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Volume 36
Number 4

Orthotics and Prosthetics

Journal of the American Orthotic and Prosthetic Association

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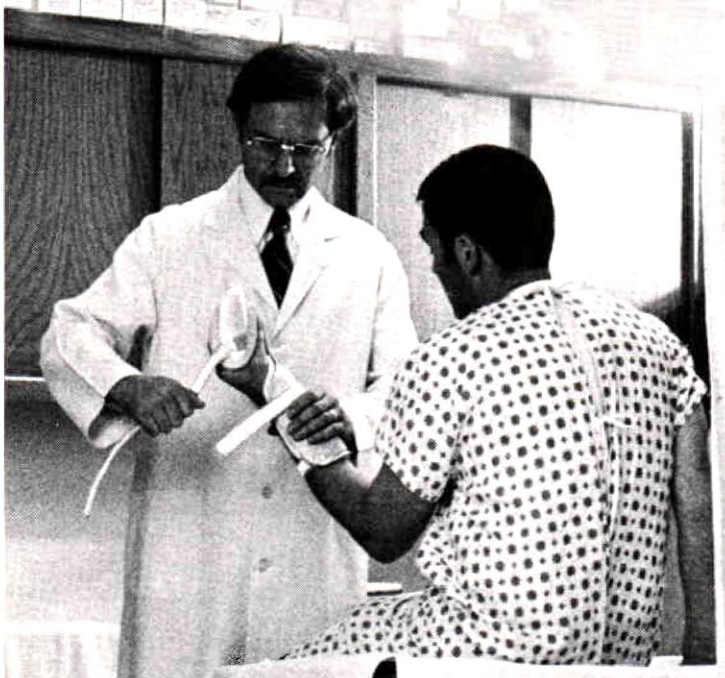

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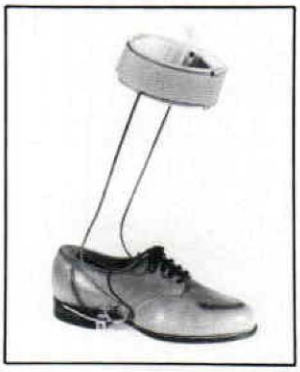

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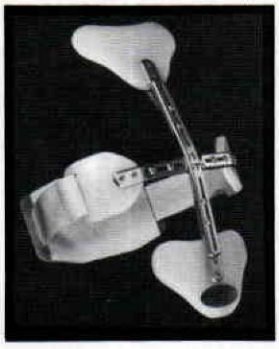

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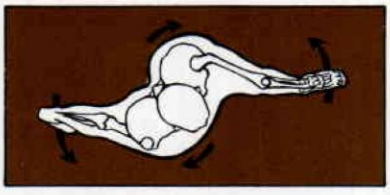

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Please notify the National Office immediately concerning additional meeting dates. It is important to submit meeting notices as early as possible. In the case of Regional Meetings, it is imperative to check with the National Office prior to confirming date to avoid conflicts in scheduling.

1983, April 6–8, First European Conference on Research in Rehabilitation, Edinburgh, Scotland, United Kingdom.

1983, April 14–16, AOPA Region I and the AAOP New England Chapter Combined Meeting, Boston Marriott, Newton, Massachusetts.

1983, April 16–17, ABC Written Exams, Prosthetics-Orthotics, 3 sites:
AMFAC Hotel, San Francisco, California
Holiday Inn O'Hare-Kennedy, Chicago, Illinois
Ramada Inn, Old Town, Alexandria, Virginia
Contact: ABC National Headquarters, 703-836-7114.

1983, April16–17, Blythedale Children's Hospital, "Foot Management in C.N.S. Disorders, Lecture and Practicum," Valhalla, New York. Contact: Blythedale Children's Hospital, 95 Bradhurst Avenue, Valhalla, New York 10595, Attn: Linda Fieback, 914-592-7555.

1983, April 18–20, Fracture Brace Seminar, UCLA, Los Angeles, California. Contact: UCLA Prosthetics-Orthotics Education Program, Room 22-46, Rehabilitation Center, 1000 Veteran Avenue, Los Angeles, California 90024, 213-825-6341.

1983, April 21–23, University of Texas Science Center at Dallas, School of Allied Health Sciences and AAOP Joint Seminar, "Orthotic Management of Fractures," Holiday Inn Brookhollow, Dallas, Texas. Contact: School of Allied Health Sciences, The University of Texas Health Sciences Center at Dallas, Prosthetics-Orthotics, 5323 Harry Hines Blvd., Dallas, Texas 75235.

1983, May 5–7, AOPA Region IV Annual Meeting, Downtown Holiday Inn, Jackson, Mississippi.

1983, May 12–14, AOPA Regions II and III Combined Meeting, Colonial Williamsburg, Williamsburg, Virginia.

1983, May 19–22, AOPA Region V Annual Meeting, Stouffers Dublin Hotel, Columbus, Ohio.

1983, May 25–28, AOPA Regions VII, VIII, X and XI Combined Meeting, Four Seasons Motor Hotel, San Antonio, Texas.

1983, June 3–5, AOPA Region IX, COPA, and the California Chapters of the AAOP Combined Annual Meeting, Harrah's, South Lake Tahoe, Nevada.

1983, June 7–10, UCLA Advanced Upper Extremity Prosthetics Seminar, Los Angeles, California.

1983, June 12–16, 6th Annual Conference on Rehabilitation Engineering, Town and Country Hotel, San Diego, California.

1983, June 16–19, AOPA Region VI and AAOP Midwest Chapter Combined Annual Meeting, Olympia Resort and Spa, Oconomowoc, Wisconsin.

1983, June 19–23, American Medical Association's Annual Meeting of the House of Delegates, Chicago Marriott Hotel, Chicago, Illinois.

1983, September 5–9, International Society for Prosthetics and Orthotics IV World Congress, Imperial College, London, U.K. Contact: ISPO World Congress Office, 3-5 Bute Street, London, SW7, 3EY United Kingdom.

1983, October 25–30, AOPA National Assembly, Hyatt Regency, Phoenix, Arizona. Contact: AOPA National Headquarters, 703-836-7116.

1984, January 25–29, AAOP Annual Meeting and Seminar, Dutch Resort Hotel, Lake Buena Vista, Orlando,

Florida. Contact: AAOP National Headquarters, 703-836-7118.

1984, April 3–5, Canadian Association of Prosthetics and Orthotists Annual Meeting, Westin Bayshore Hotel, Vancouver, British Columbia, Canada.

1984, April 12–15, Region IV Annual Meeting, Waverly Hotel at the Galleria, Atlanta, Georgia.

1984, April 19–22, AOPA Regions V and VI Combined Annual Meeting, Amway Grand Plaza Hotel, Grand Rapids, Michigan.

1984, May 3–4, AOPA Regions II and III Combined Annual Meeting, Concord Hotel, Kramesha Lake, New York.

1984, June 1–3, AOPA Region IX Meeting, Harrah's, South Lake Tahoe, Nevada.

1984, June 28–30, AOPA Regions VII, VIII, X, and XI Combined Meeting, North Shore Convention Center, Lake Coeur d'Alene, Idaho.

1984, October 17–22, AOPA-General Assembly and International Congress, Fontainebleau Hotel, Miami Beach, Florida. Contact: AOPA National Headquarters, 703-836-7116.

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A special issue of the AOPA journal, *Orthotics and Prosthetics*, scheduled for Fall, 1983, will be devoted entirely to the technical aspects of orthotics and prosthetics—fabrication techniques, special tools, alignment techniques and devices, etc. A less stringent editorial process will be used to judge articles submitted for this publication since actual patient management procedures will not be discussed.

All orthotists and prosthetists are encouraged to send in their ideas and inventions. Black and white glossy print photographs are required for all articles describing new tools or other devices.

Following are a few areas that will be covered:

1. Reinforcing techniques in orthotics and prosthetics
2. Special tools developed to assist in fabrication
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4. Materials used in fabrication to improve cosmesis
5. Padding techniques and materials
6. Finishing techniques—smoothing, painting, etc. used to improve the finish
7. Fabrication shortcuts
8. Modifications to existing tools and instruments
9. Laboratory layout and design
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11. Specially equipped vans or cars for hospital visits
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Please submit all ideas to Christopher R. Colligan, Managing Editor, *Orthotics and Prosthetics*, 717 Pendleton Street, Alexandria, VA 22314

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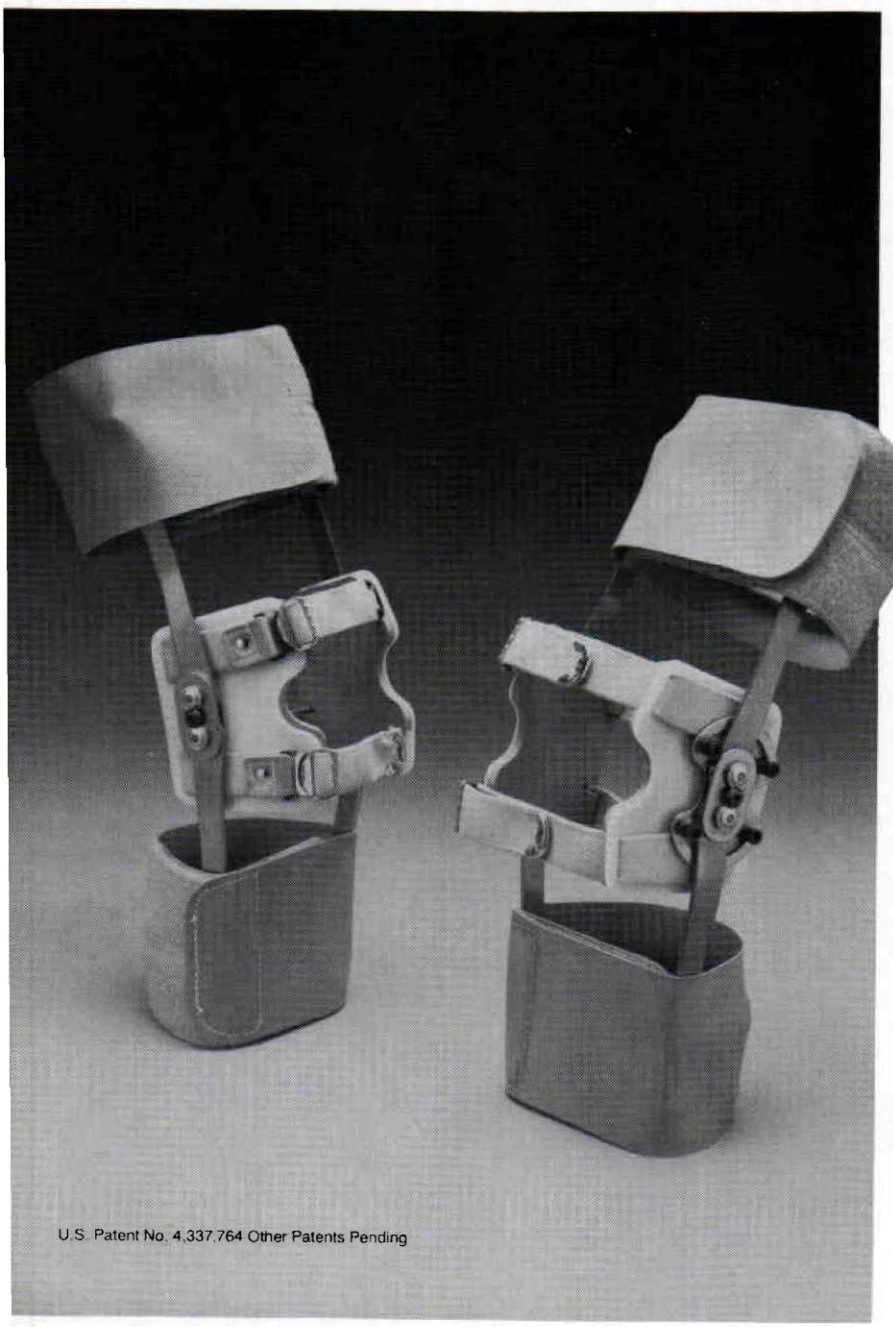

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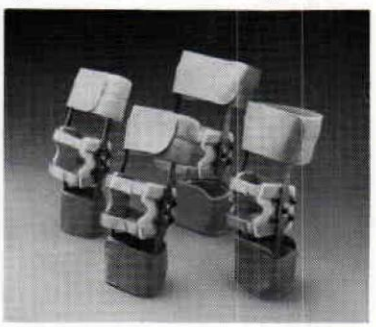

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Pitfalls in the Use of the Pavlik Harness for Treatment of Congenital Dysplasia, Subluxation, and Dislocation of the Hip

Scott Mubarak, M.D.
Steven Garfin, M.D.
Raymond Vance, M.D.
Bert McKinnon, M.D.
David Sutherland, M.D.

(Reprinted from Journal of Bone and Joint Survery Vol. 63-A, No. 8, pp. 1239–1248, October 1981.)

Abstract: We reviewed the records of treatment of eighteen infants with congenital dysplasia, subluxation, or dislocation of the hip who had problems with the involved hip following treatment with the Pavlik harness. The most common problem (seen in twelve patients with a dislocated hip) was failure to obtain reduction. This failure was attributed primarily to improper use of the harness by the physician. In some patients, three to five months elapsed before the physician recognized the lack of reduction. In nine patients, a Pavlik harness of poor quality and construction added to both the physician's and the patient's problems, and in six patients, poor patient compliance with the use of the harness was partially responsible for the failure. In three patients who were initially treated in the Pavlik harness, avascular necrosis of the hip subsequently developed, in two following open reduction and in one after closed reduction and cast application.

The physician's indications for use and application of the harness must be appropriate. The child must be examined frequently out of the harness both clinically and roentgenographically. Failure to achieve reduction or adductor relaxation must be recognized promptly and dealt with immediately.

In the twenty-four years since Pavlik first reported its use in 1,912 patients, the Pavlik harness has been used widely as an orthotic device for the management of congenital dislocation of the hip.

When appropriately applied, the harness prevents adduction and extension of the hip while allowing further flexion, abduction, and rotation. This position and motion are designed to aid the gentle, spontaneous reduction of the dislocated hip and acetabular development of the dysplastic hip[2-4,6]. The purpose of this study was to review the use of the Pavlik harness by physicians in our community

and to identify the complications and pitfalls encountered in its use.

MATERIAL AND METHODS

This review is a report of the experience of the orthopaedic surgeons at the University of California at San Diego affiliated hospitals in the use of the Pavlik harness in treating congenital dislocation of the hip. The names of the patients to whom Pavlik harnesses had been prescribed during the period of 1975 through 1979 were obtained from the orthotic agencies in the San Diego area. Additionally names also were obtained from orthopaedic surgeons, clinics, and hospitals who either supplied or constructed their own Pavlik harnesses for distribution to patients.

The records and roentgenograms of 110 patients were reviewed. Eighteen patients with congenital dysplasia, subluxation, or dislocation of the hip in whom problems developed related to the Pavlik harness and its proper use were identified. These patients were divided into two groups based on their ages at the time of diagnosis. In Group I the diagnosis was made in the newborn period. The problem hip was classified as dislocatable or dislocated based on the treating orthopaedist's clinical examination of the patient. In Group II

TABLE I
Group-I Patients

Case	Age (Mos.) At Diagnosis	Age (Mos.) When Harness Initiated	Diagnosis	Time in Harness (Mos.)	Problem	Reason	Other Treatment	Result
1	Newborn	Newborn	Dislocated, bilat.	3	Failure of reduction, left; femoral-nerve palsy	Orthopaedist: inadequate hip flexion	Traction; open reduction; spica; Pavlik	Reduced; avasc. necrosis
2	Newborn	3	Dislocated, right	3	Failure of reduction	Orthopaedist: inadequate hip flexion; poor parent compliance	Traction; closed reduction; spica; Camp brace	Reduced; avasc. necrosis
3	Newborn	¼	Dislocatable, left	4	Failure of reduction	Orthopaedist: inadequate hip flexion; poor-quality harness allows adduction; poor parent compliance	Traction; open reduction; spica; Camp brace	Normal
4	Newborn	Newborn	Dislocatable, left	5	Failure of reduction	Orthopaedist: inadequate hip flexion	Traction; open reduction × 2; spica	Normal
5	Newborn	½	Dislocatable, right	3	Failure of reduction	Orthopaedist: poor-quality harness allows adduction	Traction; open reduction; spica	Reduced; avasc. necrosis
6	Newborn	Newborn	Dislocated, bilat.	3	Failure of reduction, right	Orthopaedist: no roentgenogram in harness to confirm position	Traction; open reduction; spica	Normal
7	Newborn	1	Dislocatable, right	3	Failure of reduction,	Orthopaedist: inadequate hip flexion; poor-quality harness allows adduction	Traction; open reduction; spica	Normal
8	Newborn	Newborn	Dislocated, left	5	Failure of reduction	Orthopaedist: inadequate hip flexion; poor-quality harness allows adduction	Traction; closed reduction; spica	Normal
9	Newborn	Newborn	Dislocatable, bilat.	3	Failure of reduction, left	Orthopaedist: poor-quality harness allows adduction	Traction; closed reduction; spica	Normal

the diagnosis was made after the age of one month (range, one to ten months). These problem hips were classified as having acetabular dysplasia, subluxation, or dislocation, depending on the appearance of the patient's initial roentgenograms.

