsiflexed position during swing phase of gait and will assist M-L stability of the ankle during stance.

Fig. 6
AMBRL Posterior-Bar Drop-Foot Brace.

2. Description

The fiber glass-epoxy posterior bar is attached to the shoe by means of a metal insert in the heel and is attached to the calf band by means of a slip fit. The bar is slightly flexible and is aligned to provide dorsiflexion assist. The amount of force can be varied by the thickness and alignment of the bar. Because the bar is located posterior to the ankle joint, there is relative motion between the bar and the leg; this motion is accommodated by the sliding of the bar in the cuff.

3. Prescription

It is indicated for drop foot with some M-L stability and for mild spasticity.

It is contraindicated where marked M-L ankle instability or marked spasticity exists.

4. Fabrication

Reference (a) covers the fabrication of the AMBRL Posterior-Bar Drop-Foot Brace in detail. It can be assembled from prefabricated parts—metal heel insert, bar, and calf band. The insert is attached to the heel, the bar is attached to the insert, and the bar cut to length and placed in the slip pocket of the calf band.

5. References

a. Hill, J. T., and A. L. Fenwick, *A Contoured, Posterior, Fiberglass-Epoxy Drop-Foot Brace,* US-AMBRL Technical Report 6805, May 1968.

b. Hill, J. T., and R. W. Stube, *An Improved Manufacturing Tech-*

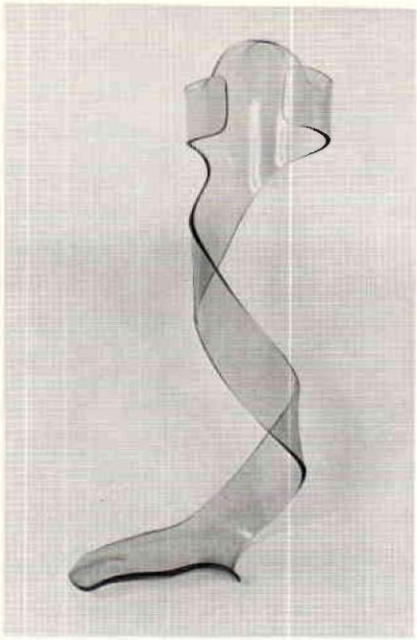


Fig. 7
IRM Spiral BK Brace.

nique for the USAMBRL Fiberglass-Epoxy Drop-Foot Brace, USAMBRL Technical Report 6910, July 1969.

G. IRM Spiral BK Brace (Fig. 7)

1. Purpose

To permit controlled plantar flexion, dorsiflexion, eversion, and inversion of the foot while allowing normal transverse rotation of the extremity on the foot.

2. Description

The spiral brace is made of a two-piece, contoured, Plexidur (clear thermoplastic) material with three sections—footplate, spiral upright, and calf band. The springiness of the material provides the forces for foot control. The calf band section has an opening below the fibular head which permits donning; no straps are required to hold the brace position. It is lightweight and cosmetic.

3. Prescription

It is indicated for complete flaccidity of the foot and for mild and moderate spasticity.

It is contraindicated for severe spasticity or fixed varus or valgus deformity.

4. Fabrication

A plaster cast of the foot and lower leg is taken, the plaster model is modified, and the pre-cut Plexidur is heated to 275 deg. F. and formed over the model. The nyloplex brace is then carefully trimmed for fitting.

5. References

a. Lehneis, H. R., *New Concepts in Lower Extremity Orthotics,* Medical Clinics of North America, *53*:3:585-592, May 1969.

b. *Progress Report,* Project Number SRS-RD-3129-M, IRM, New York University Medical Center, (New York), June 1969.

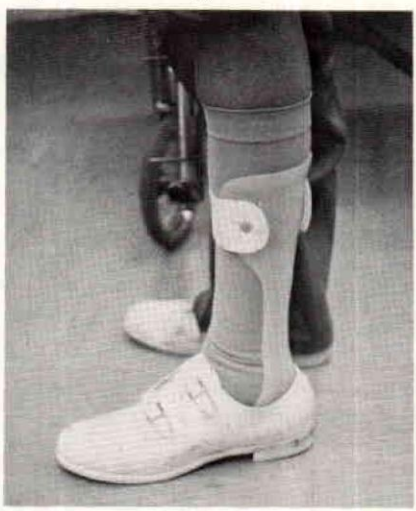


Fig. 8
Rancho Polypropylene Drop-Foot Brace.

H. Rancho Polypropylene Drop-Foot Brace (Fig. 8)

1. Purpose

To assist dorsiflexion and resist eversion and inversion of the foot.

2. Description

The brace is a one-piece unit made of polypropylene—translucent thermoplastic material which has superior fatigue resistance. It is molded to the foot and lower leg and is lightweight and cosmetic. Springiness of the material provides dorsiflexion force.

3. Prescription

It is indicated for flaccid or mildly spastic conditions of the foot.

It is contraindicated in case of severe spasticity of the foot.

4. Fabrication

A plaster model is made from a plaster cast of the foot and lower leg, a sheet of polypropylene material is heated to 400 deg. F. and formed over the model, and the brace is trimmed for fitting.

5. References

None.

I. Teufel Ortholen Drop-Foot Brace (Fig. 9)

1. Purpose

To assist dorsiflexion and resist eversion and inversion of the foot.

2. Description

The brace is a lightweight and cosmetic, one-piece unit made of Ortholen, a Caucasian-colored thermoplastic material in the polyethylene family. It is molded to the foot and lower leg, and elastic webbing is used on each side of the ankle to provide dorsiflexion force. Velcro is used to strap the upper portion on the calf.

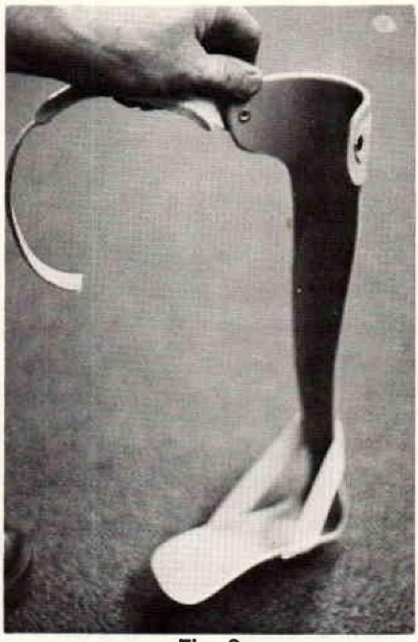


Fig. 9
Teufel Ortholen Drop-Foot Brace.

3. Prescription

It is indicated for flaccid conditions of the foot.

It is contraindicated for spasticity of the foot.

4. Fabrication

A sheet of the material is heated to 300 deg. F. and formed over a plaster model of the foot and leg. (Ortholen can be cold formed with a hammer for other applications.) The brace is trimmed and the elastic webbing and Velcro attached for fitting.

5. References

None.

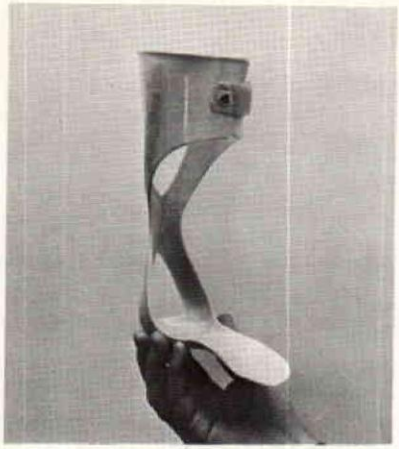


Fig. 10
TIRR BK Brace.

J. TIRR BK Brace (Fig. 10)

1. Purpose

To assist dorsiflexion of the ankle during swing phase without conventional shoe attachment.

2. Description

It is a one-piece, molded brace of polyester plastic laminate reinforced with strips of polypropylene and formed over a plaster model of the foot and lower leg. The springiness of the material provides the dorsiflexion force. It is a lightweight and cosmetic brace.

3. Prescription

It is indicated for a flail foot.

It is contraindicated when spasticity and severe deformities are present in the foot-ankle complex.

4. Fabrication

After making a plaster model of the foot and lower leg from a plaster cast of the patient, strips of polypropylene are put between layers of nylon stockinette on the model—two strips forming a cross on the back of the lower leg and additional strips on the plantar surface of the foot. The nylon stockinette is then impregnated with polyester resin and the brace trimmed for fitting after the resin has cured. A Velcro closure is used on the calf band.

5. Reference

Engen, T. J., *Progress Report,* Project No. SRS-RD-2982-M, Texas Institute for Rehabilitation and Research (Houston), September 1969.

K. Swedish Knee Cage (Fig. 11)

1. Purpose

To prevent genu recurvatum while allowing flexion of the knee for walking.

2. Description

It consists of a plastic-coated aluminum piece which forms up-

Fig. 11
Swedish Knee Cage.

rights connected posteriorly with a horizontal band. The webbing which is attached anteriorly to the upper and lower portions and the posterior padded band at the knee provided a three-point force system to control hyperextension. Though it has no joint, it protrudes very little with knee flexion while sitting.

3. Prescription

It is indicated for mild genu recurvatum with some M-L knee stability.

It is contraindicated where marked M-L instability or fixed valgus or varus deformity of the knee exists.

4. Fabrication

The Swedish Knee Cage is commercially available in one size, which will fit left or right sides. It is being recommended to the manufacturer by CPRD that it also be made in a child size.

5. Reference

The Swedish Knee Cage, Artificial Limbs, *12*:2:54-57, Autumn 1968.

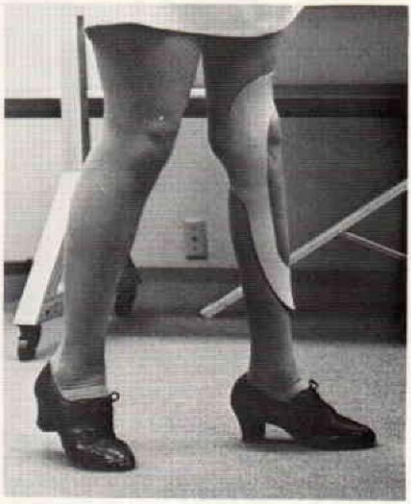


Fig. 12
IRM SK Brace.

L. IRM SK (Supracondylar-Knee) Brace (Fig. 12)

1. Purpose

To prevent genu recurvatum and to provide M-L stability of the knee while allowing flexion for walking.

2. Description

It is a one-piece brace of polyester plastic laminate molded to the leg. The unique shape is designed to provide a three-point force system for control of hyperextension and to provide M-L stability of the knee. The contoured plastic is very cosmetic, though the suprapatellar portion does protrude slightly while sitting.

3. Prescription

It is indicated for mild and moderate genu recurvatum with M-L instability of the knee.

It has no effect on a fixed valgus or varus deformity of the knee. There is some question whether the concentrated force on the suprapatellar area is excessive on the quadriceps tendon or the femur at least for some patients.

4. Fabrication

A plaster cast is taken of the lower leg and the knee with the knee in slight flexion. After a plaster model has been made and modified, the brace is laminated over the model and carefully trimmed so proper forces are exerted on the patient's leg. The shell has to be trimmed to permit donning, which is accomplished by putting the foot

Fig. 13
Nitschke PTS Knee Brace.

through the posterior opening and rotating the shell up the leg in place over the knee. The proximal-medial and proximal-lateral portions of the brace are trimmed according to the desired function of controlling valgus or varus deformity.

