

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

## FOREWORD

The Subcommittee on Design 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

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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 to-

day. 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

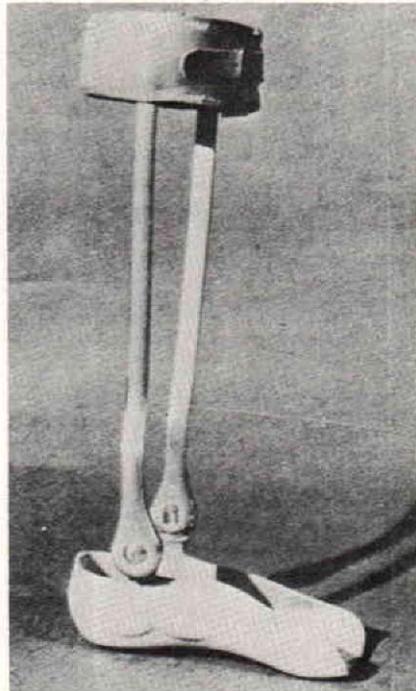


Fig. 3  
NYU Insert Brace.



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*, US-AMBRL 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*, US-AMBRL 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 Fiber-*

*glass-Epoxy Drop-Foot Brace*, USA-MBRL 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-

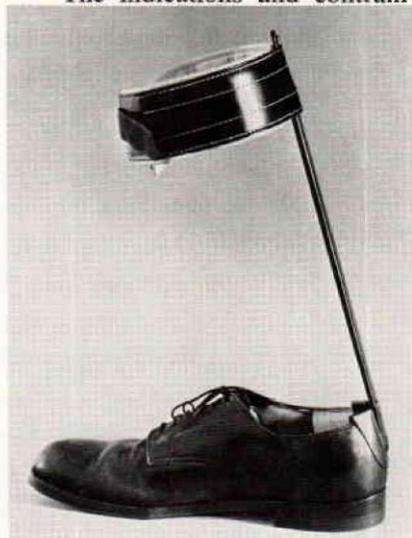


Fig. 5  
VAPC Drop-Foot Brace.

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



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

M-L stability of the ankle during stance.

#### 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, Fiber-glass-Epoxy Drop-Foot Brace*, US-AMBRL Technical Report 6805, May 1968.

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

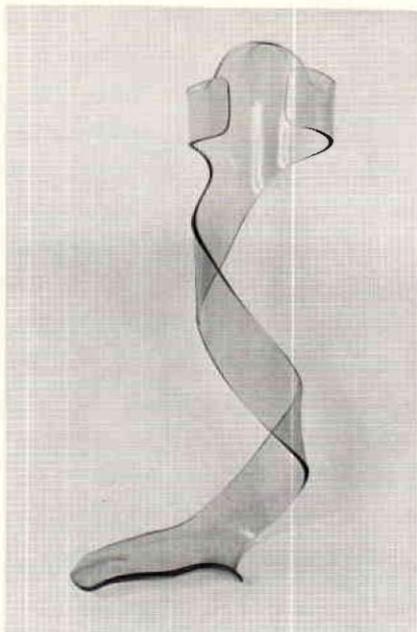


Fig. 7  
IRM Spiral BK Brace.

*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.

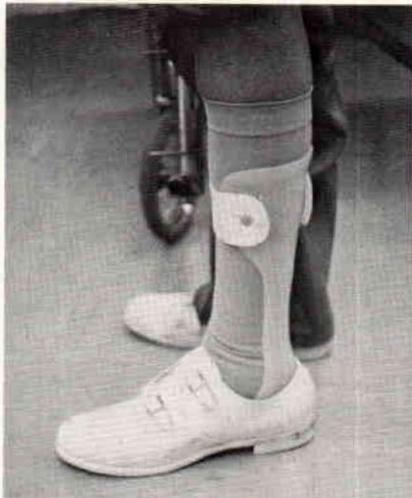


Fig. 8  
Rancho Polypropylene Drop-Foot Brace.

## *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

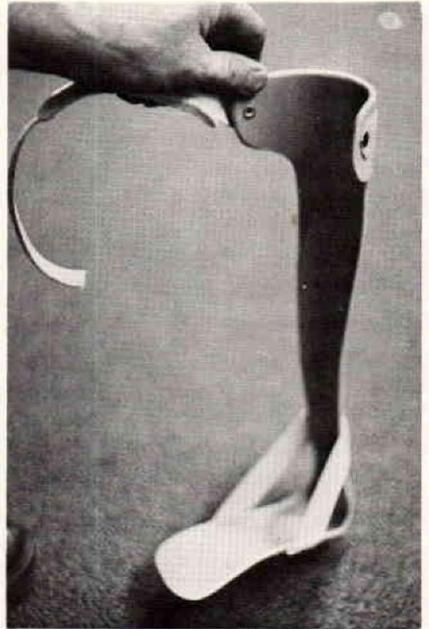


Fig. 9

Teufel Ortholen Drop-Foot Brace.