The major problems that have been reported to occur with the use of this device for the treatment of congenital dislocation of the hip are failure to achieve a concentric reduction and avascular necrosis[3-5,7-9]. Other problems that we encountered were delayed acetabular development, failure to stretch the hip adductors, femoral-nerve palsy, and inferior dislocation. The reasons for these problems were determined and classified as being due to:

1. The physician—The physician's indications for the use or application of the harness were inappropriate. In some cases the Pavlik harness used was of poor-quality design and allowed inadequate control of hip position.
2. The parents—The parents failed to have the child wear the harness or use it properly.
3. Idiopathic—No physician or parental fault was evident, and other reasons could not be identified.

RESULTS

Eighteen patients were identified as having failures of treatment following use of the Pavlik harness.

Group I

In Group I there were nine patients who were diagnosed as having dislocatable or dislocated hips at birth (Table I). In no instance did the treating orthopaedist's initial recorded examination indicate whether a dislocated hip was reducible or not. Two of the nine patients had bilateral dislocated hips, and one had bilateral dislocatable hips. Following application of the harness, roentgenograms were made for eight of the nine patients. Failure to achieve concentric reduction with the harness was the major problem in all nine patients. One patient (Case 1) also had a transient femoral-nerve palsy.

In six of these patients, the amount of hip flexion obtained in the harness as determined on the roentgenogram never was sufficient to direct the femoral head toward the triradiate cartilage. In five patients a Pavlik harness of poor-quality constructed was used, which allowed adduction and internal rotation of the hip. Futhermore, in all nine patients three to five months passed before the physician recognized that the hip was not reduced. All of these nine patients subsequently required traction, general anesthesia, reduction, and a spica cast. Six of the nine patients eventually required an open reduction. In three patients avascular necrosis subsequently developed, following open reduction in two and after closed reduction in one.

Group II

In Group II, failure to obtain reduction was the problem in four of nine patients for reasons similar to those in Group I (Table II). In Case 17, a ten-month-old boy, attempted reduction of bilateral dislocation failed. This patient did not obtain adequate hip flexion in the harness and was at the upper limit of the age recommended for use of the harness[4]. Furthermore, the six-week trial of spontaneous reduction in the harness was too long. In Case 16, the proper degree of hip flexion first achieved reduction, but excessive flexion then produced an inferior (obturator) dislocation. In three other patients the hip adductors remained contracted. One of these patients (Case 14) was in a poor-quality harness which allowed hip adduction. The other two were in a well made harness that was properly positioned, and no specific reason for the tight hip adductors was found. There were no patients with avascular necrosis in Group II.

Other

Five other patients with instability or dislocation of the hip who had problems with the Pavlik harness were encountered.

TABLE II
Group-II Patients

Case	Age (Mos.) At Diagnosis	Age (Mos.) When Harness Initiated	Diagnosis	Time in Harness (Mos.)	Problem	Reason	Other Treatment	Result
10	2	2	Dislocated, left	2	Failure of reduction	Orthopaedist: inadequate hip flexion; poor-quality harness allows adduction	Traction; closed reduction; spica; Camp brace; open reduction	Normal
11	1½	1½	Dislocated, left	2	Failure of reduction	Orthopaedist: poor-quality harness allows adduction	Camp brace; closed reduction; spica	Normal
12	3	3	Dysplasia, right	5	Failure to stretch adductors after 3 mos.	Idiopathic	Tenotomy; spica; Pavlik	Normal
13	5	5	Dysplasia, left	3	Failure of acetab. development	Orthopaedist: poor-quality harness allows adduction; poor parent compliance	Camp brace	Normal
14	5	5	Subluxated, left	1½	Failure to stretch adductors after 1½ mos.	Orthopaedist: poor-quality harness allows adduction	Tenotomy; spica	Normal
15	4	4	Dysplasia, left	2	Failure to stretch adductors after 2 mos.; parents refused further treatment	Idiopathic	None	Lost to follow-up
16	6	7	Dislocated, left	4	Inferior dislocation	Orthopaedist: too much hip flexion; improper use	Spica	Lost to follow-up
17	10	10	Dislocated, bilat.	1½	Failure of reduction, bilat.	Orthopaedist: poor indication—child too old; inadequate hip flexion; harness trial too long	Traction; closed reduction; spica	Normal
18	5	5	Dysplasia, right	1	Used for 1 mo.; parents refused further treatment	Poor parent compliance	None	Lost to follow-up

They were not included in this review because of their diagnoses: myelodysplasia (two), Ehler-Danlos Syndrome (one), teratogenesis (one), and sepsis (one).

DISCUSSION

The construction, application, and use of the Pavlik harness is guided by a few simple principles and practical techniques (Figs. 1-A through 1-D). With commercial production of the Pavlik harness, some of the principles of construction have been violated, which in some cases has resulted in an inadequate harness. A few important points in harness construction must be noted. First, the shoulder straps on the halter (chest-strap) should cross in the back to prevent them from sliding over and down the child's shoulders. Second, the buckles for the anterior (flexor) stirrup-straps should be located at the child's anterior axillary line. If they are placed too far medially, tightening the anterior stirrup-strap will cause not only flexion but also adduction of the hip. Third, the buckles for the posterior (abduction) stirrup-straps should be located over the scapula. Fourth, the Velcro strap for the proximal part of the

Fig. 1-A: Step A. The chest halter is positioned at the nipple line and fastened with the Velcro® closure. The crossed shoulder straps then stablilize the halter at this position.

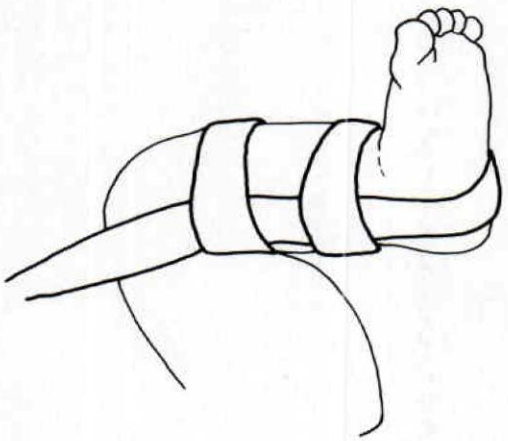

Fig. 1-B: Step B. The leg and foot are set back into the stirrups and fastened with the Velcro® straps. Care must be taken to ensure that the flexor and abduction straps are oriented anteriorly and posteriorly with respect to the child's knee.

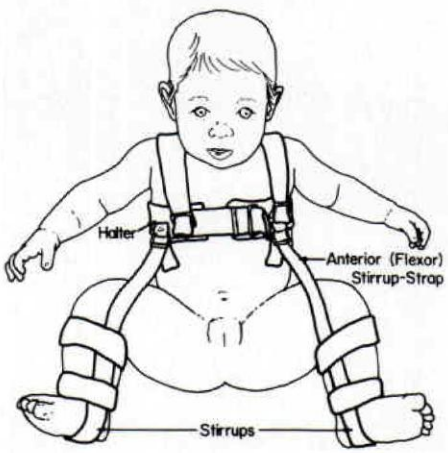

Fig. 1-C: Step C. The anterior (flexor) stirrup-straps are connected to the halter. The straps are adjusted so that hip flexion is between 100 and 110 degrees to achieve optimum position of the femoral head relative to the acetabulum. Occasionally, more flexion will be necessary initially to achieve reduction. It is important that the insertion of the anterior stirrup-straps on the halter be at the child's anterior axillary line.

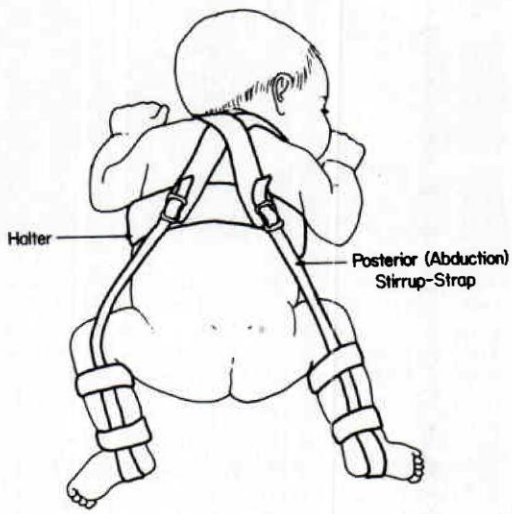

Fig. 1-D: Step D. Lastly, posterior (abduction) stirrup-straps are attached to the halter. The insertion point of these straps on the halter should be located over the child's scapula. The posterior stirrup-straps should be adjusted so that there is approximately five to eight centimeters between the knees when both hips are abducted and the hips have free abduction.

Figs. 1-A through 1-D:
Application of the Pavlik Harness

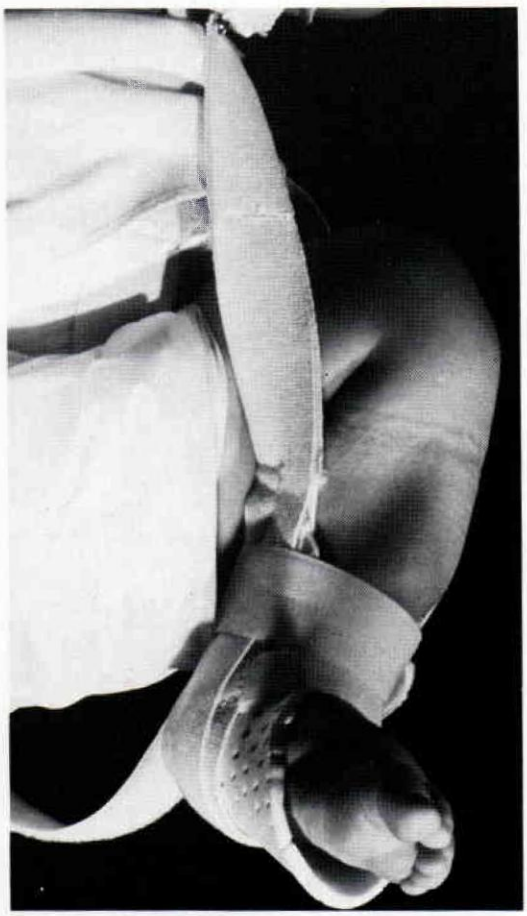

Fig. 2-A. If the Velcro® straps are too far distal, the anterior and posterior stirrup-straps will bowstring behind the knee axis. Further tightening of these straps will cause increased knee flexion and relatively poor control of hip position. Abduction and internal rotation of the hip is possible.

Fig. 2-B. With a properly positioned proximal Velcro® strap just distal to the popliteal fossa, there is better control of hip flexion and abduction and less flextion of the knee.

leg should be located just below the child's popliteal fossa (Figs. 2-A and 2-B). This strap stabilizes and controls the knee and prevents bowstringing of the anterior and posterior stirrup-straps. With bowstringing of the stirrup-straps, internal rotation and adduction of the hip can occur as the posterior stirrup-strap is tightened (Fig. 3).

The Pavlik harness is indicated in the treatment of hip dysplasia or subluxation in children from birth to about the age of ten months. As the child approaches the age of one year, it usually becomes too difficult to hold the patient in the harness, and a more conventional fixed-position brace will be necessary.

The harness may be used to reduce a congenital dislocation of the hip in a child who is less than eight months old if the criteria of Ramsey et al. are met. They noted that adequate hip flexion must be obtainable so that the femoral head is directed toward the triradiate cartilage, and made a roentgenogram of the hips in flexion prior to application of the harness. The harness is not indicated in patients in whom the dislocated hip is not centered toward the acetabulum in flexion or in infants who

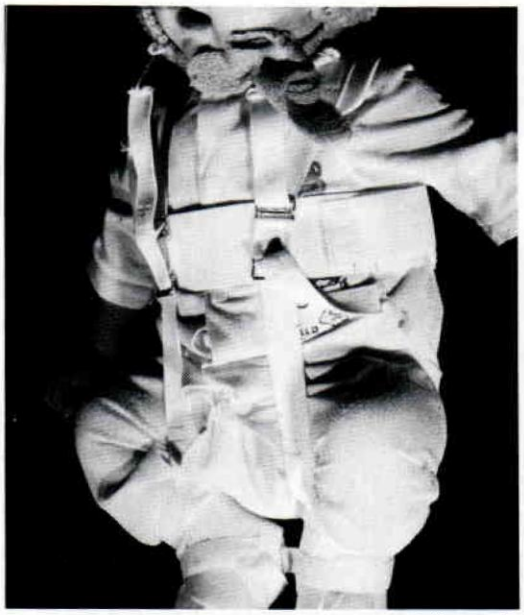

Fig. 3. This infant is wearing a commercially available Pavlik harness. Note that the insertion points of the anterior (flexor) stirrup-straps are placed medially. Further tightening of these straps will cause not only flexion, but also abduction, of the hips. Also note that the Velcro® leg straps are located too far distally. There is bowstringing of both the anterior and the posterior stirrup-straps behind the knee. There is poor knee and hip control for this reason.

are more than eight months old with a congenital dislocation of the hip. We have found it more practical to apply the harness on the child and then make the roentgenogram. In disorders such as myelodysplasia (second to fourth lumbar functional level), teratogenic dislocation, and arthrogryposis, either muscle imbalance or stiffness, or both, makes application of the harness nearly impossible. Furthermore, it also usually is inappropriate for use in infants with connective-tissue disorders or as a means of positioning a septic hip after drainage. The generalized capsular laxity found in these conditions may cause inferior dislocation of the hip.

To achieve spontaneous reduction of a congenital dislocation of the hip in an infant who is less than eight months old, the harness is applied and a roentgenogram with the child in the harness is made to confirm adequate flexion (Fig. 4). The harness is worn constantly until hip stability is achieved. The patient is examined clinically, out of the harness, at weekly intervals. By two or three weeks after harness application, both clinical and roentgeno-

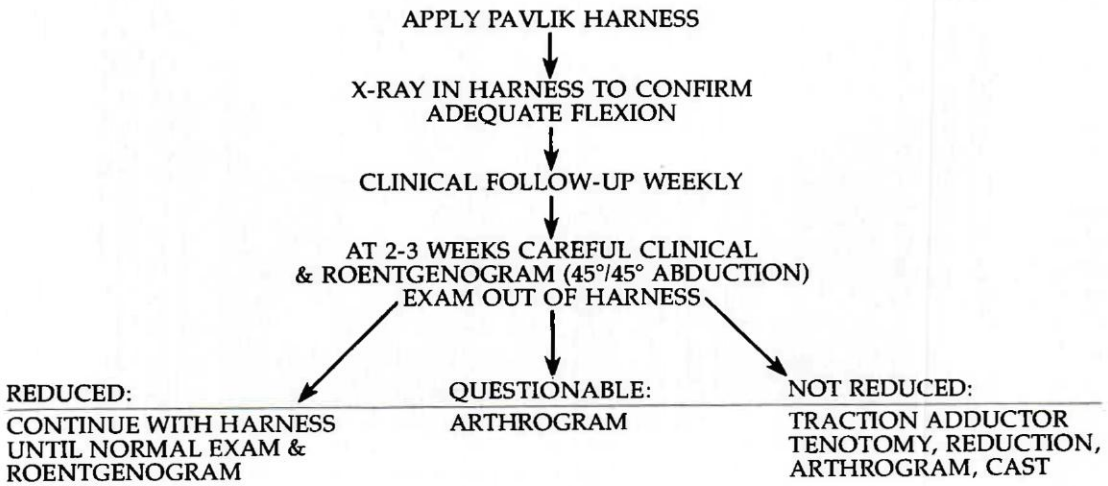

Fig. 4. Plan of use of the Pavlik harness in the treatment of congenital dislocation of the hip in an infant less than eight months old.