5. Reference

Lehneis, H. R., *New Concepts in Lower Extremity Orthotics,* Medical Clinics of North America, *53*: 3:585-592, May 1969.

M. Nitschke PTS Knee Brace (Fig. 13)

1. Purpose

This brace prevents genu recurvatum and provides M-L stability of the knee while allowing flexion for walking.

2. Description

It is very similar to the upper part of a PTS below-knee prosthesis except that it is made in two halves, with a Velcro or taped closure, to permit donning. The high suprapatellar portion limits hyperextension and the low popliteal portion allows flexion of the knee. It is cosmetic but does protrude slightly while sitting.

3. Prescription

It is indicated for mild genu recurvatum with M-L instability of the knee.

It is contraindicated where fixed valgus or varus deformity exists. There is some question whether the concentrated force on the suprapatellar area is excessive on the quadricep tendon or the femur at least for some individuals.

4. Fabrication

A plaster cast is taken of the knee and lower leg, the plaster model is modified, and the two halves are made over the model in separate

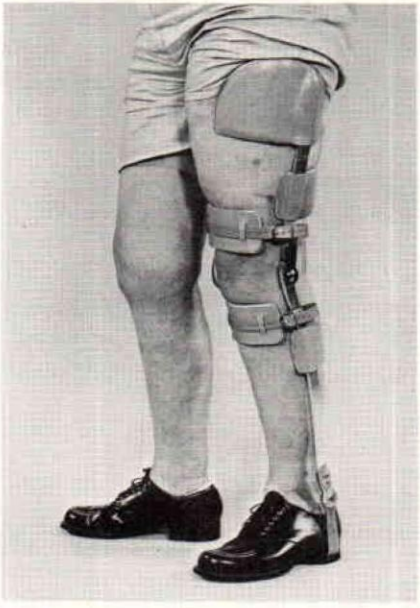


Fig. 14
University of Michigan Arthritic Knee Brace.

laminations. The halves are cut so they overlap and are held together by Velcro straps or tape if a thinner dimension is desired.

5. Reference

Nitschke, R. O., and K. Marschall, *The PTS Knee Brace,* Orthotics and Prosthetics, 22:3:46-51, September 1968.

N. University of Michigan Arthritic Knee Brace (Fig. 14)

1. Purpose

To reduce pain and hence increase ambulatory function of selected patients with unstable arthritic knees.

2. Description

Though variations are sometimes needed, the brace essentially consists of a single lateral upright attached to the shoe with a split stirrup, free ankle and knee joints, posterior bands at the calf and midthigh, anterior cuffs just above and below the patella, a lateral band at the proximal thigh, and a medial pressure pad at the knee. The brace functions in the following manner: a three-point system produces a laterally directed force on the knee to correct the valgus deformity and a four-point system produces forces to prevent anterior displacement of the tibia usually associated with the arthritic knee.

3. Prescription

It is indicated for patients with unstable arthritic knees whose pain upon weight bearing can be reduced by manual correction of M-L or A-P instability.

It is contraindicated for those patients who are candidates for corrective surgery or who have flexion contractures, fixed valgus deformities exceeding 15-20 deg., serious hip involvement, or poor motivation.

4. Fabrication

The brace is constructed of components similar to conventional long-leg braces. Two points should be noted. Tracings are taken with the patient held manually in corrected position, and considerable adjustment to fit and alignment is usually necessary during the early period of wear.

5. Reference

Smith, E. M., R. C. Juvinall, E. Corell, and V. J. Nyboer, *Bracing the Unstable Arthritic Knee,* submitted for publication in Archives of Physical Medicine and Rehabilitation, 1970.

O. Rancho Functional Long-Leg Brace (Fig. 15)

1. Purpose

To provide knee stability during stance phase while allowing knee flexion during swing phase and to maintain proper alignment of the leg.

2. Description

The brace has metal uprights with plastic thigh shell, tibial cuff, and a shoe insert or a metal stirrup attached to the shoe. The ankle joints have a 90-deg. dorsiflexion stop with no mechanical damping to resist plantar flexion or dorsiflexion up to 90 deg. The tibial cuff can be fitted anteriorly or posteriorly as desired for knee A-P stability or prevention of genu recurvatum; it also provides control for valgus or varus of the knee. The knee joints

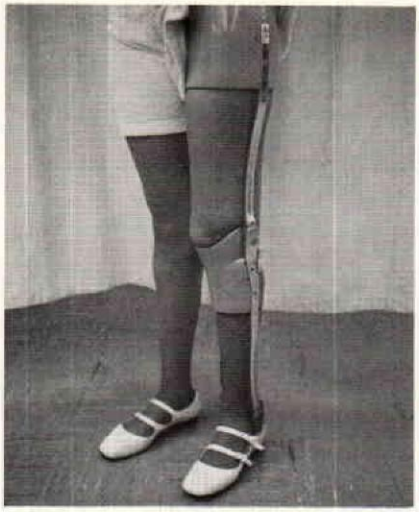


Fig. 15
Rancho Functional Long-Leg Brace.

are J-shaped to provide a posteriorly offset mechanical knee center for alignment stability during stance phase. The thigh shell is a quadrilateral shaped brim, similar to the upper part of an above-knee prosthetic socket, which bears some vertical weight but is not designed to be ischial weight bearing.

3. Prescription

It is indicated for a unilateral flail leg with some hip musculature but requiring alignment stability for stance. As a rule of thumb, the patient should be able to walk a few steps on level floor without a brace to successfully wear the Rancho Functional Long-Leg Brace.

It is contraindicated if the patient has no hip control, if there is severe bilateral involvement, if there is a fixed valgus or varus knee deformity, or if weight bearing is required.

4. Fabrication

The tibial cuff is made of polyester plastic laminated over a plaster model from a plaster cast. The thigh shell is made in a similar manner with the plaster cast taken in an above-knee prosthetics casting fixture and the model modified so that the shell will fit looser than an AK socket. The shoe insert is made according to UC-BL procedures but with the stirrup laminated in the insert. Or, if a conventional stirrup is used, it is attached to the shoe. The uprights are bent to a tracing of the patient's leg manually held in alignment position. An aluminum plate is laminated into the thigh shell and tibial cuff to prevent the rivets to the uprights from pulling out.

5. References

None.

P. UCLA Functional Long-Leg Brace (Fig. 16)

1. Purpose

To make it possible for some unilateral lower-extremity paralytics to walk with a free-swinging knee and M-L stability at the knee using less energy than required with conventional long-leg braces. It is presently being re-designed to make it more practical and to extend its application.

2. Description

The brace is made of the following components: a polyester plastic thigh shell similar to the upper part of an AK socket; solid-bar aluminum uprights; ball-bearing knee joints with a one-inch posterior offset; a polyester plastic pretibial cuff; heavy-duty ankle joints with adjustable stops; a hydraulic damper

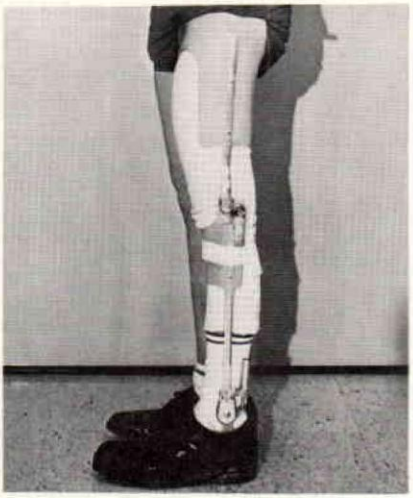


Fig. 16
UCLA Functional Long-Leg Brace.

to provide resistance to ankle dorsiflexion; and a stainless-steel foot-ankle section. It provides knee A-P stability primarily by the posteriorly positioned knee joint and the knee extension torque caused by resistance to dorsiflexion. Knee M-L stability is provided by the alignment of the uprights and pretibial cuff. The hydraulic damper also provides slight resistance to plantar flexion to reduce or prevent foot slap.

The present re-design of this brace includes a shoe insert in place of the foot-ankle section and a mechanical damper in place of the hydraulic one.

3. Prescription

It is indicated for unilateral lower-extremity paralysis with some hip musculature present. It is important to have some active hip extension for knee stability. Valgus or varus knee tendency can be controlled.

It is contraindicated for severe bilateral involvement, flexion contractures of the knee and/or hip, where ischial weight bearing is required, or if there are fixed valgus or varus knee deformities.

4. Fabrication

Making the UCLA Functional Long-Leg Brace consists of the following steps: making a tracing of the patient's leg held manually in alignment; making the thigh shell from a plaster cast and model using an AK casting fixture; making the pretibial shell from a plaster cast and model; shaping the foot-ankle section and attaching it to the shoe; laying out and shaping the uprights; and aligning and fitting the brace. The UCLA Prosthetics-Orthotics Program has an instructional course on this brace.

5. References

a. Anderson, M. H., *Biomechanical Considerations in the Design of a Functional Long Leg Brace,* Orthopedic and Prosthetic Appliance Journal, *18*:4:273-280, December 1964.

b. Anderson, M.H., and J. J. Bray, *The UCLA Functional Long Leg Brace,* Clinical Orthopaedics, No. 37:98-109, 1964.

c. Scott, C. M., *Biomechanical Analysis of the UCLA Functional Long Leg Brace,* University of California at Los Angeles, September 1, 1966.

Q. VAPC Single-Bar Long-Leg Brace (Fig. 17)

1. Purpose

To stabilize the knee and ankle in M-L and A-P directions during stance phase of gait. It is designed

to be a light, modular brace which can be easily fitted.

2. Description

It is a locked-knee, nonweight-bearing brace which provides stability of the leg during stance. The single-bar construction has the advantage of reducing weight and bulk. The brace is comprised of the following components: a half stirrup with ankle joint mounted to the shoe; a lateral, round, stainless-steel upright; a metal calf cuff which extends upward medially to the tibial condyles; a locked knee joint with posteriorly offset center of rotation; and a metal thigh cuff which spirals downward medially to encompass two-thirds of the thigh. The cuffs are covered with leather and closed with Velcro. The modular system permits the following functions: various diameter uprights for strength; posterior or anterior ankle stops; telescoping uprights that accommodate axial and rotational movement; proximal extension of uprights to include hip joint; and use of free knee if patient is able.

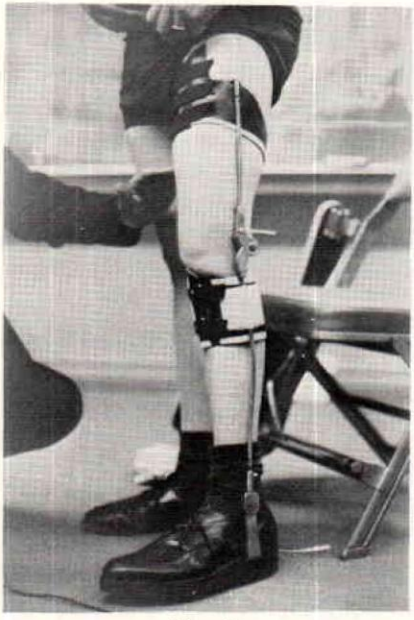


Fig. 17
VAPC Single-Bar Long-Leg Brace.