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.

### 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.

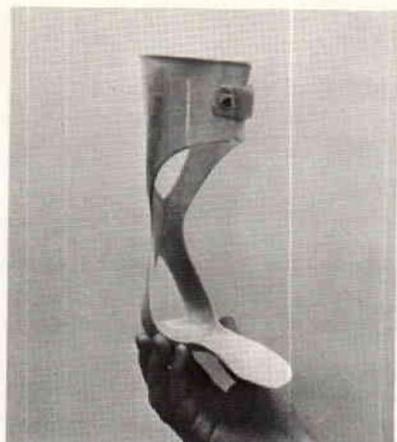


Fig. 10  
TIRR BK Brace.

#### 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, Arti-*



Fig. 12  
IRM SK Brace.

ficial Limbs, 12:2:54-57, Autumn 1968.

### *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 quadriceps 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

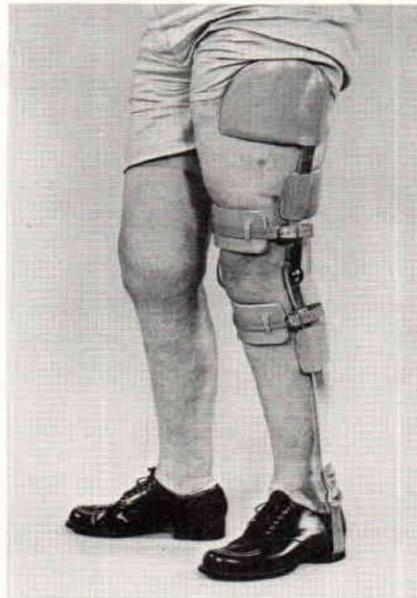


Fig. 14  
University of Michigan Arthritic Knee Brace.

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. Marshall, *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 mid-thigh, 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 cor-

rective 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

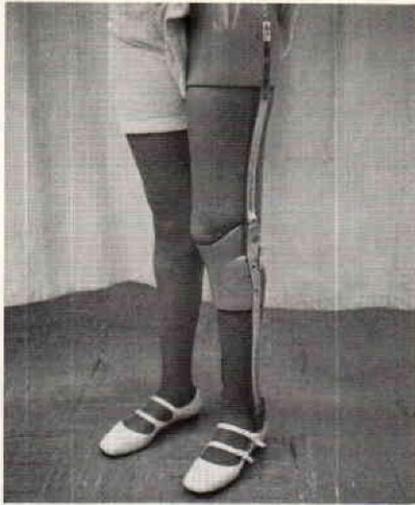


Fig. 15

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 poly-

ester 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

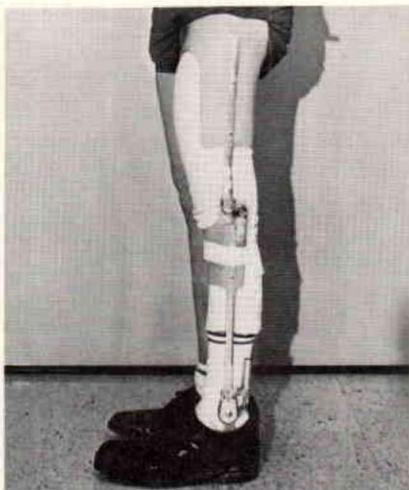


Fig. 16

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 con-

tractures 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



Fig. 17

VAPC Single-Bar Long-Leg Brace.

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.

## 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 necessary. 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.

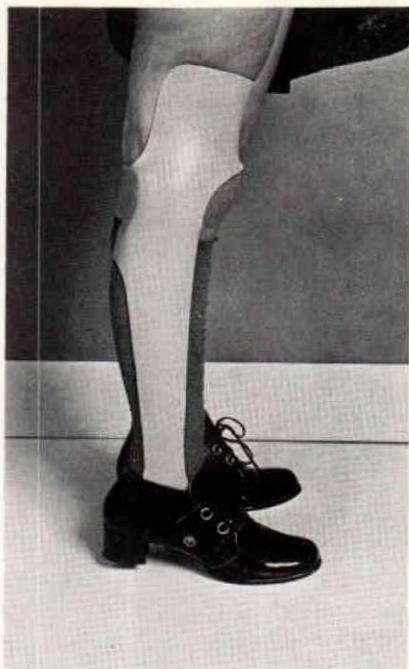


Fig. 19  
IRM SKA Brace.

#### 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.