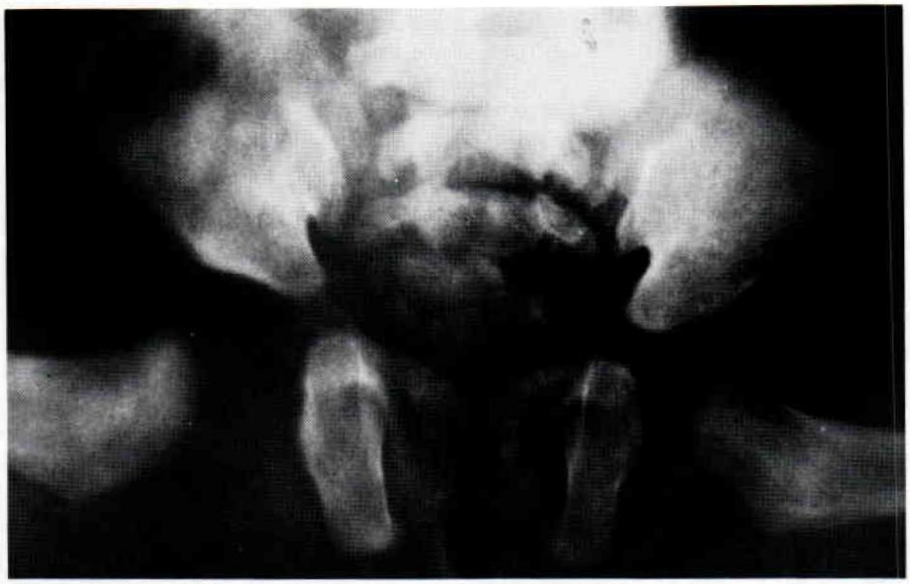

Fig. 5-A. This child was diagnosed at birth as having bilateral dislocated hips. This roentgenogram, made at the age of three months in the Pavlik harness, demonstrates asymetry of the distance from the femoral metaphysis to the triradiate cartilage. The left hip is abnormal and the Pavlik harness is maintaining the hip dislocated, posterior to the acetabulum. Note that the acetabular margins look quite good because of the outlet-type view of the pelvis when roentgenograms are made with the child in the Pavlik harness. The obturator foramen is visualized poorly and the sciatic notch is well demarcated.

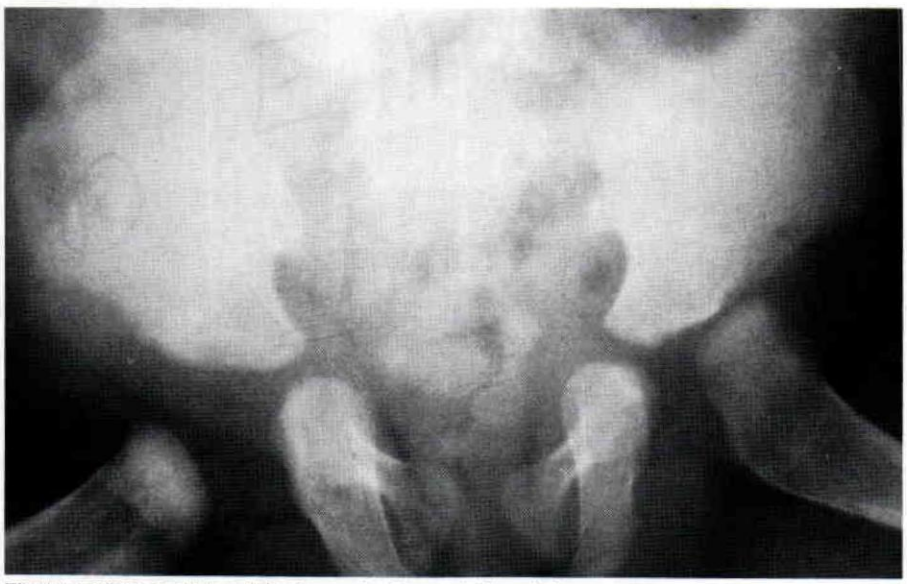

Fig. 5-B. Because of the clinical examination and the ambiguous roentgenogram shown in Fig. 5-A, a second roentgenogram was made with the child out of the harness with the femora in 45 degrees of abduction. This clearly demonstrates the dislocation of the left hip and more accurately demonstrates a true view of the pelvis, showing the acetabular dysplasia which is greater on the left than on the right. This child subsequently underwent a period of skin traction and required an open reduction of the left hip at the age of three months. Subsequently, avascular necrosis developed in the left capital femoral epiphysis.

graphic examination must confirm reduction of the hip. If the hip is not reduced during the three-week trial of harness use, the more conventional approach of traction, general anesthesia, closed reduction, arthrography, and a spica cast should be instituted Fig. 4). As roentgenograms made with the child in the harness are difficult to interpret, we prefer to make a 45-degree abduction (frog-leg lateral) roentgenogram of the hips out of the harness to confirm their position at the three-week visit. Furthermore, evaluation of acetabular development is easier when roentgenograms are made with the child out of the harness. A roentgenogram in the harness produces an outlet view of the pelvis because of the loss of lumbar lordosis and pelvic tilt (Figs. 5-A and 5-B). If the treating physician is still in doubt as to the hip's position, arthrography under general anesthesia should be performed to confirm a concentric reduction (Fig. 4). If the femoral head is in the acetabulum, the patient is followed at two to four-week intervals until the clinical and roentgenographic examinations are normal. Again, these should be performed with the patient out of the harness. Generally, we have weaned a child from the harness according to the plan of Ramsey et at.

The two major problems previously reported with the use of the Pavlik harness are failure to obtain reduction of the dislocated hip and vascular necrosis of the capital femoral epiphysis. Failure to obtain spontaneous reduction of the congenitally dislocated hip with the harness has occurred in 19 per cent of previously reported cases[1-7]. Pavlik reported a failure in reduction of 16 per cent, while others have reported a range of 2 to 92 per cent[1-7]. In the treatment of subluxation and acetabular dysplasia, however, good results have been reported in 98 per cent of the published series[2,4-6].

The most common problem was the failure to maintain reduction or to achieve spontaneous reduction of a dislocated hip. The treating orthopaedist did not observe the proper indications for the use of the Pavlik harness, and either applied the harness improperly or used a harness of poor quality construction, or both. The most common error was a failure to obtain enough hip flexion in the harness to achieve reduction (Tables I and II). Moreover, in most cases the orthopaedist failed to recognize the lack of reduction for an average of three and a half months after application of the harness. This delay, more than any other factor, probably accounted for the necessity of open reduction in six of the patients in this series and may be a contributing factor in the cases of avascular necrosis (Figs. 5-A and 5-B).

As noted in the literature, the incidence of avascular necrosis was higher when the harness was used to treat congenital dislocation of the hip rather than subluxation or acetabular dysplasia[5,8,9]. Pavlik, in treating 632 dislocated hips, reported an incidence of avascular necrosis of 2.8 per cent, although it only occured in hips requiring manual reduction after failure of spontaneous reduction in the harness. Tönnis reported a 15 per cent rate of avascular necrosis in a multicenter study of 4,046 hips[9]. Others have reported rates of 4 per cent[3], 5 per cent[7], and 9 per cent[10]. More recently, Kalamchi et al. have reported no incidence of avascular necrosis with use of the harness in the treatment of seventy-seven dislocated hips, 141 subluxated hips, and 105 hips with acetabular dysplasia.

In this series there were three patients with avascular necrosis (Table I). In these patients the failure of spontaneous reduction in the harness necessitated traction, closed reduction (one patient) or open reduction (two patients), and spica-cast application. Although it is difficult to incriminate any specific procedure, it seems likely that the avascular necrosis resulted from surgical intervention or the cast rather than the harness. However, as noted in the European literature[8,9], overly vigorous tightening of the abduction strap may result in avascular necrosis.

Although sufficient hip flexion in the harness to direct the femoral head toward the triradiate cartilage is necessary to achieve spontaneous reduction, excessive flexion may produce problems. In Case 16,

first the proper hip flexion achieved reduction and then excessive flexion produced an inferior (obturator) dislocation. Another problem noted with overly vigorous hip flexion was a transient femoral-nerve palsy (Case 1). This complication has been reported by others[4,6]. Hip flexion of more than 120 degrees should be maintained only for the two to three-week trial of spontaneous reduction. If reduction is obtained, the flexion is reduced to 90 to 100 degrees.

In two other patients the hip adductors remained contracted in spite of a well made harness and its proper use (Case 12 and 15). Adductor tenotomy was necessary before acetabular development could proceed. In hip dysplasia, the adductors usually have stretched in one to two weeks after application of the harness. If they remain tight at four to six weeks, percutaneous adductor tenotomy under general anesthesia and possibly an arthrogram may be necessary.

The final problem evident from this series was poor compliance of the parents in maintaining the harness on the child. In two cases (Cases 15 and 18) the parents discontinued use of the harness and refused further treatment. In four patients (Cases 2, 3, 11, and 13), another brace alternative was necessary because of poor acceptance by the parents. Better parental education by the orthopaedist as to the disease process being treated and the use of the harness might have obviated these difficulties.

CONCLUSIONS

The primary difficulty associated with the use of the Pavlik harness in this series was failure to achieve reduction of the dislocation. The orthopaedist must realize that merely applying the harness on the patient with congenital dislocation of the hip does not guarantee reduction of the hip. The important aspects in the use of the harness include: (1) appropriate indications, (2) adequate hip flexion in the harness as verified by roentgenograms, (3) use of a good-quality harness, (4) confirmation of concentric reduction after three weeks of harness use, (5) maintenance of the patient in the harness until a normal clinical and roentgenographic examination is achieved, and (6) education of the parents.

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Orthotic Management of Knee Injuries in Athletics with the Lenox Hill Orthosis

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INTRODUCTION

The knee is a complex structure and any structural change results in a lessened ability to withstand the stresses of athletic competition. The subsequent material is a brief discussion of knee instabilities secondary to injury and the role of a Lenox Hill Orthosis in compensating for any functional deficit. The various instabilities of the knee can be separated into four categories:

- Straight.
- Rotatory.
- Combined.
- Patellar.

Straight lateral or straight medial instability is demonstrated by widening of the joint space with varus or valgus stress exerted on the knee at full extension and in various degrees of flexion.

- The straight anterior and posterior instabilities are illustrated by the classic anterior-posterior drawer sign.
- The rotary instabilities involve abnormal motion about a rotary axis of the tibia in relation to the femur. These can be categorized as posterior/medial, antero/medial, antero/lateral, and posterior/lateral rotatory instabilities.
- Two or more of the above instabilities can and commonly do occur in the same knee, forming a combined instability.
- Lateral displacement of the patella from the patellar-femoral groove produces an instability that will not be a part of this discussion.

COMPONENTS OF KNEE STABILITY

The stabilizing components of the knee joints include bone, meniscii, muscles and ligaments.

Bone

The bony stability of the knee is derived from the shape of the femoral condyles and saucer shape of the tibial plateaus. The intercondylar emminence of the tibia and the slight concavity of the plateau when viewed in relation to the shape of the femoral condyles plays a role in controlling the amount of rotation possible within the joint, and with weight bearing this produces some straight medial-lateral and anterior-posterior stability.

Meniscii

Meniscii additionally add to stability within the knee. The saucer shape and the ligamentous attachments allow the miniscii to move with flexion of the knee, filling the peripheral space created by the spherical configuration of the femoral condyles. The function of the meniscii include shock absorption, lubrication, reduction of contact stress and transmission of loads across the joint. The increased concavity of the plateau and the wedge effect of the moving meniscii contribute to the stability of the joint.

Muscle

The quadriceps muscle group has a function as an important dynamic stabilizer of the knee. Its primary function is extension of the tibia in relation to the femur, but it also acts as an antagonist against flexion stresses created by the hamstrings. The quadriceps also influence the anteromedial and lateral joint capsule stability.

Flexion of the tibia on the femur dynamically is a function of the hamstring muscles. Additionally the semitendonosis, gracilis, and sartorius sweep around the medial side of the upper tibia to attach anteriorly giving additional stability against rotatory and anteroposterior stresses. The biceps femoris tendon has a similar function of dynamic lateral stability.

Ligaments

The knee is enclosed in a capsule which is reinforced by ligaments. The static stability of the knee joint depends upon the integrity of the supporting ligaments of the knee.

Collateral Ligaments—The lateral collateral ligament originates from the femoral condyle and inserts into the fibular head acting as a stabilizer against varus stresses. Additionally, the iliotibial tract laterally protects against varus stress and anterolateral rotatory instability. The medial collateral ligament consists of two layers, the deep fibers originate from the femoral condyle inserting into the upper tibial margin reinforcing the capsule and the peripheral attachment of the meniscus. The superficial fibers extend three inches below the upper tibial margin to the tibial flare stabilizing the knee medially against valgus stresses contributing to resistance against anteromedial rotatory stresses.

Cruciate Ligaments—The anterior cruciate ligament originates from the lateral femoral condyle and inserts into the tibia at the intercondylar notch anteriorly. The posterior cruciate ligament arises on the lateral side of the medial femoral condyle and inserts into the posterior surface of the tibia in the midline. Cruciate ligaments contribute to stability against anterior and posterior stresses as well as rotatory and medial-lateral stresses.

Ligamentous Injuries—Ligaments are fibrous structures that function in a manner to prevent abnormal motion of the joint. A ligamentous injury can vary from tearing of a few fibers and no loss of function to complete disruption of the structure. Forced motion beyond the normal limit in any direction of knee motion can result in some degree of injury. A common type of athletic injury to the knee occurs with the foot fixed to the ground and the thigh rotated inward, and the tibia outward, causing abduction and external rotation of the leg. The stress is exerted against the medial capsular structures as well as the collateral ligament and the anterior cruciate ligament. The resultant injury varies from mild to severe disruption of the supporting structures and includes injury to the medial collateral ligament both deep and superficial, medial meniscus and/or its attachment as well as the anterior cruciate ligament. The knee severely injured in this manner may be a candidate for surgery and subsequent rehabilitation. The category of injury and subsequent surgical procedure are dependent upon the degree and specific structural changes.

ORTHOTIC MANAGEMENT WITH THE LENOX HILL ORTHOSIS

At the Upstate Medical Center in Syracuse, the rehabilitation of the previously injured knee includes the use of a Lenox Hill Orthosis. The advantages of the Lenox Hill Orthosis are:

Post Injury: non-operatively treated patients are protected against recurrent stresses to the injured structures during subsequent athletic activities.

Post Operatively: The Lenox Hill Orthosis is used to provide increased static stability during rehabilitation and when returning to athletic activities.

Two methods are used at the Upstate Medical Center for fitting of the orthosis:

1. The positive mold for the Lenox Hill Orthosis is taken before surgery so the orthosis is ready for application on cast removal in six weeks.

2. The mold is taken during the first cast change two weeks post-operatively, and the orthosis prepared for application six weeks post-operatively. The latter method allows for some atrophy during surgery and cast management, and assures a closer fit at time of application.

The Lenox Hill Orthosis is worn throughout the rehabilitation program to allow motion necessary for rehabilitation exercises and for protection against stresses on the repaired ligaments. If athletic activity is allowed, the orthosis is worn up to one full year during the activity for protection against further injury.

The Lenox Hill system has been developed and designed to control the straight medial-lateral, anterior-posterior, rotatory and combinations of these instabilities. An understanding of the various designs available, and the location of the force pressures that resist deviation, will help prevent prescription uncertainty.

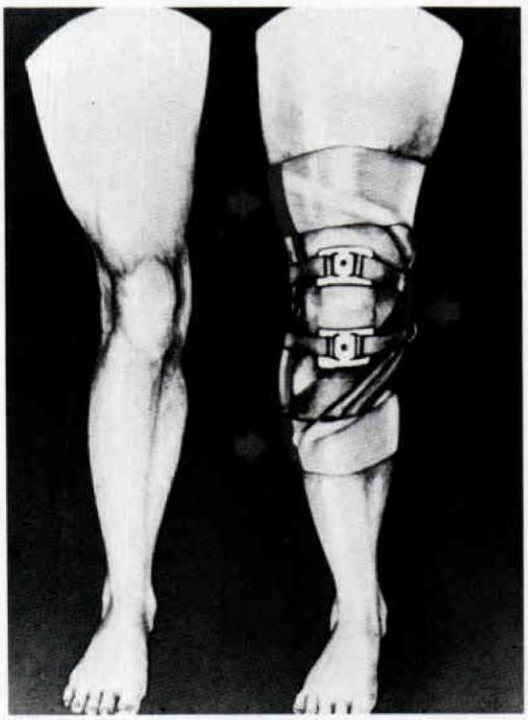


Fig. 1. Three point pressure system to resist valgus instability.