3. Prescription

It is indicated for instability of the knee and ankle with functional control of the hip. It can be used bilaterally, thereby eliminating both medial uprights present on conventional long-leg braces.

It is contraindicated where there is lack of hip control, fixed deformities of the knee or ankle, need for weight bearing, or presence of marked spasticity.

4. Fabrication

It is made similar to a conventional long-leg brace except that the thigh and calf cuffs are judiciously shaped and fitted to provide appropriate medial reactions normally provided by the medial upright.

5. Reference

Evaluation—VAPC Modular Single Bar Braces, Bulletin of Prosthetics Research, *10*:9:152-153, Spring 1968.

R. Nitschke Single-Bar Long-Leg Brace (Fig. 18)

1. Purpose

To support the long bones of the leg in normal weight-bearing position. Through the intricate PTB-like fit of the anterior calf cuff, only small horizontal forces are needed to maintain alignment, prevent knee buckling and recurvatum, and control varus or valgus of the knee. The brace is designed to fit loosely when sitting and snugly when standing.

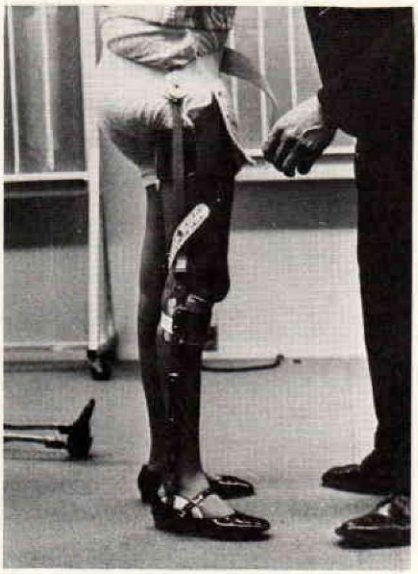


Fig. 18
Nitschke Single-Bar Long-Leg Brace.

2. Description

It is a locked-knee, nonweight-bearing brace which provides stability of the leg during stance. The single-bar construction has the advantage of reducing weight and bulk. The brace has the following essential parts: a half stirrup; an ankle joint with stops and/or springs; a single, flat, metal upright on the lateral side; an anterior Polysar X-414 calf cuff; a knee joint with lock; and a posterior metal thigh cuff.

The unique features of this brace are the carefully molded, PTB-shaped calf cuff; the strap posterior to knee which tightens when standing and loosens when sitting; the use of a Silesian belt; and the use of a "dual" or double bar. To prevent recurvatum, the knee joint is set at 5-10 deg. of flexion and locked to control buckling. To control varus of the knee, the Silesian belt is attached at the proximal end of the upright just distal to the greater trochanter, thereby replacing the force normally present at the proximal medial thigh and helping to support the weight of the brace. To control valgus of the knee, a leather strap on the thigh cuff can be used, though patients prefer the help of the Silesian belt. In the absence of M-L hip control, a well-padded disc fitted on the proximal end of the upright over the greater trochanter and the Silesian belt fastened below or above the pad make it possible to control hip abduction or adduction. The dual bar is used when greater horizontal forces are necessary, such as where a combination of uncorrectable valgus or varus and flexion deformities exist.

3. Prescription

It is indicated for M-L or A-P instability of the knee and will provide some M-L control of the hip if necesary. It can be used bilaterally, thereby eliminating both medial uprights present on conventional long-leg braces.

It is contraindicated where there is a necessity for ischial weight bearing.

4. Fabrication

The most important aspects of this brace are the calf cuff and the Silesian belt. The calf cuff is made of Polysar X-414 and is formed on the patient, with a high medial or lateral portion as desired for control of valgus or varus, and is reinforced with a metal band. A strap of dacron webbing closes the posterior part of the cuff and then runs through a loop laterally and up-

ward to the side bar to make a three-point attachment which loosens on sitting and tightens on standing; this provides comfort when sitting and control when standing. The Silesian belt goes around the waist and attaches to the lateral bar below or above the trochanter, thus helping to support some weight and to provide desired control.

5. Reference

Unpublished case study and summary, by Robert O. Nitschke.

S. IRM SKA (Supracondylar-Knee-Ankle) Brace (Fig. 19)

1. Purpose

This brace provides knee M-L stability, prevents genu recurvatum, and stabilizes the foot and ankle while allowing knee flexion for walking.

2. Description

The upper portion is like the SK Brace described previously, and the lower portion is contoured plastic laminate which extends down to and around the ankle and midfoot. The upper portion stabilizes the knee in the M-L direction and prevents genu recurvatum. The lower portion holds the foot in slight plantar flexion, thereby preventing drop-foot and causing a toe gait which produces a knee extension moment to prevent knee buckling. With this design the heel should not touch the ground. The plantar flexion compensates for the difference in leg shortening, if any. If there is no shortening, the sound side heel must be built up.

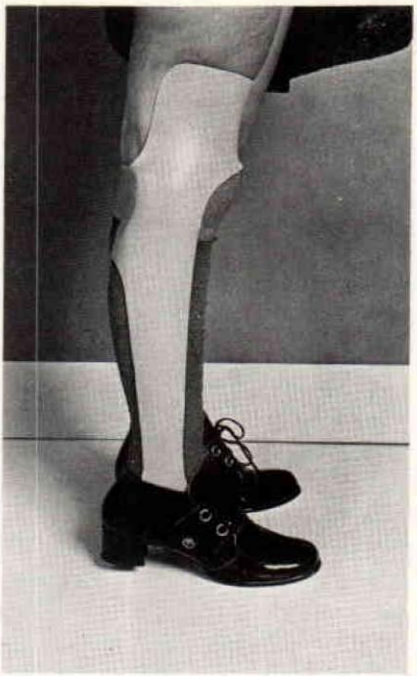


Fig. 19
IRM SKA Brace.

3. Prescription

It is indicated for a flail leg with hip control.

It is contraindicated for severe bilateral involvement, marked spasticity, lack of hip control, presence of knee or hip flexion contractures, or for weight bearing. Some fixed varus or valgus knee deformity can be accommodated but not improved.

4. Fabrication

A plaster cast is taken of the foot, lower leg, and knee. The foot is positioned with the heel and toes level and the ankle slightly plantar flexed. The knee is positioned in slight flexion. The plaster model is modified and laminated with polyester plastic reinforced with fiber glass. The SKA shell is then carefully trimmed to provide the correct

biomechanics and to permit donning.

5. Reference

Lehneis, H. R., *New Concepts in Lower Extremity Orthotics,* Medical Clinics of North America, *53*: 3:585-592, May 1969.

III. RECOMMENDATIONS FOR EACH BRACE

A. *UC-BL Shoe Insert*

It was concluded that this device is a valuable addition to lower-extremity orthotics. The Spring 1969 issue of the *Bulletin of Prosthetics Research* contains the necessary casting and fabrication procedures, and NYU has evaluated it independently on several children. No further clinical evaluation is needed. It was recommended that the UC-BL Shoe Insert be incorporated into educational programs and patient usage.

B. UC-BL Dual-Axis Ankle Brace

It was concluded that this brace, which is the only one providing subtalar as well as ankle joint motion, has existing potential even though its application appears more limited than originally anticipated. To further assess its usefulness, it was recommended that the UC-BL Dual-Axis Brace be evaluated by CPRD under controlled conditions in several clinics, and that it be included in the comparative study of the short-leg braces listed below.

C. *NYU Insert Brace*

It was concluded that this device, which combines the benefits of the shoe insert with the short-leg brace, offers increased function and usefulness over conventional, shoe-mounted braces. In view of the fact that it has been formally evaluated by NYU, it was recommended that the NYU Insert Brace be concurrently incorporated into educational programs and independently evaluated by CPRD under controlled conditions in various clinics and that it be included in the comparative study of the short-leg braces listed below.

D. *AMBRL Two-Rod Drop-Foot Brace*

E. *VAPC Drop-Foot Brace*

F. *AMBRL Posterior-Bar Drop-Foot Brace*

G. *IRM Spiral BK Brace*

H. *Rancho Polypropylene Drop-Foot Brace*

I. *Teufel Ortholen Drop-Foot Brace*

J. *TIRR BK Brace*

These seven braces were considered together. It was concluded that each offers definite improvement over conventional short-leg braces. However, a formal clinical evaluation is not indicated because of the number and similarity in function of these braces. It was therefore recommended that each brace be written up by the developer and published in one of the technical journals for exposure and usage, and that CPRD undertake a comparative study of them along with (B) and (C) above.

K. *Swedish Knee Cage*

It was concluded that since this device is commercially avail-

able, no formal CPRD effort is needed. However, a few improvements were suggested, and it was recommended that it be made in a child size. The Subcommittee on Design and Development will convey these comments to the manufacturer.

L. *IRM SK Brace*

It was concluded that this brace offers knee stability with greatly enhanced appearance over conventional braces. To delineate possible medical contraindications and to study the forces involved in more detail, it was recommended that more IRM SK Braces be fit in the New York area for further analysis and follow-up.

M. *Nitschke PTB Knee Brace*

It was concluded that while this device has limited application, it does have potential for successful usage. It was recommended that the developer continue fitting and follow-up study with the help of VAPC if necessary.

N. *University of Michigan Arthritic Knee Brace*

This brace is still in design and development. After more refinements and patient trial fittings, the brace will be presented to CPRD for recommendations and possible clinical evaluation.

O. *Rancho Functional Long-Leg Brace*

While the orthotic principles are sound, actual fittings of this brace have been hampered by lack of necessary hardware. Development is still proceeding at Rancho.

P. *UCLA Functional Long-Leg Brace*

The UCLA FLLB has been taught at UCLA for several years now. The original brace is currently in the final stages of redesign to make it more practical and to extend its application.

Q. *VAPC Single-Bar Long-Leg Brace*

This modular brace has been presented to the Subcommittee on Evaluation for clinical trial. The VAPC manual and evaluation protocol are nearly complete.

R. *Nitschke Single-Bar Long-Leg Brace*

It was concluded that this brace has several interesting features such as the Polysar cuff and the use of a Silesian belt for control and unweighting. It was suggested that the round bar of the VAPC LLB might be used effectively on the Nitschke LLB. It was recommended that VAPC provide assistance for the developer to perhaps combine some of the best ideas of both braces in the further development of the Nitschke LLB.

S. *IRM SKA Brace*

Similar to the SK Brace, it was concluded that this brace offers knee and ankle stability for walking and that the one-piece plastic laminate contoured construction provides a very aesthetic appearance. However, more needs to be known about indications and contraindications, and several centers are anxious to experiment with it. It was recommended that Duke University and VAPC assist IRM in further fittings and analysis of the SKA Brace.

IV. GENERAL RECOMMENDATION

There is need for a further meeting primarily of orthotists and manufacturers to consider a few problems in the design of current hardware and the development of new hardware for new types of braces, such as the NYU Insert Brace.

APPENDIX A
Definitions and Rules for Technical Analysis Form

I. DEFINITIONS

A. Translatory Motion—Motion in which all points of the distal segment move in the same direction with the paths of all points being exactly alike in shape and distance traversed.

B. Rotary Motion—Motion of a distal segment in which one point in the distal segment or in its (imaginary) extension always remains fixed.