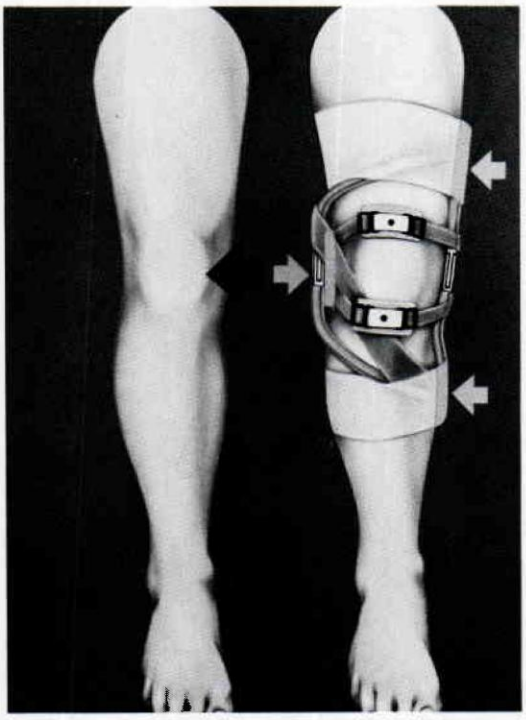


Fig. 2. Three point pressure system to resist varus instability.

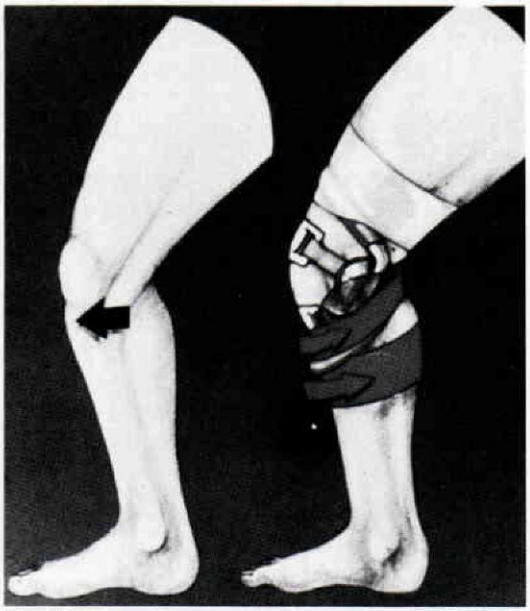


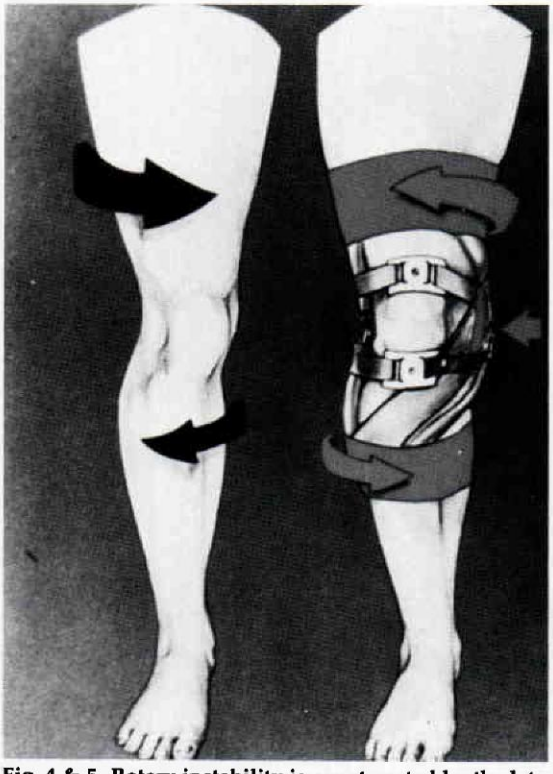
Fig. 3. Force system to prevent anterior-posterior instability includes the pre-tibial bar, distal knee loop and circumferential rubber. A hyperextension stop and non elastic popliteal strap are also used.

CONTROL OF STRAIGHT MEDIAL-LATERAL INJURIES

With the knee in full extension (Fig. 1.), the valgus deviation (medial instability) is resisted by the three point force of the Lenox Hill created by the lateral leg pads, above and below the knee, opposed by the medial knee disc. With the knee in full extension (Fig. 2.), the varus deviation (lateral instability) is resisted by the three point force created by the medial leg pads, above and below the knee, opposed by the lateral knee disc.

CONTROL OF STRAIGHT ANTERIOR-POSTERIOR INJURIES

With the knee in flexion (Fig. 3.), the anterior-posterior excursion of the tibia,



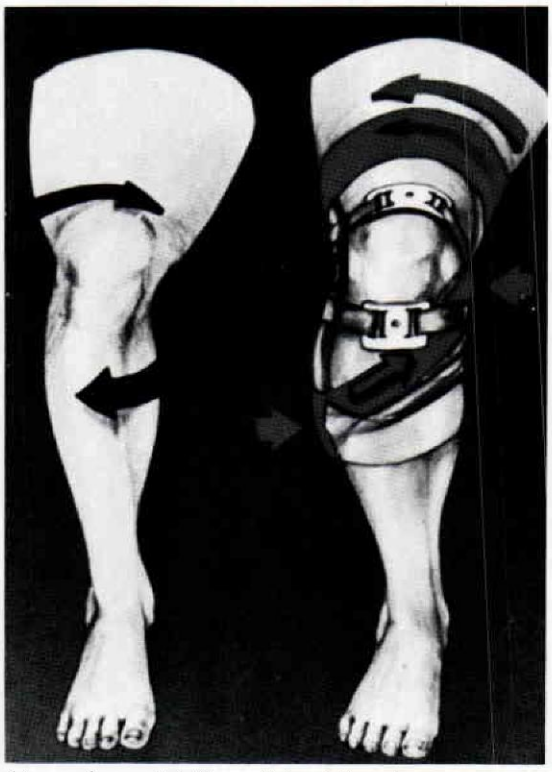


Fig. 4 & 5. Rotary instability is counteracted by the lateral leg pads, medial disc and derotation straps.

(anterior-posterior instability) is resisted by the Lenox Hill forces created by the pre-tibial bar, the derotation strap, the distal knee loop and the circumferential rubber, all opposed by the circumferential rubber above the knee. With anterior-posterior instability, a hyperextension stop at the joint, and a non-elastic popliteal strap to resist hyperextension is added to the Lenox Hill. In post-surgical application, the stop may be adjusted to limit the degree of extension.

CONTROL OF ROTATORY INJURIES

With the knee in full extension (Fig. 4.), the rotational deviation, (rotatory instability) is resisted by the contour and placement of the lateral leg pads and the medial knee disc, the circumferential rubber above and below the knee, and the derotation strap. With the knee in flexion (Fig. 5.), the anti-rotation resistance is augmented by the derotation strap.

CONTROL OF COMBINATION INJURIES

With the addition of the second below-the-knee leg pad, second derotation strap, and hyperextension stop, the Lenox Hill is designed to resist the combination antero-medial rotatory, antero-lateral rotatory, and antero-medial-lateral rotatory instabilities.

In the combined medial design (Fig. 6.), the knee disc is positioned on the medial side, with lateral leg pads above and below the knee, medial leg pad below the knee, and a hyperextension stop incorporated into the knee joints. This combination design is for primary antero-medial, lesser antero-lateral, rotatory instabilities.

The combined lateral design (Fig. 7.), the knee disc is positioned on the lateral side with medial leg pads above and below the knee, lateral leg pad below the knee, and a hyperextension stop incorporated into the knee joint. This combination design is for

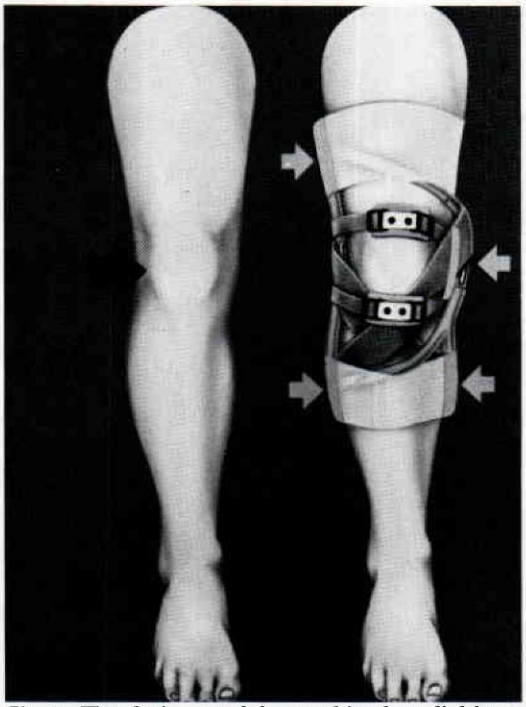


Fig. 6. The design used for combined medial knee injuries.

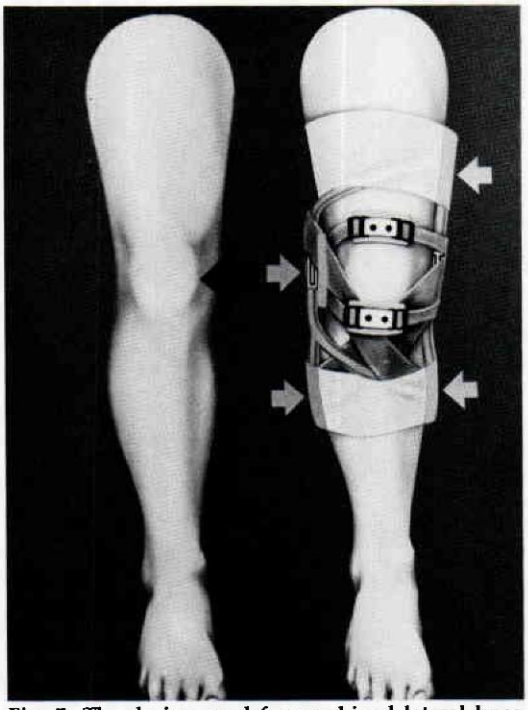


Fig. 7. The design used for combined lateral knee injuries.

primary antero-lateral, lesser antero-medial rotatory instabilities.

SUMMARY

At Upstate Medical Center, Syracuse, New York, the Lenox Hill Derotation Orthosis has been prescribed for athletic injuries to the knee since 1972. Its use post-injury and post-operatively has been consistently positive.

The Lenox Hill advantages are:

1. Individual design and custom fabrication insure intimate fit and proper application;

2. Simple measurement procedures with plaster mold and materials available to physician and orthotist;

3. Ample design choices and the ability to design the orthosis to resist specific instabilities.

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Mobility Aids and Prostheses For a Child with Four Anomalous Limbs

Karen Beck, R.P.T.
J. Martin Carlson, M.S., C.P.O.
Richard J. Johnson, M.D.

A child with a complex physical disability requires the involvement of many health care professionals. This review of the management of the prosthetic and mobility needs of an infant with four anomalous limbs underscores the need for full cooperation among all those team members.

SF was seven months old when first referred to Gillette Children's Hospital for an assessment of her developmental and orthopaedic needs. She came from a generally rural area over 400 miles from the hospital. Both of her upper extremities were absent at the shoulder except for fleshy nubbins approximately one inch long. Both femora, both fibulae, and the lateral two rays of both feet were also ab-

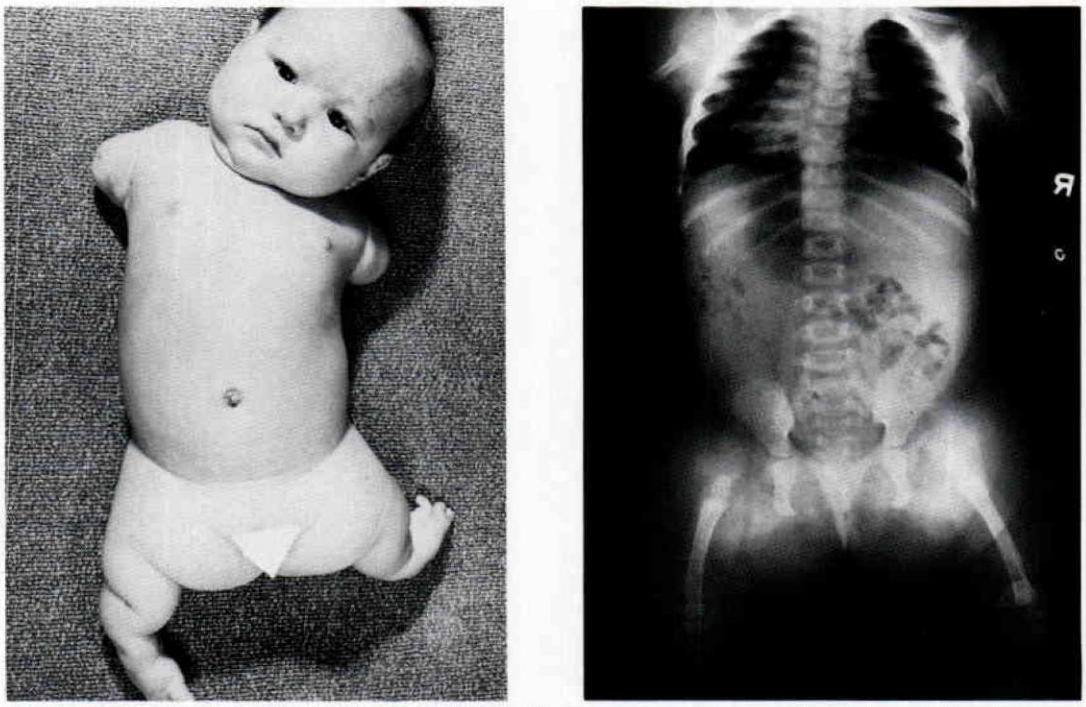

Fig. 1. Patient SF at seven months of age. Both upper limbs were missing except for fleshy nubbins about one inch long. Both femora, fibulae and the lateral rays of both feet were also absent.

sent (Figs. 1a and 1b). According to her medical chart, SF was delivered vaginally and her APGARS were ten at both one minute and five minutes. Her mother had been taking monthly prophylactic penicillin injections for rheumatic fever. No neurological or other medical problems were noted.

When SF was nine months old, a developmental assessment was done by a team consisting of a speech-language pathologist, an audiologist, an occupational therapist, a physical therapist, and a genetic counselor. At that time, her social intellectual and communication skills were considered to be within normal limits. She had good head control and rolled well, but was unable to sit independently. She attempted to manipulate toys with her tongue, her toes and her shoulders. Because of her inability to sit, she was provided with low posterior and lateral trunk support by a block of carved Ethafoam®[1] covered with Plastazote®[2]. An overhead bar was attached to the base from which to suspend toys, which she could then explore with her mouth (Fig. 2). She used this support at home until she acquired independent sitting balance, at approximately 12-14 months of age. No upper extremity prostheses were fabricated because they may have hindered her mobility and deprived her of sensory input.

SF was seen again when she was 16 months old. She manipulated toys with the toes of both feet, although she was more dextrous with the right. She also had learned to grasp objects quite successfully between her chin and shoulder on either side. Inasmuch as she had achieved sitting balance, she was considered a good candidate for an upper extremity limb so she was fitted with a left shoulder disarticulation prosthesis with a fixed elbow and passive hand. The passive hand was interchangeable with a passive hook. It was placed on the left to facilitate her using it in combination with her dextrous contralateral toes. An occupational therapist worked with SF in the use of her new limb daily for about one week and she began to use the prosthesis to push and pull objects that were positioned in the terminal devices for her.

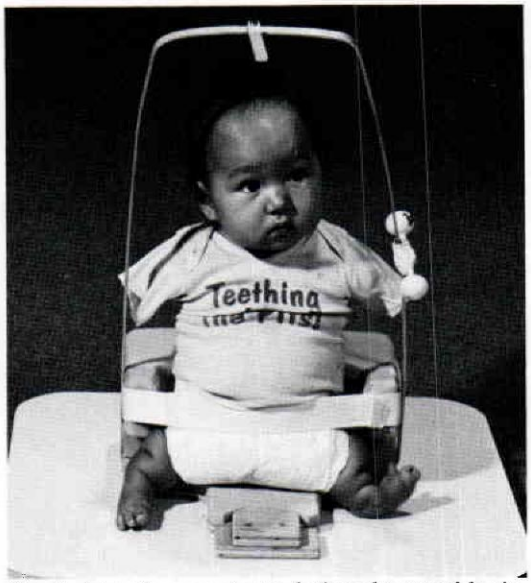

Fig. 2. A trunk support was designed to provide sitting balance at nine months of age. Toys were suspensed from the overhead bar so she could explore with her mouth.