II. RULES

A. Rules pertaining to recording motion

1. The degrees of rotary motion or centimeters of translatory motion are to be obtained from passive manipulation, and are to reflect passive, not active motion at the site being examined. In addition, however, joints are to be observed during weight bearing, and if the degree of joint excursion is greater under conditions of loading than by passive manipulation, this figure is diagramed rather than the smaller figure (e.g., recurvatum of the knee).

2. Translatory motion

Linear arrows horizontally placed below the circle indicate the presence of (abnormal) translatory motion at one or more of the six designated levels of the lower extremity listed on the left side of the form. The head of the arrow always points in the direction of displacement of the distal segment relative to the proximal segment. Linear arrows vertically placed on the right side of the circle indicate (abnormal) translatory motion along the vertical axis at the site indicated.

3. Rotary motion

Normal ranges of rotary motion about joints are pre-shaded on the diagram. Abnormal rotary motion, either as limited or as excess motion, is indicated by a double headed arrow placed outside and concentric to the circle, to indicate the extent of available motion present in the joint on the side (or sides) of the neutral joint position which is affected. The double headed arrow thus describes the available range of motion on the affected side (or sides) of the neutral joint position. If one head of the arrow fails to reach the pre-shaded margin, limitation of joint motion is denoted. Conversely, if one head of the arrow projects beyond the pre-shaded margin, excess motion is designated. Numbers in degrees are placed adjacent to the arrows to indicate the arc described. In addition, radial lines drawn from the center of the circle and passing through its perimeter at the tips of the double headed arrow are to be used for more graphic representation of the

arc of available motion. At sites where rotary motion does not occur, (e.g., fracture site, or knee joint in the coronal plane) the presence of abnormal rotary motion is similarly designated by a double headed arrow with adjacent numerical value in degrees.

4. Fixed position

Double radial arrows indicate a fixed joint position, and describe in degrees the deviation from the neutral joint position. Horizontal or vertical double arrows indicate a fixed joint position in a translatory sense, and the extent of abnormal translation is indicated in centimeters adjacent to the arrow (e.g., subluxed tibia in a hemophiliac knee).

B. Rules pertaining to muscle dysfunction

1. *Flaccid muscles*

Flaccid muscle is designated by the symbol "FL", and its grade by sub-letter as indicated in the legend. The letter grade (e.g., FLp) for *muscle group* strength (e.g., knee extensors), not individual muscles, is to be placed adjacent to the skeletal outline at the proper location for each muscle group. Flaccid muscle strength estimates are obtained by conventional means on the examining table, and correspond to the conventional grading system for poliomyelitis. No symbol is used if muscle strength is normal.

2. *Spastic muscle*

Spastic muscle is designated by the symbol "SP", and its grade by sub-letter as indicated in the legend. the letter grade (e.g., SPmo) for *muscle group* strength, not individual muscles, is to be placed adjacent to the skeletal outline at the proper location for each muscle group. Spastic muscle estimates are to be made with the patient in the functional position for the lower extremity, i.e., observation during standing and walking. The sub-letter grades for spastic muscles are as follows:

m indicates a mild degree of spasticity

mo indicates a moderate degree of spasticity, sufficient for useful holding quality

s indicates severe spasticity, obstructive in terms of function

C. Rules pertaining to fracture or bone deformity

All translatory or rotary motions at the fracture on the shaft of a long bone are diagramed on the circle located at the mid-shaft of each bone. The actual fracture site is indicated by the fracture symbol. All bony deformities such as valgus angulation of the shaft are likewise diagramed on the circle located at the center of the shaft, regardless of the position of the angular deformity. The location of the angular deformity is designated by circling the appropriate level of the left hand side of the chart.

D. Rules pertaining to limb length

Clinical measurements are to be made and the discrepancy in length is to be recorded in the appropriate space on the front sheet for the following:

Ischial tuberosity to sole of heel

Ischial tuberosity to medial tibial plateau

Medial tibial plateau to sole of heel

In leg length discrepancies exceeding one-half inch, X-ray studies of leg length may be indicated and an appropriate space is provided for this measurement.

E. Rules pertaining to balance

Balance is estimated during gait and recorded on the front sheet as follows:

Mild impairment of balance is compatible with independent ambulation.

Moderate impairment of balance is compatible with ambulation plus external support.

Severe impairment of balance necessitates personal assistance for ambulation or standing.

DIAGNOSIS _____ NAME _____

_____ NO. _____ SEX _____

_____ AGE _____ HEIGHT _____ WEIGHT _____

DATE _____

MAJOR IMPAIRMENTS:

A. Musculoskeletal:
   1. Bone & Joint: Normal ☐ Abnormal _____
   2. Muscle: Normal ☐ Flaccid ☐ Spastic ☐
      Other _____

B. Sensation: Normal ☐ Abnormal ☐
   1. Anaesthesia Location _____
      Protective Sensation: Lost ☐ Retained ☐
   2. Proprioceptive Loss
      Location _____ Degree: Mild ☐ Moderate ☐ Severe ☐
   3. Pain Location _____

C. Skin: Normal ☐ Abnormal _____

D. Vascular: Normal ☐ Abnormal ☐ RT ☐ LT ☐
   1. Arterial ☐ 2. Venous ☐ 3. Coagulation Defect ☐

E. Balance: Normal ☐ Impaired ☐ Mild ☐ Moderate ☐ Severe ☐

F. Extremity Shortening: None ☐ LT ☐ RT ☐
   Amount of Discrepancy:
   I.T. – Heel _____
   I.T. – M.T.P. _____
   M.T.P. – Heel _____

X-ray _____

LEGEND

= Direction of Translatory Motion

= Abnormal Degree of Rotary Motion (60°)

= Fixed Position (30°, 1 CM.)

= Fracture

Flaccid Muscle (FL)
- FL_G = Good
- FL_F = Fair
- FL_P = Poor
- FL_T = Trace
- FL_Z = Zero

Spastic Muscle (SP)
- SP_M = Mild
- SP_{MO} = Moderate
- SP_S = Severe

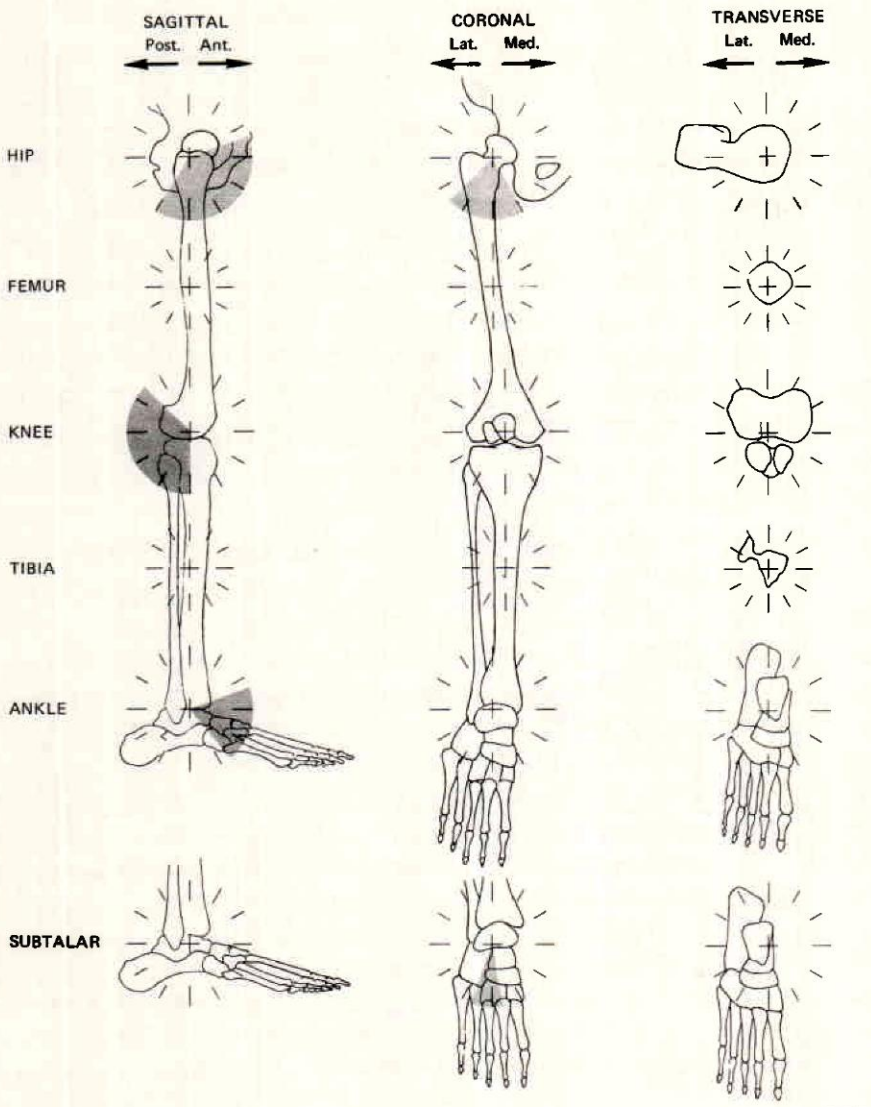
= Pseudarthrosis

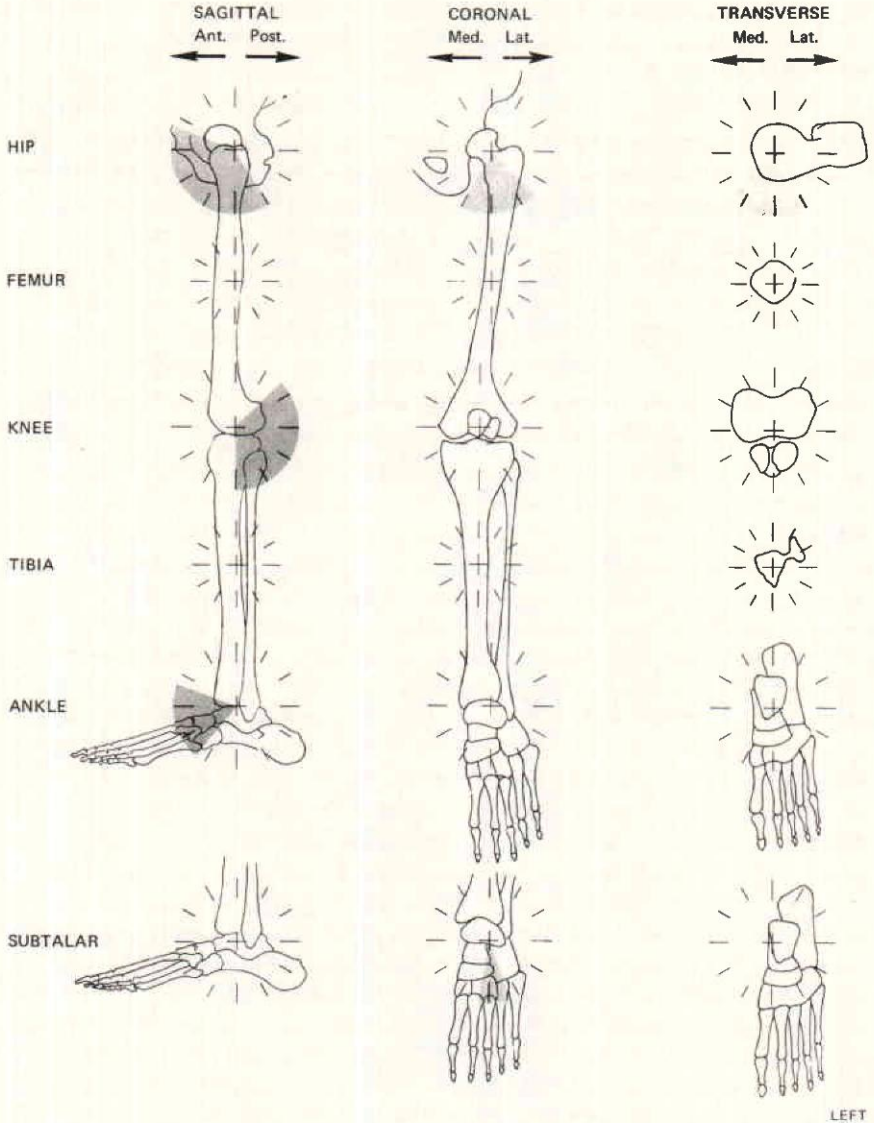
= Absence of Segment

= Abnormal Force Due to Distant Factors

E = Edema

D = Local Distension or Enlargement


SAGITTAL
Post. Ant.
CORONAL
Lat. Med.
TRANSVERSE
Lat. Med.
HIP
FEMUR
KNEE
TIBIA
ANKLE
SUBTALAR
RIGHT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Ant. Post.
CORONAL
Med. Lat.
TRANSVERSE
Med. Lat.
HIP
FEMUR
KNEE
TIBIA
ANKLE
SUBTALAR
LEFT

Summary of Factors Requiring
Correction or Support _____

_____

_____

_____

_____

_____

Brace Prescription _____

_____

_____

APPENDIX B

LOWER-EXTREMITY ORTHOTIC ESTIMATES FOR FISCAL YEAR 1970

Panel of Lower-Extremity Orthotics
Subcommittee on
Design and Development
Committee on Prosthetics
Research and Development
National Academy of Sciences

a. There are about 3,370,000 orthotic patients in the U.S. as opposed to about 311,000 amputees (10:1 ratio).

b. The distribution in site of orthotic impairment is approximately:

54%	—lower extremity—	1,808,000
29%	—upper extremity—	987,000
17%	—spine —	575,000
100%		3,370,000 total

c. The distribution in cause of lower-extremity orthotic impairments is approximately:

82%	—deformity—	1,476,000
18%	—paralysis —	332,000
100%		1,808,000 total

d. The distribution in age of lower-extremity orthotic patients is roughly:

LE deformity—

46%	—under 21—	679,000
41%	—21 to 64—	605,000
13%	—65 and over —	192,000
100%		1,476,000 total

LE paralysis—

5%	—under 21—	17,000
52%	—21 to 64—	172,000
43%	—65 and over —	143,000
100%		332,000 total

e. There are 514 Certified Orthotists and 224 Certified Prosthetists-Orthotists for a total of 738. The ratio of total orthotic patients per CO is therefore 3,370,000:758 or 4450:1 (as opposed to 311,000:648 or 480:1 amputees per CP).

f. More and more research is being directed to lower-extremity orthotics. During FY 1970, $1,276,800 ($.71 per patient) is being spent on LEO research ($469,000 on design and development).

Appendix C

Selected Bibliography on Lower-Extremity Orthotics

This listing covers references other than those in the CPOE annotated bibliography of July 1969 on braces, splints, and assistive devices. Also, references to the eighteen different braces being fitted and reviewed at the meeting of the CPRD Panel on Lower-Extremity Orthotics at Rancho Los Amigos Hospital on March 9-12, 1970, will be listed separately in the report of that meeting.

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Orthotic Management of The Problematic Scoliosis*

by Siegfried W. Paul, C.P.O.**

A study of 135 patients under treatment with the Milwaukee Orthosis conducted two years ago revealed excellent results which are to be expected for the properly treated case. Missing in my presentation as well as in most known publications was a discussion of the Problematic Case, i.e., those patients which require the fullest attention of all of the members of a "Scoliosis Team."

The Scoliosis Clinic at Newington Children's Hospital has seen a most dramatic increase in its patient load. A previous study was based on 135 patients, we now would have to discuss over 600 patients in a similar paper.

Today, I shall discuss some of these Problematic Cases and our concepts of treatment at Newington.

The initial diagnosis of Scoliosis will place the patient in one of three major categories. The idiopathic, paralytic, and juvenile scoliosis. Problematic cure patterns are most frequently seen in the paralytic and juvenile groups.

Problematic idiopathic curves are basically related to the following circumstances: A rigid lumbar curve, severe pelvic obliquity, the high thoracic lordosis observed in conjunction with a narrow A-P diameter of the chest and the high thoracic curve with rotation of vertebral bodies.

Paralytic scoliosis results in the most severe structural changes which are secondary to cerebral palsy, polio, and lower motor neuron disturbances.

The congenital and juvenile scoliosis cases demand our special attention since problems primarily due to scoliosis easily shadow the spinal problem. Scoliosis is frequently seen secondary to neurofibromatosis, amyotonia congenita, Wernig Hoffmans disease, osteogenesis imperfecta, arthrogryposis, hemivetebra, Marphans syndrome, and Ehlers-Danlos syndrome.

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*This Paper was prepared for and presented at the 1970 Assembly of Interbor in Turin, Italy.

**Director, Orthotic and Prosthetic Department, Newington Children's Hospital, Newington, Connecticut.

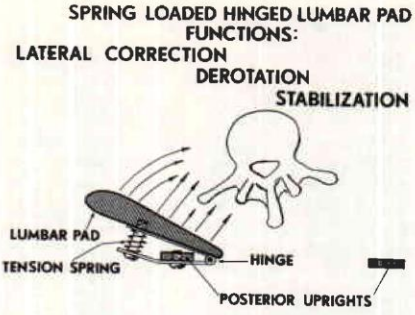


Fig. 1

Functional Principle of Spring Loaded Lumbar Pad.

Our basic approaches to these problems can be summarized as follows:

The idiopathic curve is ordinarily treated according to concepts outlined by Drs. Schmid, Blount, and Moe. Although the purpose of this presentation is not to discuss the Milwaukee routine, I would like to show the functional Milwaukee orthosis as applied at Newington.

As you will recall, careful placement of the pressure pads will result in a three-point pressure system aided by the distraction from pelvic and head support. The problematic curve will require precise arrangement of this pressure system.

The rigid lumbar curve should be first treated with a localizer cast in an attempt to loosen the structure of the curve.

The Milwaukee orthosis with a pelvic section fitted tight on the side of the curve and loose on the opposite side with a functional lumbar pad and pressure coordinating components will be most effective in stabalizing and balancing of the curves.

The Orthotist can do little for the patient with a severe pelvic obliquity. A level pelvis is mandatory for the proper fit of the Milwaukee orthosis and a shoe lift will frequently establish this prerequisite.

The high thoracic lordosis in conjunction with a narrow chest is treated with anterior pressure pads in addition to the routine pressure system. Exercises intended to expand the chest are also helpful.

High thoracic primary curves with severe rotation respond to a shoulder flange.

Fig. 2

Spring Loaded Lumbar Pad Applied to Patient.

This shoulder ring flange will actively derotate the veterbral bodies as well as control the high thoracic curve. Over-correction is possible at this level and application of an L-shaped pad replacing the ring flange will be indicated.

The L-shaped pad excludes the shoulder girdle but includes the scapula, exerting greater lateral force than the regular thoracic pad.

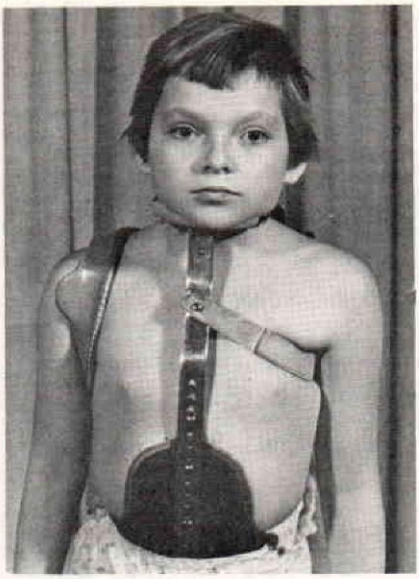


Fig. 3
Ring Flange Applied to Patient, Anterior View.

Our primary objective for the severe paralytic scoliosis patient is to achieve a cosmetically acceptable,

Fig. 4
Ring Flange Applied to Patient, Oblique Lateral View.

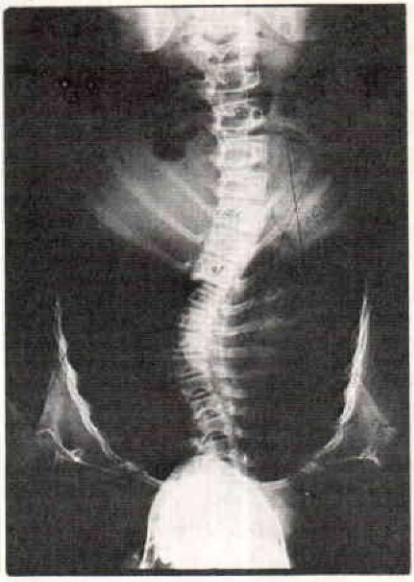


Fig. 5
X-Ray Prior to Application of Milwaukee Orthosis.

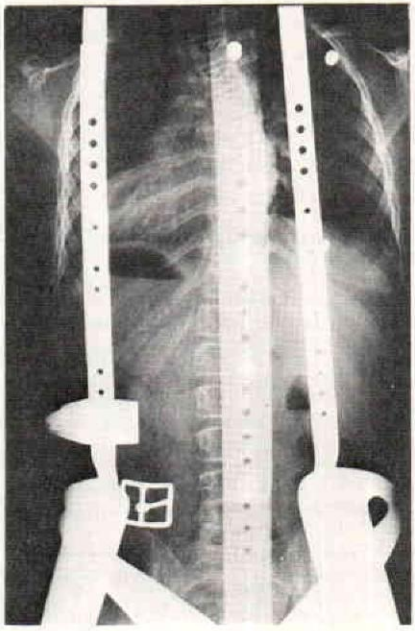


Fig. 6
X-Ray Post Application of Milwaukee Orthosis with Ring Flange.

functional correction and to maintain this correction. Severe paralytic curves will not stabilize with bony maturity and spinal fusions will be performed once bony maturity has been reached.

THE FOLLOWING CASES WILL DEMONSTRATE THIS APPROACH

Case No. 1: This is a 17-year-old boy who was first seen in 1957. He is a post-polio patient.

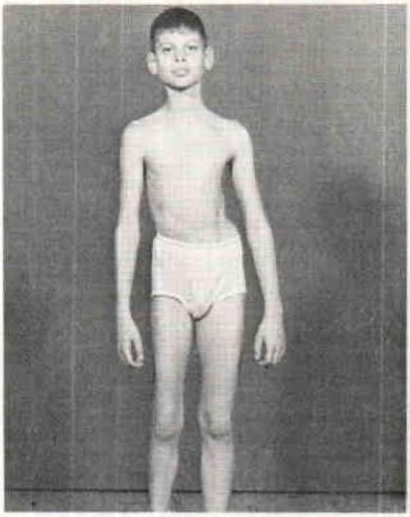


Fig. 7

Patient Post-Polio after Treatment with Localizer Casts for Two Years (treatment of choice prior to introduction of Milwaukee Orthosis).