Except for rolling, SF had not developed independent floor mobility at the age of 16 months. She made unsuccessful attempts to scoot while sitting by pulling on the floor or carpet with her toes. A special caster cart was fabricated for her, on which she could sit suspended several inches above the floor. The seat was very narrow so that her feet were directly below her trunk, and could be used effectively to propel and steer her "car" (Fig. 3). She became amazingly proficient in maneuvering it, going rapidly, stopping shortly and turning it within its own radius. The cart enabled her to be independently mobile on the floor while keeping her within reach of toys. It was still being used many hours a day when SF was 29 months old.

When SF was 23 months old, she was again admitted to the hospital for prosthetic work. The passive terminal devices were replaced with a cable-operated one. Because of a scarcity of physical or occupational therapy services in her community, training in the use of the new limb in the hospital was recommended, but it was impossible to arrange for that. Therefore, she did not make optimum use of this first cable-operated upper limb.

Fig. 3. At sixteen months of age a special caster cart was developed to allow independent mobility.

Fig. 4. At twenty-nine months of age a left above elbow prosthesis was provided along with lower limb extension prostheses.

When seen again at the age of 29 months, SF had begun to lift herself to stand at a chair or table and maintain that position by leaning her trunk against the supporting surface. She was fitted with short bilateral lower extremity extension prostheses to povide stability for stance, as seen in Figure 4. She was seen in the physical therapy department for training in their use. After approximately two weeks, she was able to walk five feet without external support or assistive devices and some times independently came to stance from a sitting position. It was anticipated that she would use them primarily for indoor mobility.

At the same time a left above-elbow prosthesis was fitted (Fig. 4). It had a passive constant friction elbow and wrist unit and a functional model 12P terminal device. An occupational therapist worked with her daily for three weeks, during which SF learned to use the prosthesis to manipulate pegs, formboards, pullstring toys and nesting boxes with some assistance. She also began to learn to position objects in the limb with the toes of her right foot, although the terminal device had to be prepositioned for her.

During the same hospital admission, an A–Bec Fireball®[3] powered wheelchair was made available for several days' trial. The control box was positioned within reach of SF's right lower extremity digits and it was "geared down" to its slowest speed. After approximately six 15-minute sessions of physical therapy, she mastered maneuvering it. If funding is approved for purchasing such a chair for SF, adaptations will be made to seat her securely and at the proper height to reach the control stick.

SF's mobility needs can be met by combining the use of the special caster cart, the lower extremity prostheses, and the powered wheelchair. There is considerable potential for SF to become proficient in the use of the lower extremity prostheses. They may become her primary means of indoor,

and even possibly outdoor mobility. In later years, she herself will have to decide if she wants to continue with them. At her young age, the caster cart provides her with speed and quick access to toys and peers on the floor. It has limited use outdoors because of the wear and tear on her feet and the relatively high energy needed to propel it. The powered wheelchair, however, would allow SF to move around freely in the community and place her high enough to interact with other persons. It would be most beneficial for movement in school when she reaches that age. At this time, the goal is to provide her enough mobility to experience social activities similar to those of other children her age.

A concentrated team effort was, and will continue to be, essential for managing SF's mobility and prosthetic needs. Choosing appropriate items and training SF in their use required input from physicians, physical and occupational therapists, prosthetists, engineers, orthotists, nurses, social workers and family members. SF's daily needs, developmental abilities and family circumstances, as well as her orthopaedic status, influenced the decision making. Creative thinking and cooperative efforts enabled this seriously physically handicapped child to achieve some degree of age-appropriate mobility and independence.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the significant contributions to SF's care and management made by her family, Robert Fielden, M.D., David Lawson, Rehabilitation Engineer, Rebecca Lucas, RPT, Michael Pearl, CPO, Kama Norton, BUS, Social Worker, Susan Swanson, OTR, and David Wilkie, Adaptive Equipment Specialist. The photography is by Ken Jandl. This project was partially funded by the Medical Education and Research Association of Gillette Children's Hospital.

NOTES

[1]Dow Chemical, Midland, Michigan.
[2]Apex Foot Products Corp., 200-T Forest Avenue, Englewood, New Jersey.
[3]A-Bec Electric Wheelchairs, Inc., 20803 Higgins Court, Torrance California 90501.

Principles of Design For Lower Limb Orthotics

Andre Bahler

INTRODUCTION

When designing an orthosis, care should be given to the principle that the still existing motions must not be restricted more than is necessary and that the patient is secure. The position of the orthotic joint axes will have to be chosen in such a way that they match the body axes as perfectly as possible. At each joint which does not coincide with the natural joint, new "shear stresses" will appear which are contrary to the natural motion and therefore limit it.

FRONTAL PLANE CONSIDERATIONS

The cornerstone of every lower limb orthosis is, of course, the foot section; when designing this part it is of vital importance that the basic static laws are respected and to make full use of all available possibilities. A house cannot be built on an unstable foundation. The foot section alone, through its shape and through its structure greatly determines the statics. In Anglo-Saxon countries the foot part is often attached onto the outside of the shoe. In Central Europe it is customary to integrate the foot part in the shoe. Both solutions present advantages and disadvantages.

When the orthosis is attached to the shoe the effective positioning of the stop is especially difficult and cosmesis is compromised. The built-in sandal requires space-causing problems with the shoe size. In general, the foot part which is independent of the shoe has the advantage of offering more possibilities and clearer proportions in regards to the entire orthosis.

Basically, the same fabrication principles apply to both designs of foot sections. The point of reference for the fabrication of an orthosis is a level flat surface. The shoe and the foot support have to form a unity with the level floor, i.e. the support in the shoe and the shoe on the floor have to have a solid base, so the patient gains a feeling of stability. It is of secondary importance whether the foot is in pronation, supination or a neutral position. The necessary balance, whatever its extent, can be adjusted. In the end, the support and the shoe have to conform to the floor.

The length and cut of the support are very important. A low lateral trim gives less hold on the outside. Depending on the status, the tip of the support will be trimmed straight or, in order to avoid an outside tilt, a slight detorsion cut may be used.

CONTROL OF THE HEEL

The positive model should be of the natural heel when the weight of the body is on it. Because the foot of a patient is usually molded with the weight off of it, the heel

must be slightly flattened on the plaster positive model. The plaster is added to the side to give the calcaneus enough room. In the case of a correcting heel wedge, it is important that this should be in the shape of a flat surface and must not be left round. To leave a roundness would mean to invalidate the correction, because the heel would be left unstable and could slide back into the original position.

below the ankle. Should the support be kept too medially the patient will always tilt towards the outside.

This correctional position is a great help in holding the foot. The displacement of the support toward the outside will have a greater correctional effect than any pronation wedge can. If these rules are applied carefully when aligning pronation and supination, pressure symptoms will be

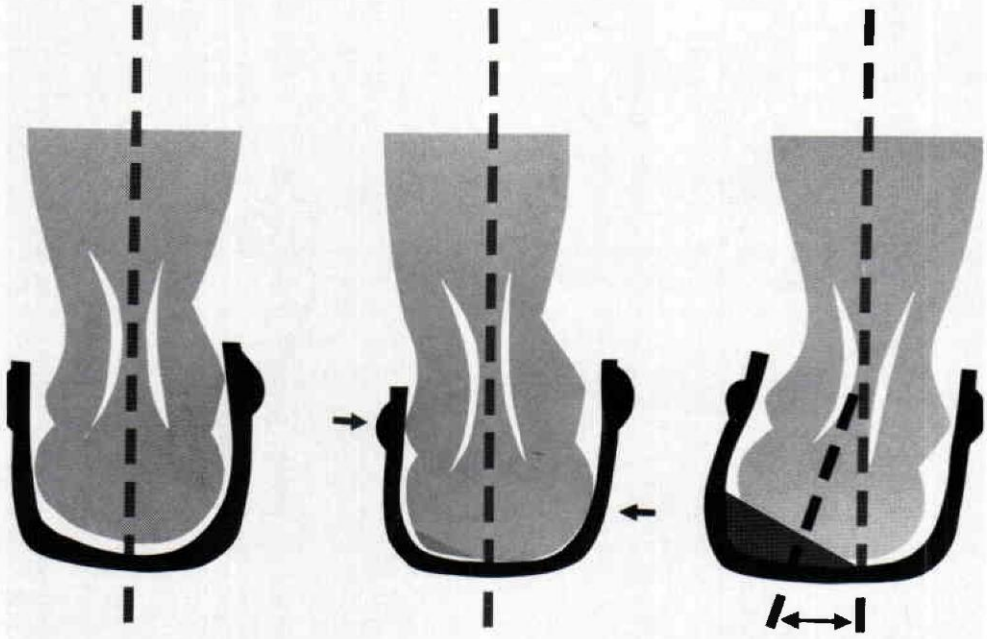

Fig. 1. Left: Alignment of the foot section. If foot correction is possible, the foot and the foot section of the orthosis should be centered under the plumb line center of the leg. Center: A varus deformity cannot be accommodated or corrected if the foot section is centered under the leg; instead laterally align the foot section and add a wedge with a flat surface.

ALIGNMENT OF THE FOOT SECTION

A strategic point in the construction of the foot section is the lateral positioning of the support in relationship to the ankle. If it is possible to correct the foot actively or passively and to set it back into the neutral position then it is indispensable that the plumb line of the leg and of the orthosis coincide with the plumb line of the foot part (Fig.1). Since this is not always possible when dealing with a pes varus, laterally align the support. In the case of a pes valgus the support remains straight and avoided on the foot. When pressure symptoms appear on the outside or the inside of the ankle after fitting the orthosis, the principle of the structure has to be checked over. In the case of pes valgus a support having been set too much on the outside leads to an unintentional bend which invalidates every internal correction.

The angle of the toe out depends on standing and walking alignment of the patient. The joints should, if at all possible, lie on the sagittal plane; no matter what the outward turning of the foot is, this contributes to a lessening of the energy con-

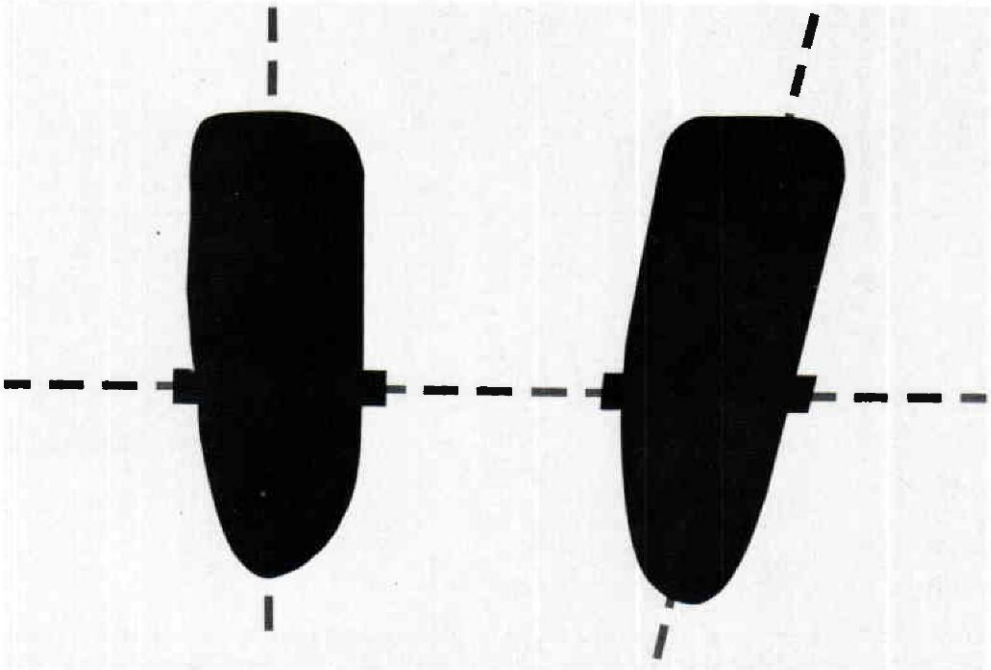

Fig. 2. No matter what the amount of toe out is, the ankle joint should be aligned in the sagittal plane in order to decrease energy consumption and wear on the orthotic joints.

sumption during walking and the wear of the brace (Fig.2).

THE KNEE

To correct a valgus knee or a varus knee, correctional forces above and below the knee must be applied. The positioning of the counter pressures on the hip and below the knee is also very important (Fig.3). Overcorrection of a valgus knee or a varus knee *limits* the extension of the leg. In the case of valgus knee, an over-correction results in flexion; a decision must be made between a full correction and the freedom of movement. The following could be used as a rule of thumb: if the patient is a child, choose correction; if he is an adult, choose movement.

THE HIP AND THIGH

The main principle to be retained for the hip and thigh is: avoid any free-play between the orthosis and the leg. In other words, do not allow the leg to move inside the orthosis. This is absolutely detrimental to the security and the sure footing of the patient.

The weaker the muscles of the hip joint, the tighter the orthosis must be fitted above the knee. With a weak gluteus medius, the use of an above-knee encasing is recommended. The result will be immediate in that the patient will walk with a surer step. If pistoning is allowed, at each movement it will cause great discomfort and possibly result in an open sore. Girdles may be of varied shape and construction. Each girdle will have to be made individually to suit the patient and the treatment.

SAGITTAL PLANE CONSIDERATIONS

The above-knee prosthesis is a mechanical substitute for the leg and the same mechanical principles apply for knee ankle foot orthoses. When in a free erect position, the torso is upheld by the legs in such a way that the body's center of gravity is in a stable balance. A healthy person does this

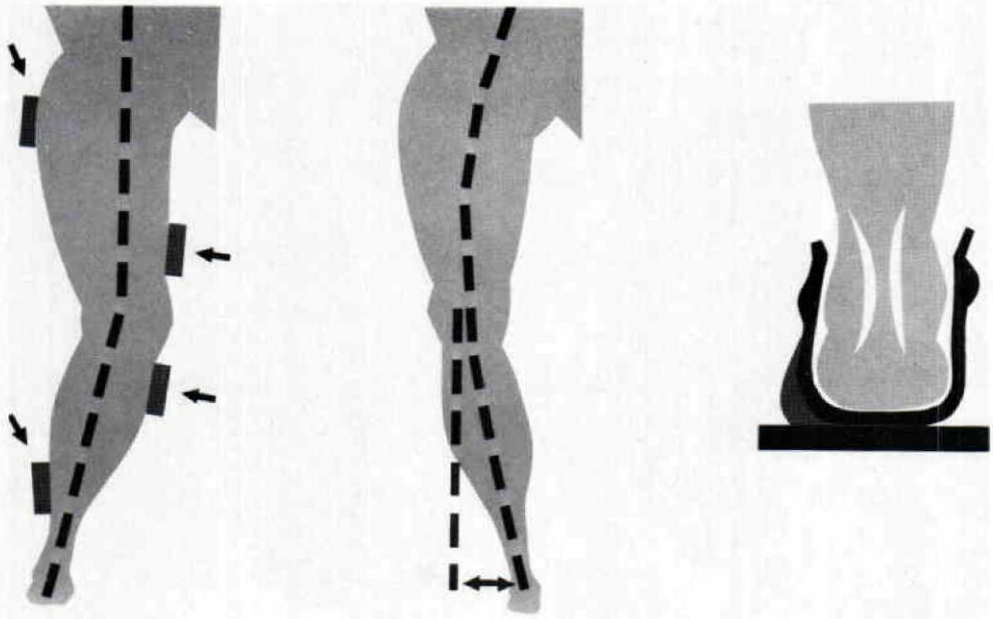

Fig. 3. Left: Correctional forces applied for valgus knee correction. Center: Forces emanating from the foot section should be placed as laterally as possible to control Genu Varum. Right: A lateral flare added to the foot section will help to diminish varus forces at the knee.

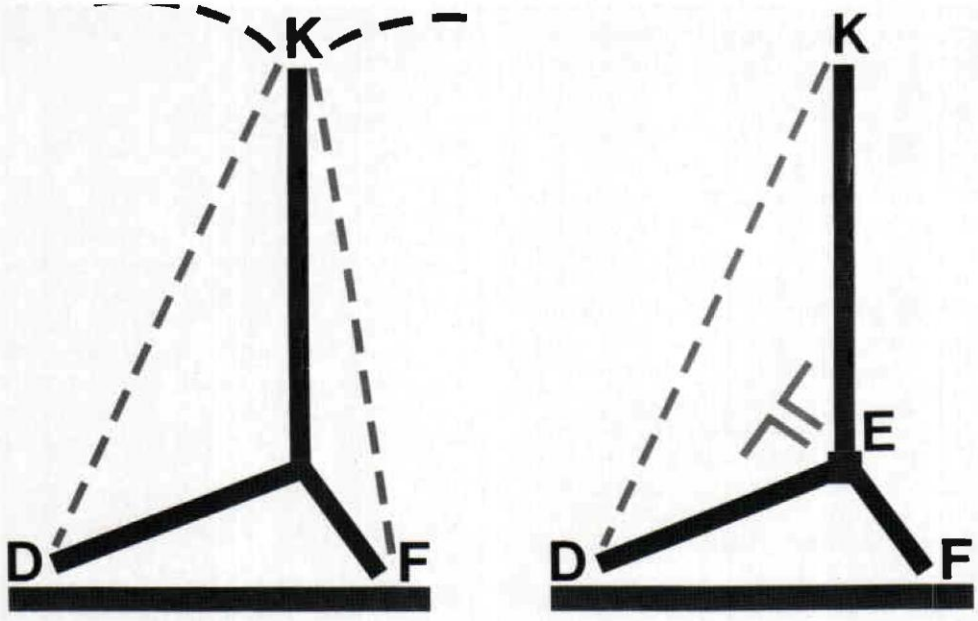

Fig. 4. Statics of the standing position. Left: If the ankle is locked completely, there are essentially two physical bars present, designated by the dotted lines K-D and K-F. The center of gravity must rise if bar K is moved in either direction. Left: If only one direction of fall is blocked there are again two physical bars, K-D and K-E Bar K-E is unstable if a clockwise rotation occurs. This simulates the mechanics of a dorsiflexion stop ankle foot orthosis, which is adequate for knee stabilization with patients having slight to medium quadriceps paralysis and an intact iliopsoas and gluteus maximus.

both actively and passively. Active stabilizing is caused by the muscles; the paralyzed patient either cannot perform or can partially perform this stabilization. The ligaments take care of the passive stabilization by preventing a bending of the joint in certain directions which limits the keeping of a firm stance to only one position, but saves energy. Of all true mammals, man is the only one to possess such a safety device and he is therefore the only one to be able to stand erect such a long time.

Only the passive stabilization functions can be reinforced by orthoses because the muscular system is not intact; this is where the hinge-joints with their stopping mechanism come into play.

THE STATICS OF THE STANDING POSITION

A body is in equilibrium when the plumb line emerging from the center of gravity of the body runs through the base of support. The equilibrium remains if the center of gravity raises when the body changes position; it is unsteady if the center remains in place, or lowers.

If a bar is balanced vertically it is unstable and will remain so if weight is applied to it. If an angular lever is added in the shape of a foot then the bar is stabilized. Physically speaking, there is not a branching bar but two straight ones, the mechanical axes, running from K to D and from K to F, respectively. Now if a hinge is placed on E, then there is again one single bar, K-E, which is in an unsteady equilibrum. But if one direction of fall is blocked there is again in the presence of two physical bars, one in the blocked direction K-D, the other in the unblocked direction K-E. This leads us to the following conclusions:

1. If one joint is blocked then the two adjacent limbs can be considered as one unity. The limbs form a rigid lever whose mechanical importance lies in the line connecting the two free ends. This line corresponds to the shared mechanical longitudinal axis of both limbs which incidentally does not match the anatomical longitudinal axis.

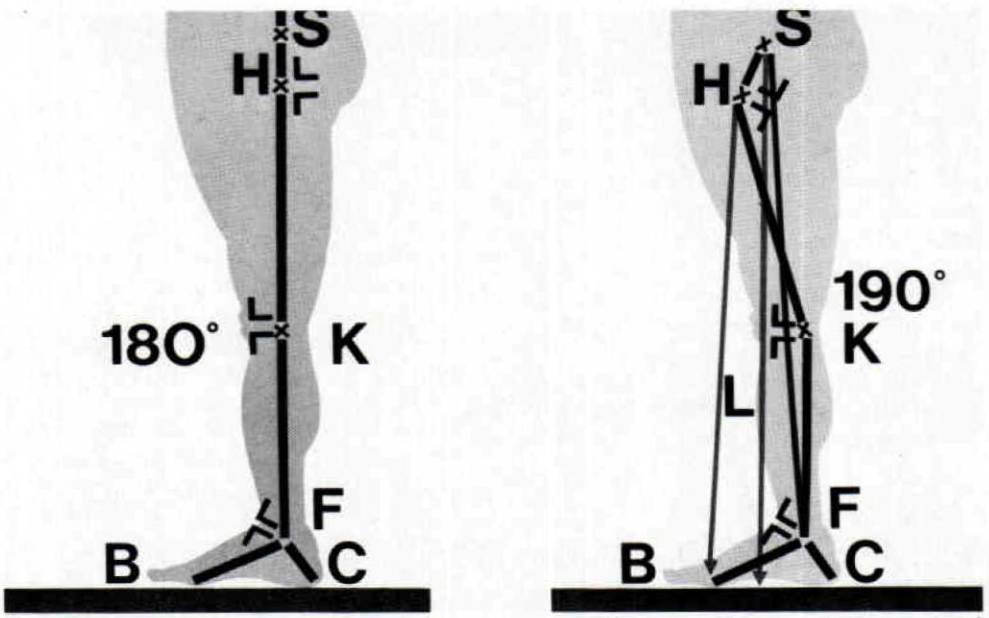

Fig. 5. Mechanics of a KAFO with a dorsiflexion stop and different knee joints. Left: Conventional KAFO knee alignment. This alignment should be used when little or no iliopsoas and gluteus maximus are present. The orthotic knee joint can be used when good hip control is present. The posterior position of the orthotic knee joint, combined with a lengthened foot support, can stabilize the knee without a lock.

2. For all static and dynamic studies only the mechanical axes are of importance.

Applying these conclusions to orthotics allows the use of a light ankle foot orthosis with a blocked dorsiflexion stop on patients having only slight to medium paralysis of the quadriceps and an intact iliopsoas and gluteus maximus. If a locked knee joint becomes necessary because of the degree of paralysis, the dorsiflexion stop must be reduced considerably because the knee and foot movements should not be blocked at the same time.

The mechanics of a KAFO with dorsiflexion stop and offset knee joints will now be described. The further back the knee joint is placed, the greater the stability (Fig. 5). In order for the altered position of the knee joint of the orthosis to show any results, the orthosis has to be fitted perfectly; if this is not the case, the upward sliding of the orthosis will cause friction and render the effect negative.

The angle of the dorsiflexion stop has a very important stretching function; experience has shown that the angle, making allowance for the heel height, should never exceed 90 degrees. Should the angle of the dorsiflexion stop be more than 90 degrees, the knee will be hyperextended and the patient will have trouble rolling his foot properly.

In order to increase stabilization of the knee, do not extend the angle of the dorsiflexion stop but *lengthen* the foot support. The exact structure and the choice of a dorsiflexion stop have to be determined and mounted on the patient while he is standing. He should stand as straight as possible, wearing the orthosis and shoes, keeping his feet parallel and the toes aligned; in this position the stop should be fixed without play and pressure.

PREREQUISITES FOR THE APPROPRIATENESS OF SUCH AN ORTHOSIS

- The affected leg should show no contractures at the hip and the knee-joint. The patient should be able to stretch the knee-joint passively without problems.
- The iiopsoas and the gluteus maximus should not be too weak. In any case, the patient must be able to move the knee joint back and forth actively and easily while in a standing position.
- The patient, especially children, must be willing to get used to the orthosis and practice a certain walking discipline.

The remaining muscle tone of the quadriceps does not play an important role, while a well-calculated dorsiflexion stop and the length of the foot support are of decisive importance. Assuming that the adjustment of the plantarflexion stop is common knowledge, it should be remembered that the stop, in the case of a drop foot, hinders the stretching of the knee and may even have a knee-bending effect when the heel is ready to strike the floor. For this reason one should opt for a soft

Fig. 6. Knee joint used in Switzerland extends the knee and provides stability by using an offset alignment. A spring extension mechanism and optional knee lock are incorporated into the design.

plantarflexion stop, although this is not a very esthetic solution, since a bulkier ankle joint is required.

Since the patient wearing an orthosis with an offset knee joint has some trouble moving his lower leg forward, it is often necessary to insert a spring extension mechanism into the knee joint which may also be hade to serve to stabilize the knee.

For about twenty years a knee-lock has been used in Switzerland which both stretches the knee and may be locked (Fig. 6). The patient feels more secure and the joint facilitates the forward motion of the lower leg. No system, even under the most favorable conditions, can replace the quadriceps. Although by making small improvements here and there, the patient's comfort and appearance can be improved.

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The Orthoglas Transparent Test Socket—An Old Idea, A New Technology

Alvin C. Pike, C.P.
Lynnette K. Black, R.T.(P)

INTRODUCTION

A comfortable functional fit of the socket in a prosthesis is the first, and most important, aspect of prosthetic fitting. A great amount of ingenuity and effort have gone into methods to ensure an excellent socket fit, including special casting procedures and devices, modification techniques, socket materials and padding, and the use of test sockets. Test socket procedures, frequently called "check sockets" have been used and taught for over forty years, but without the advantage of transparency. Materials such as wax, plaster bandage and a variety of resins have been used.

In his presentation to the Minnesota Physiatric Association in May, 1982, Frank Zondlo, M.D., stated that the benefits of using the TTS far outweighed the additional cost. If a lower extremity amputee is prevented from returning to a normal, productive life due to an ill-fitting socket, the cost to society can be substantial. As an above knee amputee and a resident physician in Physical Medicine and Rehabilitation at the University of Minnesota, Dr. Zondlo has had first hand experience with Transparent Test Sockets. He believes the TTS provides a more objective way of determining proper socket fit by allowing the prosthetist to see what is happening inside the socket during both static weight bearing and dynamic alignment.

USE OF TEST SOCKETS

Prosthetists throughout the country who have been using TTS, have begun to develop criteria to "read" the tissue within the socket. Primary criterion so far is to achieve a slight, uniform blanching over the entire residual limb. Excessive pressure may be indicated by a very white blanching. It can be relieved by giving the area more space or by increasing the pressure around the area. Lack of total contact is indicated by a reddish tinge (erythema) and if excessive, some bluing (Fig. 1-7). Various materials (alginate, pour-a-pad, etc.) can be injected into the socket and allowed to migrate during weight bearing to fill voids and assure total contact. Pressure sensitive areas can be located by probing with a corset stay or by probing through holes drilled into the test socket.

ADVANTAGES

The advantages of any type of test socket are as follows:

- Socket fit can be evaluated and minor changes be made without ruining the final socket.
- Major changes can be noted and made on the positive plaster model. In some

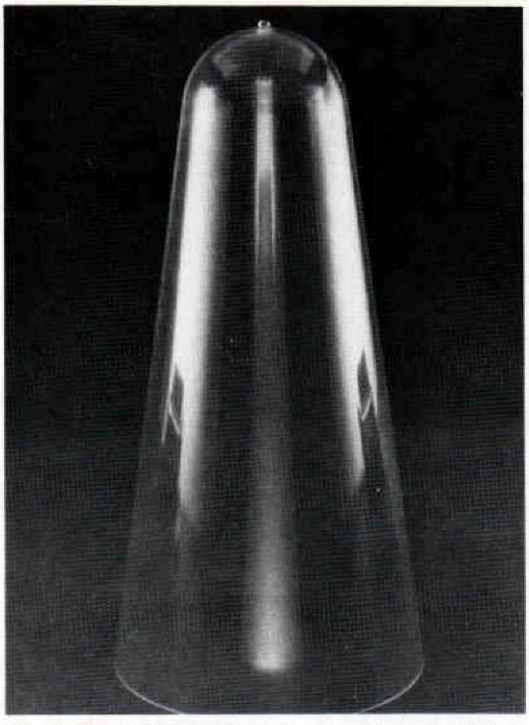


Fig. 1. The Orthoglas Cone is an acrylic material that comes preformed in a cone shape for vacuum forming.

cases, these can also be made on the test socket.

- If the test socket is attached to the other components of the prosthesis, socket fit can also be evaluated during walking.
- Since the test socket will be discarded anyway, the prosthetist is more likely to make adjustments, sometimes on a trial and error basis, to improve the fit.

DISADVANTAGES

Although test sockets have many advantages, they are not used by many practitioners who consider the following items to be disadvantages to using them:

- Socket fit does not seem to be a problem with most patients, so test sockets are not necessary.
- Test sockets are costly in time and money, requiring an extra patient appointment and the fabrication of an additional socket, often using expensive materials and requiring special equipment.
- The effect of test sockets is diminished when prosthetic socks are worn by the patient, as actual skin contact cannot be seen.

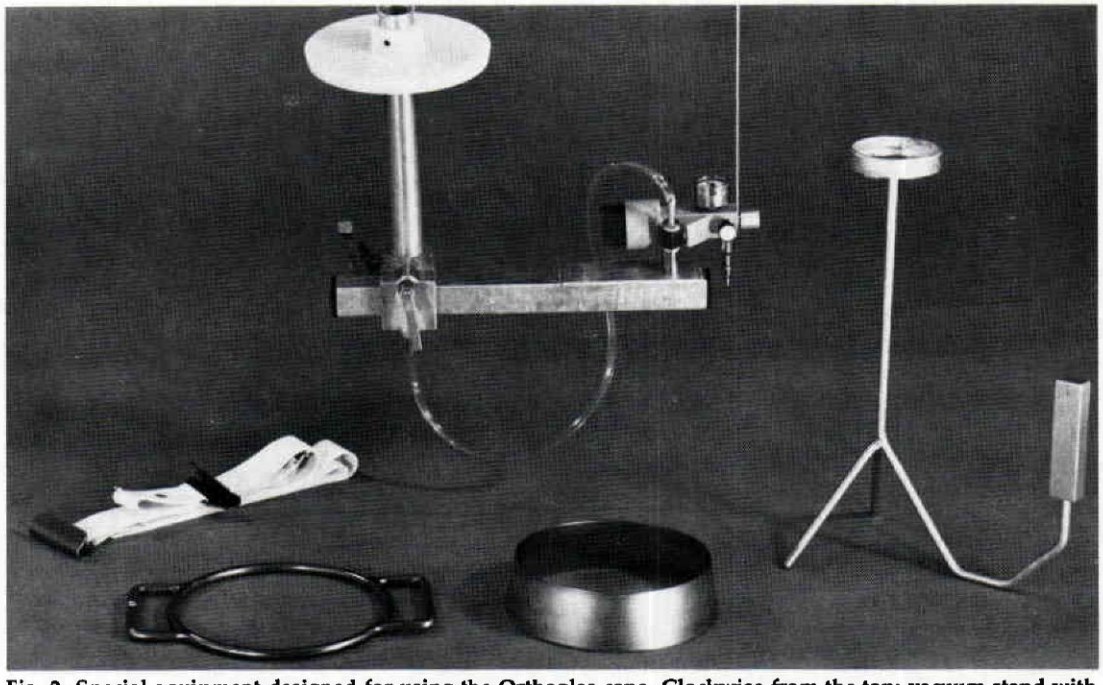


Fig. 2. Special equipment designed for using the Orthoglas cone. Clockwise from the top: vacuum stand with Delrin Ring, oven stand for the Orthoglas Cone, inner and outer rings, and foot strap.

• A test socket is not effective unless the patient walks while wearing it. Many test sockets are used statically and the effect of walking forces cannot be determined.