His severe curve was treated in localizers for two years. The first Milwaukee orthosis was applied in 1959. A spinal arthrodesis was performed in November 1967 and the orthosis continued till June 1969. This patient was fitted with three orthoses during this 10-year period. His curve was improved and today's clinical examination demonstrates a cosmetically acceptable result.

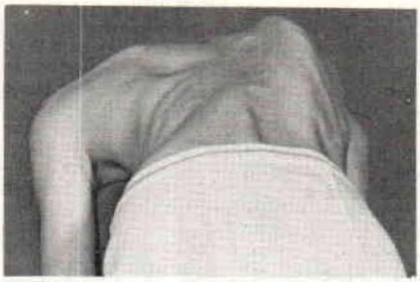


Fig. 8

Same Patient Posterior View Bending (Note sharp razoring).

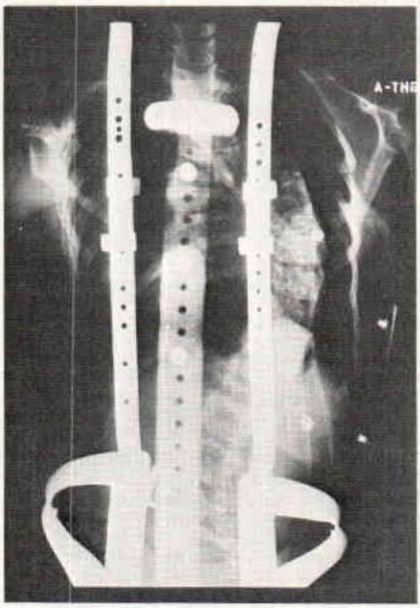


Fig. 9

X-Ray of This Patient in His Second Orthosis.

The next patient is a twenty-year-old female who was diagnosed as amyotonia congenita with secondary scoliosis. This patient is a good example for a case where an error in judgement led us to do too little too late. The patient was ambulatory till age seven at which time the scoliosis became decompensated. Early holding of the curve was attempted with corsets, followed by

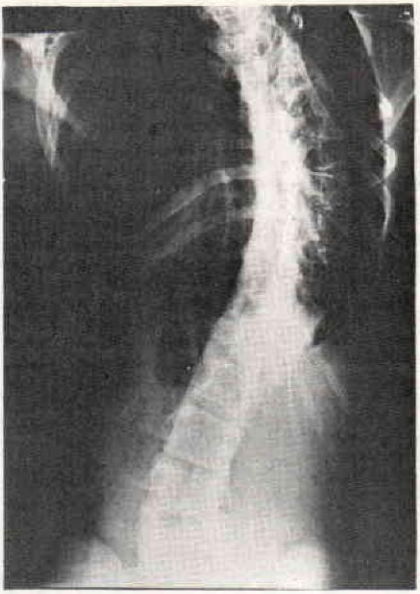


Fig. 10
X-Ray of This Patient Post Arthrodesis.

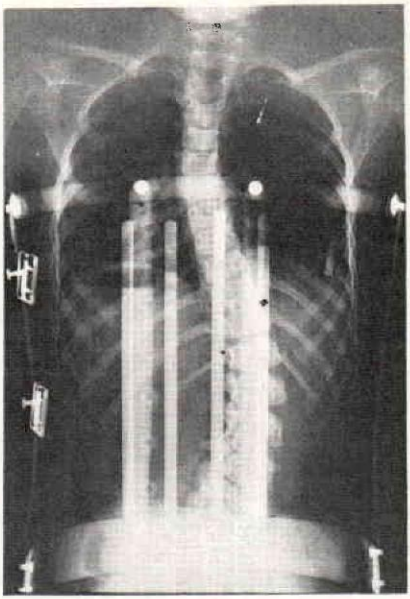


Fig. 12
X-Ray of Patient in Corset.

an early version of the Milwaukee orthosis. A Harrington instrumentation was utilized two years ago. She is now a wheel chair patient who is gainfully employed.

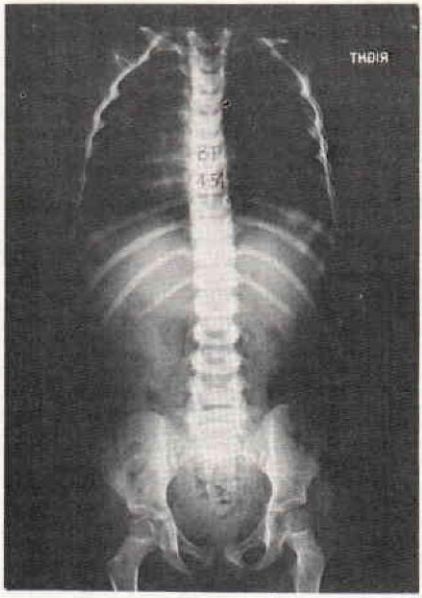


Fig. 11
Initial X-Ray of This Patient Diagnosed as Amyotonia Congenita.

Fig. 13
Posterior View of Patient Ten Years Post Initial Visit.

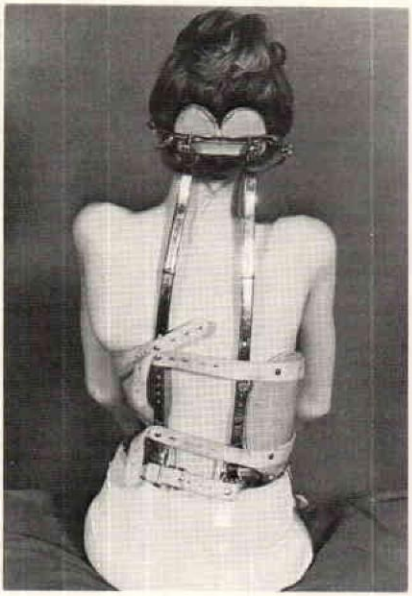


Fig. 14
Posterior view of Patient Wearing Milwaukee Orthosis.

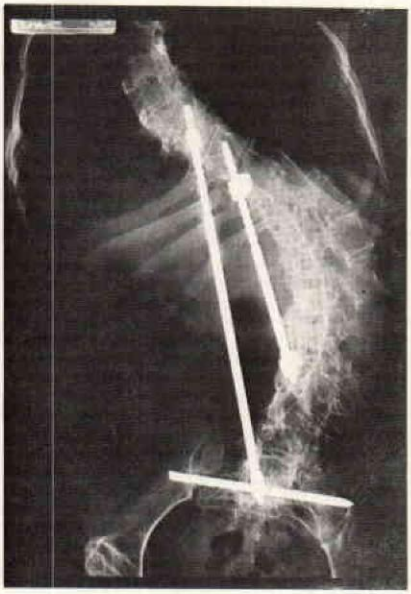


Fig. 16
X-Ray of this Patient Post Harrington Rodding.

Our congenital and juvenile groups benefit from an early treatment which is mandatory in order to prevent additional deformities. Plastic anterior or posterior body shells fabricated from vitrathene, a

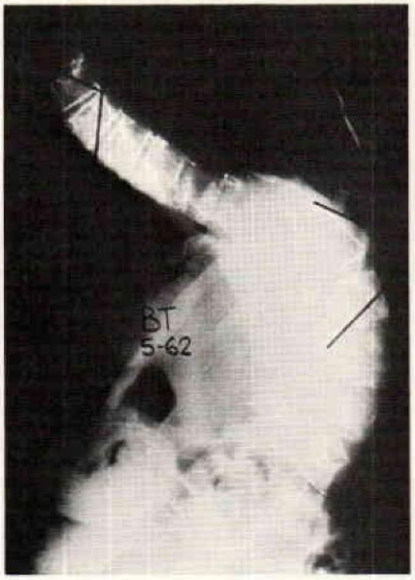


Fig. 15
X-Ray of Patient Prior to Harrington Rodding.

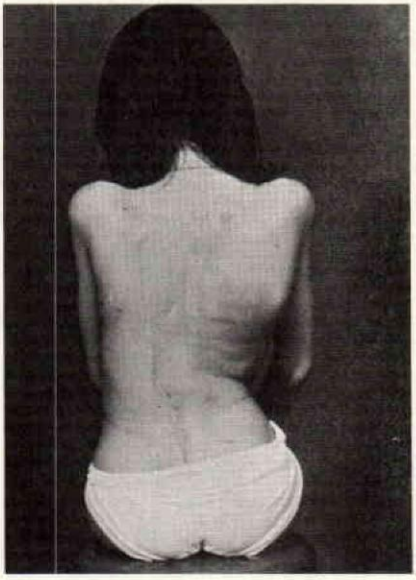


Fig. 17
Posterior View of Patient Post Harrington Rodding.

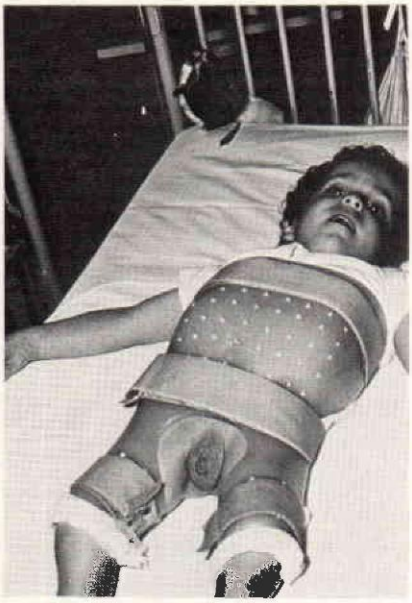


Fig. 18
Myelomeningocele Patient Wearing Anterior Body Shell, Supine View.

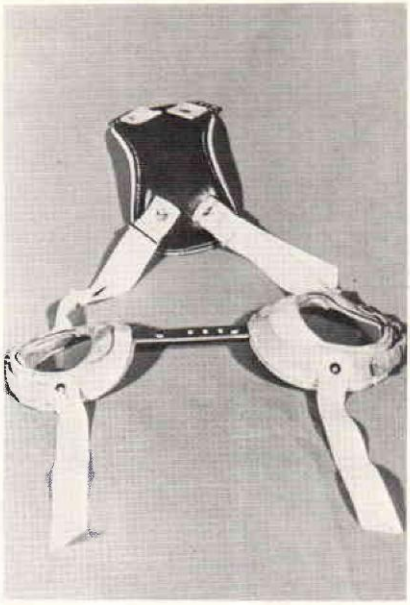


Fig. 20
Newington Infantile Scoliosis Splint.

polythene plastic, have proven to be most effective. The lower motor neuron disturbed patient will go into extensive orthotic management to become ambulatory.

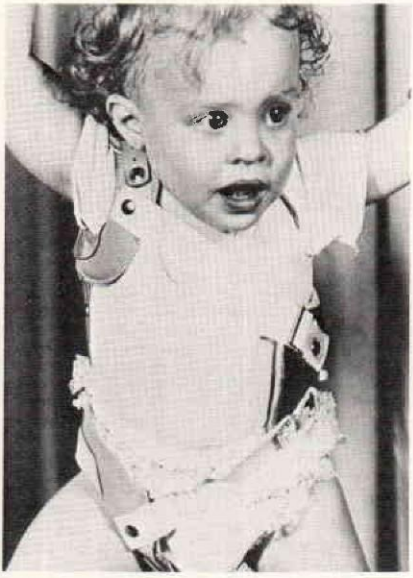


Fig. 19
Patient Wearing a Newington Infantile Scoliosis Splint, Anterior View.

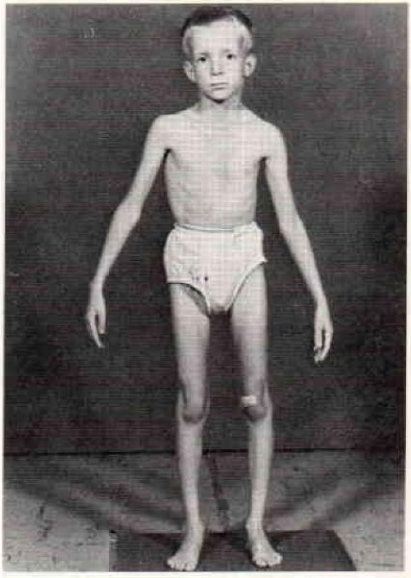


Fig. 21
Anterior View of Patient Afflicted with Marphans Syndrome.

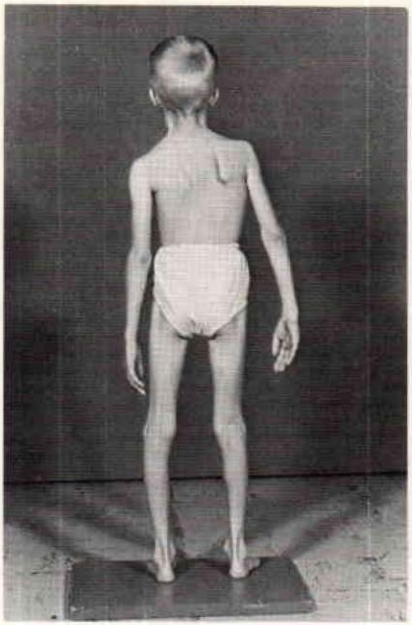


Fig. 22
Posterior View of Patient Afflicted with Marphans Syndrome.

Less involved patients will go into the Newington infantile scoliosis splint or a spinal corset. A Milwaukee orthosis will be indicated

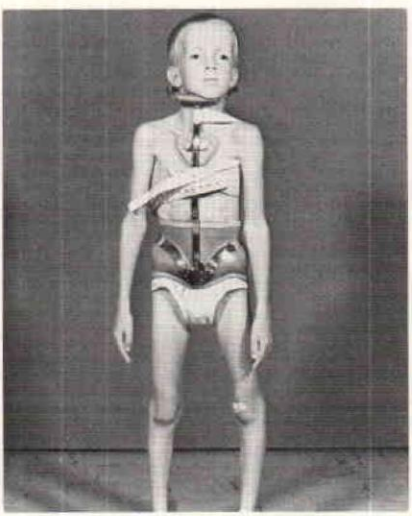


Fig. 23
Anterior View of This Patient with Milwaukee Orthosis Applied.

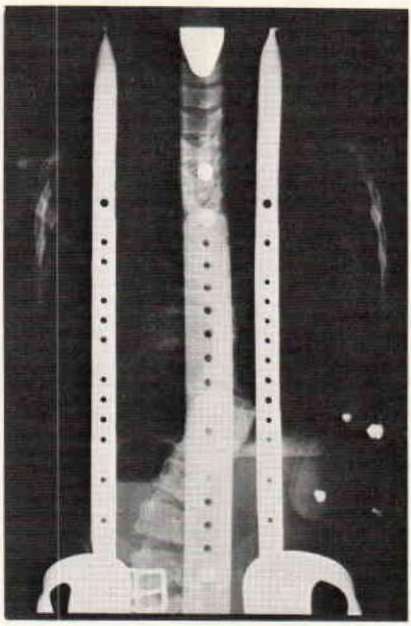


Fig. 24
Most Recent X-Ray of Patient with Milwaukee Orthosis Applied.

once the more mature age of 4 to 6 years, depending on growth, has been reached.

The next patient is a good example for this type of treatment. This patient is an 11-year-old boy afflicted with Marphans syndroms.

The initial application of a Milwaukee orthosis was at age three, which was somewhat early. However, we have been able to achieve corrections of his curves and have avoided more severe deformity. He is now wearing his fourth Milwaukee orthosis. Those patients which demonstrate no hope of future ambulation have benefitted from body jackets molded of vitrathene.

Such body jackets have proven to be of help in stabilizing the spine and preventing its collapse.

The amyotonic case was also able to exercise better respiration and

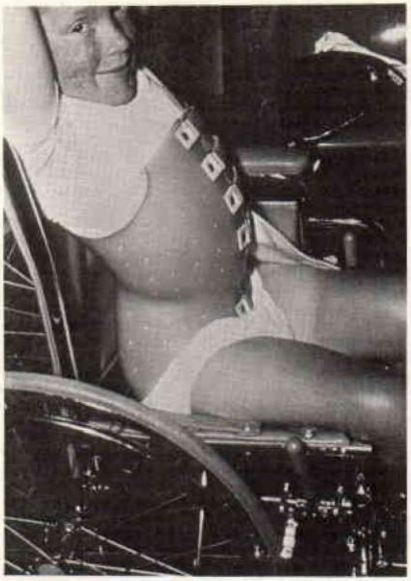


Fig. 25

Laterial View of Myelomeningocele Patient in Body Jacket.

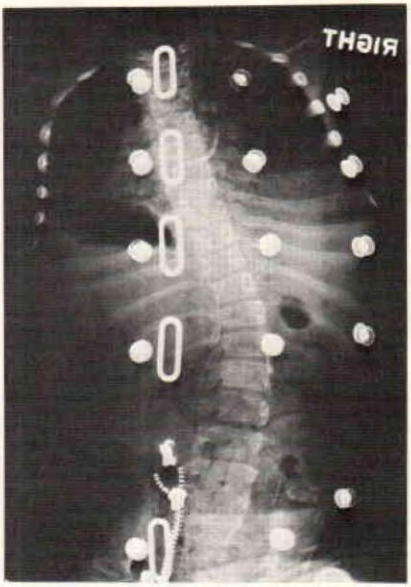


Fig. 27

X-Ray of This Patient With Body Jacket Applied.

the retarded child was easier to manage by its custodians.

The same applies to the patients with Werdnig Hoffmans disease, like this patient in a reclining seating device with lateral support.

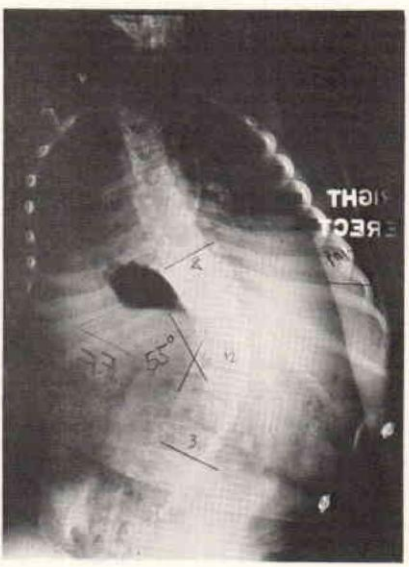


Fig. 26

X-Ray of This Patient Without Body Jacket.

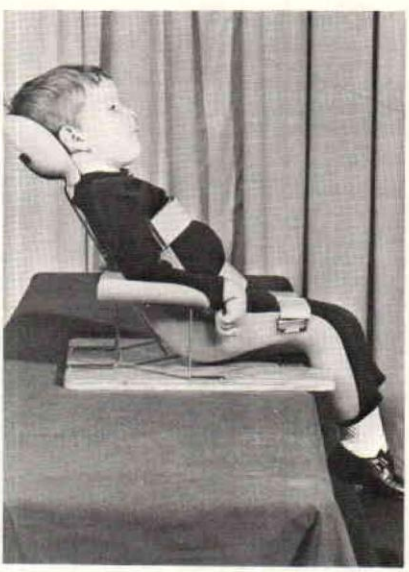


Fig. 28

Reclining Seating Device for Patient with Werdnig Hoffmans Disease.

CONCLUSION

The examples presented here can only highlight the many problems posed by scoliosis in its multitude of variations. Only the sharing of knowledge obtained by all of us will help to advance our current status of Orthotic Technology in the treatment of scoliosis.

ACKNOWLEDGEMENTS:

This paper could not have been presented without the assistance and cooperation of the staff of the Newington Children's Hospital.

My special appreciation is extended to Dr. James Hardy, Scoliosis Clinic Chief, Dr. Walter Bohne, Orthopedic Resident, the members of the Photography Department, Medical Records, the Radiology Department, and the Staff of my Department.

Blatchford Stabilized Knee
A Review

Susan Bergholtz, B.S.

The Prosthetics and Orthotics program at New York University has completed a technical and clinical review of a recently marketed knee unit, the Blatchford Stabilized Knee (BSK). Its distributors claim the knee provides a stabilizing effect that "virtually eliminates falls, increases confidence, and reduces general fatigue."

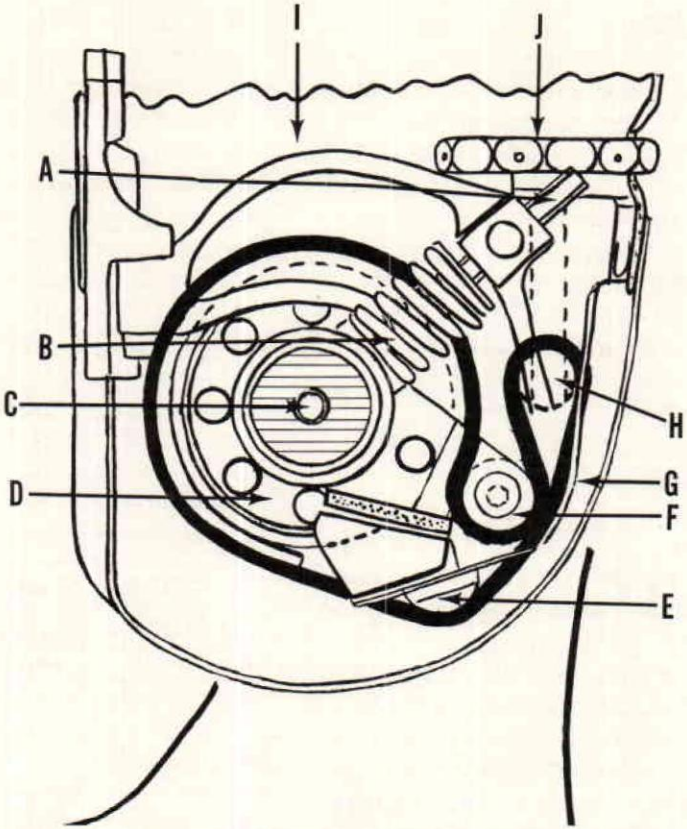
Description of Unit

The new device is a single axis knee unit with constant friction and friction lock. The amounts of swing phase friction and locking friction are controlled by a continuous terylene break band which rides on a stationary steel friction drum (Figure 1).