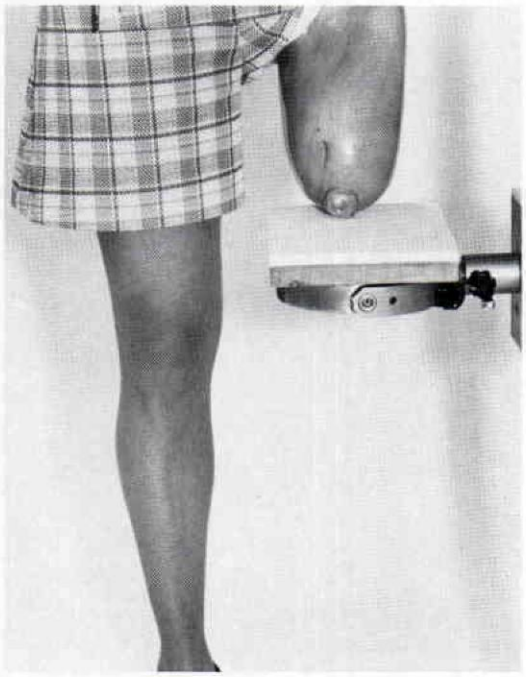
METHOD

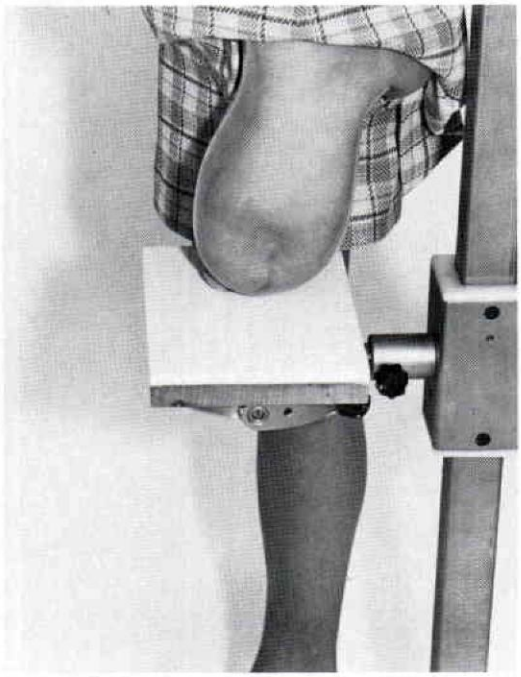
A new, simplified technology has been developed for fabricating the transparent test socket. It is a thermoplastic, acrylic material called ORTHOGLAS* and it comes in the shape of a cone rather than a flat sheet. Compared to plastic sheet material, the cone shape is more advantageous for vacuum forming prosthetic sockets. There is no time wasted measuring and cutting sheet material to size and there is less material waste. The cone retains a more uniform wall thickness during heating and forming (Fig. 8).

The ORTHOGLAS Cone has several time-saving properties. It is ready to use; no curing or drying is necessary. It can be vacuum formed over a wet or dry plaster cast. ORTHOGLAS is thermoplastic so it

Fig. 3. Vacuum forming a transparent test socket.

*Available from Otto Bock Orthopedic Industries





Figs. 4-A & 4-B. Using an Orthoglas TTS to evaluate the fit of an Above Knee suction socket.

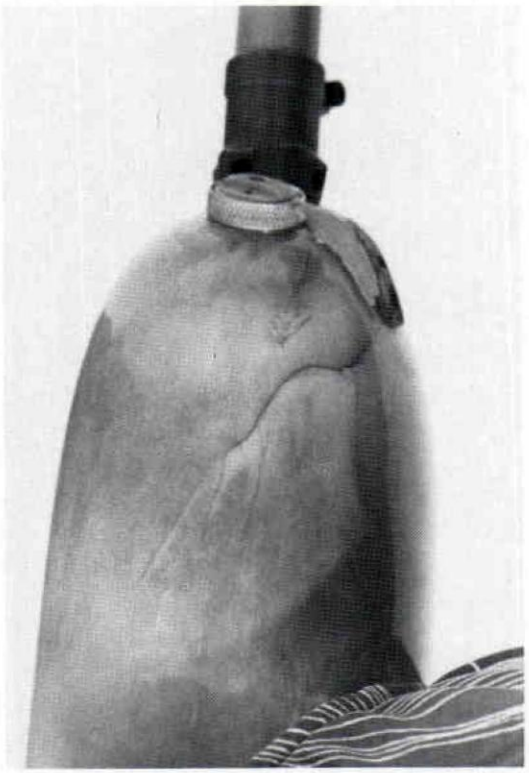


Fig. 5. The Orthoglas TTS is used for dynamic alignment by bonding it to a pylon with acrylic putty.

can be heated and reshaped for minor modifications.

Special tools were designed to ease the vacuum forming process. An inner ring and an outer ring* with handles are placed around the base of the ORTHOGLAS Cone. The Cone with rings is placed on a stand in an air-circulating oven at 190°C (375°F) for approximately ten minutes. The plaster model with a standard water pipe is placed into a vacuum pipe with delrin disk which is connected to the vacuum system (Fig. 9).

After ten minutes, or when the ORTHOGLAS Cone is milky white and slightly concave at the top, it is taken out of the oven and pulled over the plaster model. The base of the Cone will conform to the delrin disk creating a vacuum seal. Vacuum is applied and after the Cone has formed to the plaster model and cooled, it can be trimmed and finished using conventional grinding and polishing tools (Fig. 10).

Once all fitting evaluations and any needed corrections have been made to the transparent test socket during both static weight bearing and dynamic alignment, the definitive prosthesis can be made. Another significant advantage of ORTHOGLAS is that all acrylic resins, acrylic putties and polyurethane foams will bond to it without special surface preparation. Instead of laminating an inner socket, one can be vacuum formed much faster with an ORTHOGLAS Cone. Properly reinforced with an exterior lamination of ORTHOCRYL Resin, the ORTHOGLAS Cone can be used as the inner socket in the definitive prosthesis.

Patient responses to TTS fittings are very favorable, opening better lines of communication between the amputee and prosthetist. The amputee takes a more active role in the fitting and has more understanding of the complexity of prosthetic fit as well as the importance of accurate communication.

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Hip, Knee, Ankle Foot Orthosis: Lateral Bar Design With Spring Extension Assist Hip Joints

James Brown, C.P.O.A.
Gerald Tindall, C.P.O.
Robert Nitschke, C.P.
Peter Haake, M.D.
Kenneth V. Jackman, M.D.

INTRODUCTION

The lateral bar, hip, knee and ankle foot orthosis (HKAFO) was developed for patients who need an orthosis beyond the Parapodium, developed by W. M. Motlock, at the Ontario Crippled Children's Center, Toronto, Canada. This orthosis has been successfully used for patients with muscular dystrophy, spina bifida, cerebral palsy and traumatic injuries resulting in parapareses or paraplegia. Variations in design and materials have made it possible to fabricate orthoses for a broad age group of patients with neuromuscular involvement. In the case of spina bifida, the patient who graduates to the HKAFO from a Parapodium will sacrifice the free standing feature of the Parapodium, but may gain the opportunity to ambulate with a reciprocating or swing-type gait (Fig. 1).

As many of our patients approach adolescence, they express the desire to become independent; an orthosis that is cosmetically acceptable is of great importance. Acceptance of the orthosis is made easier because the orthosis can be covered, and the patient can function with new freedom. In the treatment of many patients, the need to control knee, ankle and hip contractures

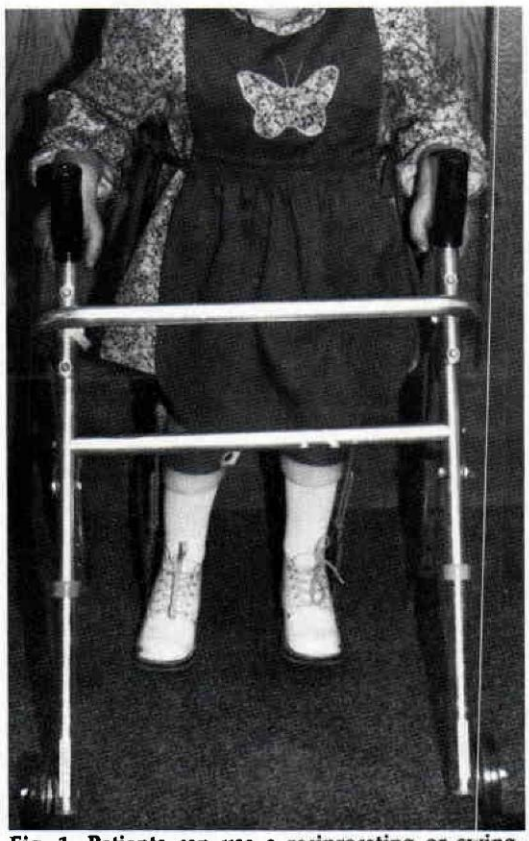

Fig. 1. Patients can use a reciprocating or swing-through gait with the orthosis.

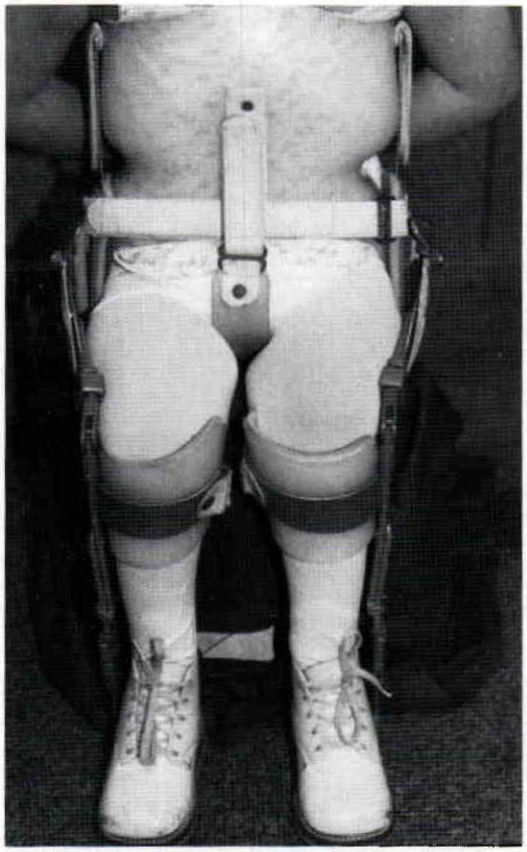

Fig. 2. A body jacket or anterior shell is used when an exaggerated lumbar curve and a forward lean are present.

to facilitate future ambulation is an ever-present challenge. This orthosis, with a three-point force design, maintains a neutral knee, ankle, and hip, once contractures have been reduced by physical therapy or surgery. When hips are so contracted that an exaggerated lumbar curve is visible and a forward lean is present, a body jacket or an anterior thoracic abdominal shell or a pad may be used to create a counter force (Fig. 2).

In the past, double upright orthoses with knee pad design were made of aluminum (Fig. 3). These orthoses were not only bulky, but functionally they fell short of accomplishing independence for the average patient. The breakage rate was very high, resulting in the device spending more time in the lab than on the patient. The breakage problem has been reduced with the use of stainless steel for strength and polypropylene for flexibility.

The beneficial features of the Parapodium were not present in the standard double upright with knee pads and pelvic band. The foremost accomplishment in the design of the HKAFO was to maintain the three-point force system as in the Parapodium (Figs. 4A, 4B). The conventional double upright with pelvic band offers very little in functional design. In the past, a hip joint that unlocked easily and would release even when the patient exerted force on it by leaning forward was not available. The hip joint designed for the HKAFO is fabricated with a spring that can be varied in size and strength. It is possible to vary the tension of the spring to achieve mild or forceful hip extension as well as a deterrent against contractures. This hip joint will also allow the young patient, who may be frightened to release the hips while standing, to lean back in the chair first and then release the hips.

Fig. 3. Conventional double upright designs are bulkier and have a higher incidence of breakage.

Fig. 4-A. The Parapodium uses a basic 3-point force system to stabilize the patient.

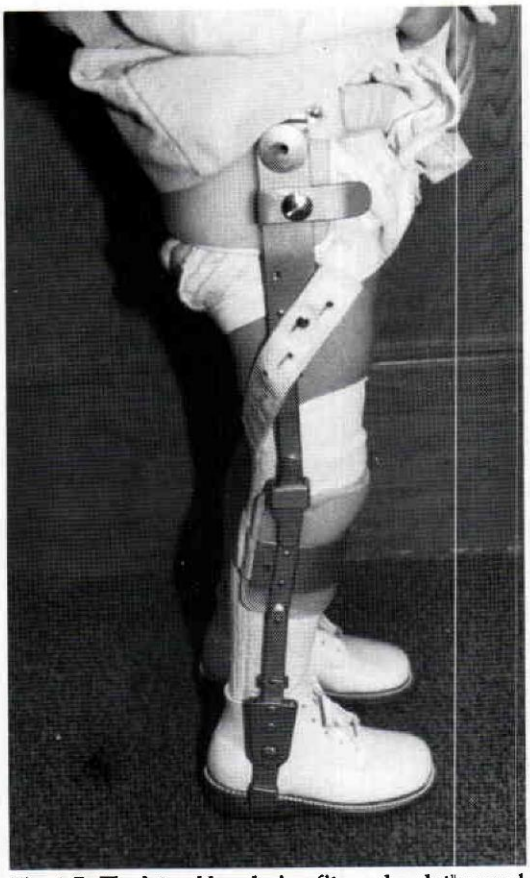

Fig. 4-B. The lateral bar design fits under clothes and uses the same 3-point forces employed in the parapodium.

DESCRIPTION OF COMPONENTS

Because of the disparity in age and other characteristics of the patients who are fitted with the lateral bar orthosis, each component of the orthosis is gauged in strength and size to the functional deficit of the patient, and to his age, weight and height. Components of each joint articulation, ankle, knee and hip are carefully chosen to use the patients' residual functions and to apply proper corrective or supportive forces where needed. For example, foot orthoses such as the UCB or arch support inserts are often used to achieve the most suitable ankle foot alignment, and to distribute weight over a larger supported area. If possible, the ankle and foot should achieve a neutral position. In cases of deformity, the UCB will distribute correcting forces by reducing the use of corrective straps (T straps) (Fig. 5). Ankle joint variations, limited, free motion, dual action or dorsiflexion assist are chosen as per anatomical and functional need.

The basic orthosis from the shoe proximal consists as follows: a caliper plate with lateral 90° stainless steel (SS) extension split stirrup with SS drop lock, which slides over the 90° SS extension. This achieves solid fixation to the caliper and eliminates use of straps to maintain stirrups in caliper.

The ankle joint (SS) is chosen as per functional deficit. There is an overlap of the ankle upright and lower knee joint, which is used for growth adjustments (not needed in adults).

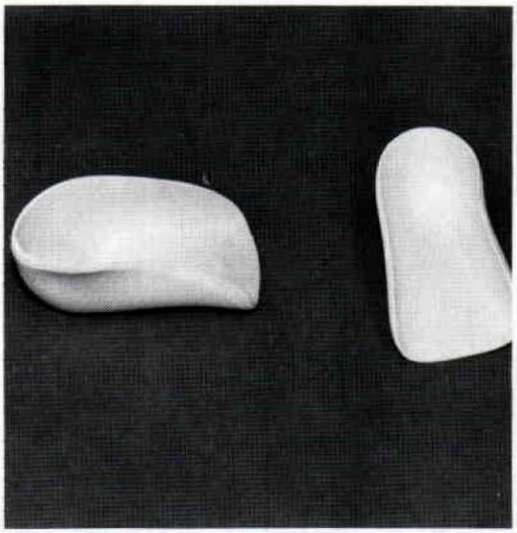

Fig. 5. The use of UCB shoe insert can oftern correct foot deformities without the need for corrective straps.

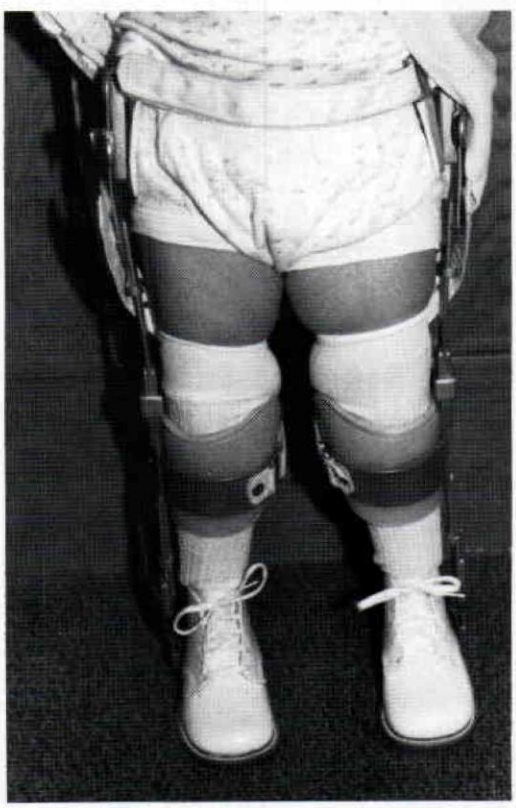

Fig. 6. Anterior view. Note the pretibial band of polypropylene reinforced with stainless steel.