The knee mechanism with its belting rotates around the axis formed by two pivots set on the same horizontal plane. The amount of friction is determined by the pressure between the belting and the drum. The friction drum is concentric with and attached to the pivots. Swing phase friction is controlled by the swing phase adjustment wheel. Clockwise rotation raises the friction belting support (Figure 2), increasing belt tension and, in turn, the friction between the drum and the band.

Any downward pressure on the posterior portion of the knee block (as by weight-bearing) stabilizes the knee. This pressure rotates the unit counterclockwise about an anterior fulcrum, causing the terylene band to grip the brake drum and thereby resist knee flexion. The more weight applied, the more resistance to flexion. Locking friction is especially important during the period from heel strike to midstance when a poorly aligned prosthetic knee is

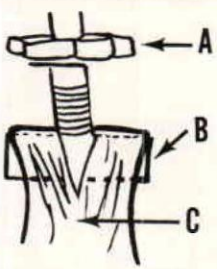
[1] Assistant Research Scientist, Prosthetics and Orthotics, New York University Post-Graduate Medical School.
This study was conducted under the general supervision of Sidney Fishman, Ph.D. Appreciation is expressed to Joan E. Edelstein, M.A., Virgil Faulkner, C.P., and Marshall Kaufman, B.S., for their assistance.



A. Stance Phase Stability Adjustment Screws
B. Release Spring
C. Single Axis
D. Stationary Friction Drum
E. Friction Regulation Bar
F. Anterior Fulcrum
G. Friction Belting
H. Friction Belting Support
I. Horizontal Knee Block
J. Swing Phase Friction Adjustment Wheel

LATERAL VIEW OF THE BLATCHFORD STABILIZED KNEE

Figure 1



A. Swing Phase Adjustment Wheel
B. Friction Belting Support
C. Friction Belting

ANTERIOR VIEW OF SWING PHASE ADJUSTMENT WHEEL WITH FRICTION BELTING

Figure 2

most likely to bend. A single axis knee depends upon alignment and stump extension force or a positive lock to keep it extended during the first part of stance phase. The Blatchford Knee, however, requires only the downward force of the amputee's body weight. The manufacturer claims that this stabilization is achieved if the knee is loaded in any position between full extension and thirty-five degrees of knee flexion.

Two release springs eliminate the stabilizing effect at toe-off. They are set to counteract the small amount of weight still applied by the amputee late in stance phase. Without such counterbalancing springs, even partial weight-bearing would lock the knee. The springs also enable the amputee to bend the knee, as when sitting.

When the basic knee unit is incorporated into a shank, an extension lever is added. Knee flexion stretches an elastic strap located at the lower end of the extension lever. The tensed strap prevents excess heel rise at toe-off and accelerates the shank forward during the initial part of swing phase. Because the axis of the lever is posterior to the axis of knee rotation, the knee remains flexed during sitting.

When the basic knee unit is incorporated into a shank, an extension lever is added. Knee flexion stretches an elastic strap located at the lower end of the extension lever. The tensed strap prevents excess heel rise at toe-off and accelerates the shank forward during the initial part of swing phase. Because the axis of the lever is posterior to the axis of knee rotation, the knee remains flexed during sitting.

A leather hyperextension strap is attached from the knee bolt to the posteroproximal portion of the shank. As the knee approaches full extension at the conclusion of swing phase, the strap is tensed, thereby reducing terminal impact.

An external cover contributes cosmesis and protects the mechanism.

The knee unit with its wood setup and cover weighs 4¼ pounds, as compared with 2¾ pounds for the Bock Safety Knee 3P23, and 2¼ pounds for a single axis knee with friction adjustment.

Clinical Findings

The one test wearer was a sixty-one year old jazz musician who acquired a left above-knee amputation in 1966 as the result of circulatory insufficiency. He required maximum stability in stance, yet could manage an unlocked knee in swing phase if external support (such as a cane) were provided. Up to the time of the study, he had worn his own prosthesis all day, every day. It was of the following design:

Proximal Socket—Quadrilateral
Distal Socket—Air chamber
Socket material—Wood, plastic coated
Suspension—Pelvic belt
Knee type—Single axis, manual lock
Friction—No adjustable friction
Extension aid—None
Shank material—Wood, plastic laminate finish
Foot-ankle assembly—SACH

After the subject was fitted with a prosthesis in which a Blatchford Stabilized Knee was installed, the following data were gathered:

1. Prosthetic Considerations
   a. Installation

The attending prosthetist reported that the time and ease of installation of the Blatchford Stabilized Knee unit was comparable to that required in mounting a Bock Safety Knee or a constant friction single axis knee unit into a new prosthesis.

b. Maintenance

One minor adjustment was required during the one-month test period. When the subject returned for the two-week followup, the swing phase friction had decreased slightly. A quarter turn clockwise of the Swing Phase Adjustment Wheel returned the unit to the friction established at the initial fitting. No decrease in the friction was apparent from the two-week followup to the final evaluation four weeks after delivery.

No further mechanical problems occurred during the test period. However, areas of potential difficulty included the following:

1) The BSK mechanism is more complex than either of the comparable conventional units. In referring to its installation, the manufacturer acknowledges "great care must be taken at all stages to keep the mechanism clean . . . to avoid having to dismantle it to remove any foreign material."

2) The two release springs on the BSK are mounted with plastic end caps, each of which has a lip covering the end of the spring. This lip might be a source of mechanical breakdown, for it bears the full force of a heavy spring.

3) It might become necessary to remove the friction belt to clean dirt that had accumulated between the belt and the friction drum. This requires a major dismantling of the unit.

2. Performance Observations

a. Initial Evaluation

Ordinarily this amputee ambulates with a manually locked knee unit and a cane. Although he states that he feels insecure with the prosthetic knee unlocked, he can walk slowly with the use of a cane. For the purposes of functional comparison with the BSK, the subject's gait was studied while he used his own prosthesis both with the artificial knee locked and with it unlocked.

With his conventional prosthesis and cane, the amputee displayed the following gait deviations whether walking with the knee locked or unlocked: (1) lateral trunk bending toward the side of the prosthesis; (2) ipsilateral arm often rigidly extended, not swinging reciprocally with the contralateral, sound, leg; (3) circumduction of the prosthesis when walking with a locked knee; (4) a longer prosthetic step and terminal swing impact with an unlocked knee and support of a cane. The subject took seventy-six steps per minute with the locked knee but slowed to sixty-six steps per minute when he ambulated with the mechanical knee unlocked.

One step stair ascent was unaffected by the status of the knee. When the knee was locked, the subject descended by the one step method. With an unlocked knee, however, he was capable of using the step-over-step technique, although he customarily descended stairs with a locked knee.

Upon delivery of the experimental prosthesis, an effort was made to

estimate stance phase stability by positioning the patient between parallel bars, and having him attempt to support most of his weight on the prosthesis with the knee unit placed at various angles. In the judgment of the observers, he bore most of the weight on the prosthesis, very little on his hands, and none on the sound extremity during the actual tests. The knee remained stable when loaded by a great deal of downward pressure. This test was repeated as the knee flexed at five degree increments to maximum angulation of thirty-five degrees (a fully extended knee being considered to be zero degrees). Stability was obtained at all test points, except the final position, where moderate weight-bearing caused the prosthetic knee to buckle.

Gait on a level surface was examined after the terylene belt tension was adjusted to provide moderate swing phase friction. The subject displayed most of the deviations found with his conventional free swinging prosthesis, namely: (1) lateral bending; (2) long prosthetic step; (3) failure to swing arms reciprocally. Since the BSK provides constant friction throughout swing phase, terminal swing impact was less with the test knee than with the previous, nonfriction unit. The cadence of sixty-four steps per minute was similar to that with the conventional unlocked knee.

He climbed stairs one step at a time. He could not descend step-over-step because he could not transfer enough weight from the prosthesis to negate the stabilizing action of the Blatchford Stabilized Knee.

Two weeks later he still used a cane, but had become more proficient in walking, utilizing more of the features of the test knee. Lateral trunk bending was still prominent, but the arm on the side of the prosthesis was now employed in reciprocal arm-leg movement and the prosthetic step length was nearly that of the sound side. Cadence increased to seventy-six steps per minute, equalling that with the locked knee in his previous prosthesis.

At the conclusion of the test period, one month after delivery, the subject's gait was re-evaluated with his two prostheses. Walking patterns with the conventional prosthesis had not changed since the initial evaluation. Performance with the BSK also remained similar to that displayed at the two-week follow-up.

3. Subject's Reactions

Initially, the amputee was skeptical about the safety of the Blatchford Stabilized knee. He stated that he lacked confidence while ambulating with it.

At the end of one month, the subject's opinion had altered considerably. He said that he would *"definitely choose"* this prosthesis over his previous one, for the following reasons:

1) **Stability in Stance**

He felt very confident that his knee would not collapse while he was walking. He stated that he felt safer on curbs and was not as "afraid of falling" when someone bumped into him on the street. The subject also related that he was

beginning to feel more confident without the cane.

2) **More Natural Gait**

The subject claimed he was "happy at not walking with a stiff leg." He felt that the unit had a definite advantage over his previous one, for it allowed him to feel safe while producing a more natural gait.

3) **Less Fatigue**

The subject stated that he was less tired when using the BSK. Because of its freedom in swing, he did not have to circumduct the prosthesis as he did with his manually locked prosthetic knee. The inherent stance stability of the BSK obviated the need to extend his stump at heel strike.

The subject was unable to descend stairs by the step-over-step method. Although he did not find this detrimental himself, he conjectured that it might limit a more active individual.

Summary and Recommendations

The Blatchford Stabilized Knee incorporates a mechanism to resist knee flexion to thirty-five degrees of knee flexion upon downward loading. The unit was fitted to an amputee who needed substantial stability in stance phase, but was also able to utilize an unlocked knee in swing phase if external support were provided. After wearing the unit for a month, he stated that he preferred it over the manually locked knee unit in his previous prosthesis. The test unit gave him stance phase stability while offering a more cosmetic gait and reduced fatigue when he walked long distances. The major difficulty noted by both the subject and the evaluator was in stair descent. A step-over-step descent could no longer be used because sufficient body weight could not be removed from the prosthesis to negate the inherent stability of the knee.

The additional weight of the unit (approximately one and a half pounds heavier than his previous unit) presented no difficulty to the wearer. This subjective reaction may relate to the fact that the BSK was mounted in a prosthesis with suction suspension, unlike the looser socket and pelvic belt on his own limb. The more intimate socket fit may have been as responsible for the "lighter feeling" as the action of the test knee.

The prosthetist encountered no difficulties in installing the knee. He predicted, however, that any internal derangement of the mechanism would require time-consuming dismantling of the entire unit.

On the basis of this study, the Blatchford Stabilized Knee appears to be a useful addition to the prosthetic armamentarium for those amputees who require maximum stability in stance, yet desire a cosmetic swing phase. Further study may answer certain other questions:

1. How durable is the unit over a prolonged period of wear?
2. How suitable is the mechanism for bilateral above-knee amputees, feeble geriatric amputees, or those with a hip distarticulation?
3. Will the additional weight of the unit affect its applicability?

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