KNEE JOINT DESIGN

Knee joints may be used with or without drop lock. The lock is not used when tension of the ankle joint and extension assist hip joint will maintain the knee in 180° upon weight bearing; this will allow the patient to ambulate with the free knee. A pre-tibial band is fabricated of polypropylene varying in thicknesses of $^{90}/_{1000}$", $^{1}/_{8}$", $^{3}/_{16}$", and $^{1}/_{4}$" (Fig. 6). Plastic is formed over the anterior medial lateral plaster splint of the knee. The lining is $^{1}/_{8}$" or $^{1}/_{4}$" Plastazote or Pelite. This band is reinforced with a stainless steel band anterior, shaped to the plastic and attached to the lateral knee joints. The thigh knee joint section overlaps with the hip joint to form growth adjustment.

Knee hyperextension is prevented by a popliteal strap (Fig. 7). This strap loosens when the patient sits because of its placement. When the patient stands, the strap tightens for posterior support during ambulation. The popliteal strap is positioned the same distance above the mechanical knee joint center as the distal attachment. A polyester 1" or 1½" strap crosses posterior from lateral calf to medial pre-tibial through a loop and back posterior to the knee support lateral upright, where it attaches to the truss stud or Velcro® loop. The medial attachment should be posterior to the vertical midline of the knee. Thigh enclosures are not needed. Foot, knee and pelvic band are aligned using a three-point force system. The advantages of this strap are increased sitting balance and comfort due to the lack of posterior thigh bands, and the reduction in number of adjustments due to growth. The orthosis eliminates forces on already taxed joints in the sitting position (Fig. 8). The advantages of an orthosis designed without thigh cuffs in consideration of the incontinent patient are obvious.

HIP JOINT DESIGN

Over the years, two types of hip joints have been used in fabricating these HKAFOs. The first was made with a chamber. The amount of extension would be

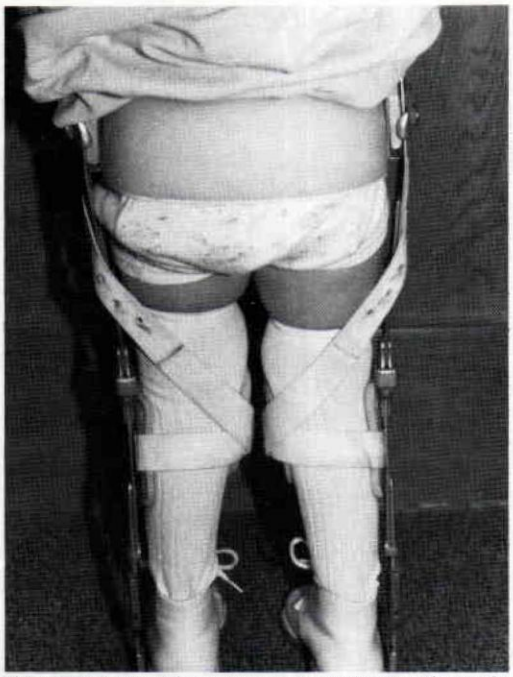

Fig. 7. Note that there are no posterior bands on the legs. A wide popliteal strap prevents hyperextension and loosens during sitting.

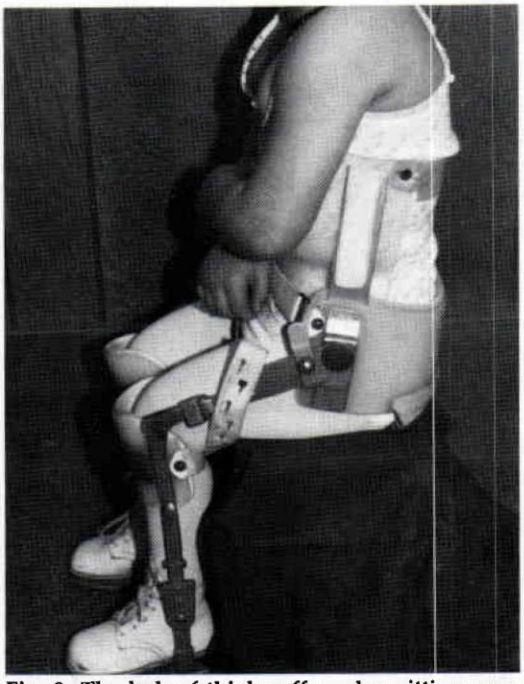

Fig. 8. The lack of thigh cuffs makes sitting more comfortable.

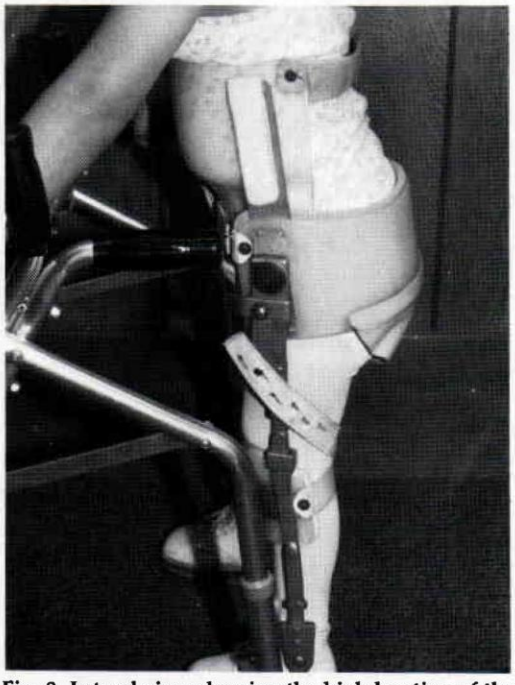

Fig. 9. Lateral view showing the high location of the hip joint and the wide pelvic band.

varied by the use of a stainless steel spring of different tension or a rubber block. A rubber block is used when the orthotist chooses to design the orthosis with a fixed hip, in conjunction with anterior thoracic shell, or sternal pad, as in the case of hip or lumbar contracture. Although the hip joint with rubber block is used when a fixed hip is desired, it also offers a cushion upon heel strike, which reduces breakage.

Introduction of the extension assist hip joint gives the patient alternative gait patterns, swing through, swing to, or reciprocating gait.

The second hip joint was of thinner design. Extension assist was accomplished using rubber bands. These bands were the same as those used on prosthetic upper extremity terminal devices. Both hip joints are designed with a stop after the joint has flexed 15°. The lock release levers are basically the same. Tension can be varied using additional bands. The second hip joints are designed with a stop after the joint has flexed 15°. The second hip joint design may be altered to a static, simply by riveting the

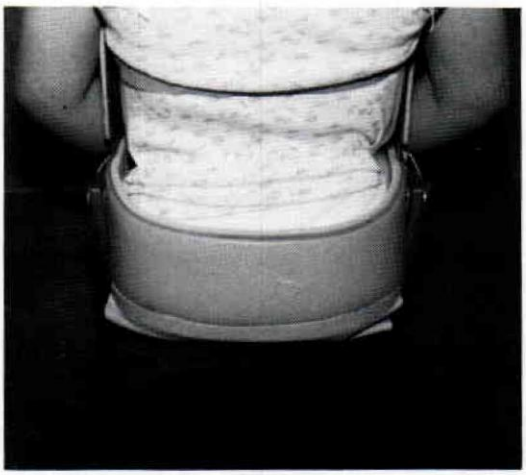

Fig. 10. The hip joint is placed higher for heavier patients to allow for the spreading of tissue during sitting.

Fig. 11. Close-up of hip joint and pelvic band during sitting.

movable components (Fig. 9). Sternal pad, body jacket or thoracic shell are supported laterally by SS extensions attached to the pelvic band. Velcro® straps are used to maintain the system in position.

The pelvic band should be of sufficient size to cover the distance between the perineum to the proximal aspect of the ilium. The lateral band is divided into thirds. The anatomical hip joint center is positioned on the lower third; the mechanical joint is located on the upper third. This alignment positions the band over the mid-aspect of the buttock. With the mechanical hip joint positioned 1/3 superior to anatomical hip joint, the distance between the centers increases when the patient sits, thereby relieving pressure on the anterior knee (Fig. 10).

The hip joint is located superior to the norm with the obese patient. This creates additional space for adipose tissue to expand when the patient sits. Pelvic band size and strength are determined by the patients' height and weight. The pelvic band is frabricated from one of four thicknesses: 90/1000", 1/8", 3/16" or 1/4" of polypropylene. These bands are formed over soft aluminum molds preshaped to initial measurements. The band is later padded with 1/8" or 1/4" of Plastazote or Pelite (Fig. 11).

SUMMARY

The lateral bar hip, knee, ankle foot orthosis with spring assist hip extension has been successfully used for patients with muscular dystrophy, spina bifida, cerebral palsy and traumatic spinal cord lesions that resulted in paraplegia or paraparesis. Breakage has been significantly reduced because of the use of stainless steel and flexible components. The weight has been reduced as compared to conventional orthoses. Many patients with residual hip flexion can ambulate with recipocating gait. Cosmesis has been improved. The orthosis, as a therapeutic device, assists in the stabilization of contractures of the knee, hip and ankle.

The patient should be given the opportunity to reach optimal ambulation with minimal orthotic application. We consider the lateral bar orthosis to be a minimal device for those patients who need bilateral HKAFO with pelvic support.

James Brown, Gerald Tindall, and Robert Nitschke are all with Rochester Orthopedic Laboratories in Rochester, New York. Peter Haake is the Senior Associate Orthopedist at Rochester's Strong Memorial Hospital. Ken Jackman is Assistant Professor of Orthopedics and Pediatrics at Strong Memorial Hospital.

The Psychological Aspects of Amputation Surgery

Steven H. Alpert

FORWARD

The goal of this article is to present the issues concerning the psychological aspects of amputation surgery in as concise and organized a manner as possible. There appears to be no straightforward approach to dealing with this most complicated topic. Broad terms and descriptions have been used so that the majority of the information could be applied to all populations. It is imperative that one realize that no goal is unattainable, and with that focus in mind, one can attempt to understand the psychological problems of the amputee, if one assumes the responsibility to do so.

INTRODUCTION

"Psychology is often neglected or glossed over in most works dealing with the rehabilitation of the amputee. This is unfortunate because, in my opinion, emphasis on this subject is necessary. Treating the psychological problems faced by the amputee often has more significance to his life than the quality of the surgery or the nature of his prosthetic device. Training in the broad sense implies, most of all, dealing with the patient's emotional state. Because most of us feel at a loss with these problems, we tend to relegate them to the "back burner" and deal with them by ignoring them. Unfortunately, the amputee cannot ignore them."[1]

The amputee is no different than any other human being that is confronted with a crisis situation, in that he must adapt rather than succumb to the handicapping condition. Difficulties encountered are often due to misperceptions of what life for an individual labeled "amputee" is actually like, and consequently, great problems in rehabilitation result. The rehabilitation process is two-fold in nature, providing physiological and psychological restoration. Ideally, the rehabilitation process should begin preoperatively. In successfully accomplishing the rehabilitation process, one must initially be aware of the basic human needs in every individual's life, necessary to maintain a proper system of equilibrium, for a normal daily existence, including both biological and environmental elements.

Once one is aware of these basic human needs, it becomes apparent that this system of balance becomes disrupted as a result of amputation surgery and, hence, must be reestablished. Postoperatively, this most effectively begins by implementing the use of an immediate or early postsurgical fitting of a temporary prosthetic device. This procedure is not practiced as a means of evading the issue of accepting the loss. In dealing with the goal of psychological rehabilitation, the amputee seldom accepts the loss, rather he adapts to it. Once the person effectively deals with the internal issues leading to successful adaptation to life as an amputee, he may then attempt to resolve the external issues of the amputation itself, and

those issues involving other individuals. Taking into account this synopsis of life prior to and after amputation, it becomes evident that the problems concerning the psychological aspects of amputation surgery cannot be viewed from a single vantage point.

How the amputee deals with the handicapping crisis situation considerably depends upon how he accomplished resolving similar crisis situations prior to the amputation.* Universal reactions to amputation are characterized by self-pity, anxiety, shock, anger, frustration, and primarily grief:

> "The problems experienced by the patient will clearly depend on the limb that is lost, the extent of the amputation, and the patient's reaction to previous experiences of loss in his life. The disability may, therefore, range from complete immobility to the need 'to acquire' new skills and a new life style with an artificial limb. Some patients seem able to cope with this very well and their rehabilitation progresses very smoothly. However, there are some patients who will have to 'unlearn' many things and for whom readjustment is a long and painful process which may never be completed.[2]

Reactions generally are not universally displayed in any chronological order and must be individually accomodated. In addition, how a person envisions the handicapping condition gives rise to his definition of what the loss means internally, thus influencing the individual's self concept. Sidney Fishman, Ph.D. feels that these perceptions are often quite inaccurate and "in most cases, relatively unrealistic and distorted self perceptions result. This is not a surprising assessment since the patient does not normally have access to any considerable experience with amputees. He does not know what to expect in living as an amputated person, and in view of the rather significant trauma associated with his loss, he tends to focus his anxieties on the amputation and to consider the amputation a more central factor in his life than is realistic."[3] The consequences of this misperception are evident postsurgically through lack of motivation, specifically in the area of rehabilitation.

THE REHABILITATION PROCESS

Rehabilitation for the amputee can be delineated as a two fold process: (1) Physiological restoration of body function, via implementation of prosthetic replacement extremities, and (2) Psychological restoration of emotional equilibrium. Problems related to the total rehabilitation of the amputee actually evolve from a combination of both the physiological and psychological losses incumbent with amputation, such that, until the time when adequate restoration for both losses, to harvest equilibrium, is implemented by the rehabilitation team, the reacclimation into a normal and healthy lifestyle cannot occur for the amputee.

PRE-OPERATIVE CONSIDERATIONS

Optimally, it would be best to initiate the process of psychological rehabilitation prior to amputation surgery. Although in emergency amputations this is not possible, in most instances this principle can be implemented. Lawrence Friedman, M.D. feels that "a frank discussion is frequently avoided by both the surgeon and the patient, and this is detrimental to both. A realistic brief discussion of the advantages and disadvantages of each course of action should be an important part of the decision to amputate."[4]

Beginning the rehabilitation process preoperatively allows the patient time to

*from an etiological perspective, amputations are either acquired or congenital, and are generally classified as to site and level of absence. An acquired amputation classifies the individual who had a normal embryonic development, but after birth, due to some extraneous circumstance, loses a limb in part or in toto. The congenital amputation classifies the individual who, due to some genetic disorder during embryonic development, is born without a limb in part or in toto. The scope of this thesis primarily deals with the noncongenital adult limb amputee, but principally, may be applied to all amputees (i.e. mastectomy, maxillo-facial, etc.) providing certain distinguishable considerations are outlined.

mentally prepare for the amputation surgery. Humm states two essential factors which may be gained from preoperative treatment; "Firstly, physical preparation is started early and the pre-proceptive impulses of balance on two legs are maintained up to the very last moment before amputation (this is most vital for a speedy progress on a prosthesis) and, secondly, it is an excellent time for making a start on the patient's mental rehabilitation by allowing him or her to meet and see other amputees at various stages of training; this is linked with a simple explanation of the importance of exercise before amputation and the reassurance that all is not lost."[5]

Behaviorly, most patients tend to suppress their aggressiveness toward the surgeon as a means of 'plea bargaining' against amputation. At this point, questions by the patient should always be encouraged. It is vitally important that the patient understand that no amputation is performed until all persons concerned have agreed that there is no reasonable alternative but to amputate:

> "Amputation is not to be mentioned to him (the patient) until all doctors concerned with the case are agreed that it is indicated and one senses that the patient is mentally prepared. Each of these considerations is an important as the other. When they are both obtained, the keystone of the approach to the patient is to inject each remark with a positive statement or implication that all efforts are being united to give him painfree ambulation."[6]

The decision to amputate must be presented to the patient in the most simplistic manner possible. It is important that the surgeon intermittently reinforce that he is making every possible effort to avoid amputation surgery, but if it is unavoidable, that he reassure the patient's postoperative level of function:

> "When the patient and surgeon consider that amputation is the mark point of failure, functional failure is frequently assured. If the patient considers amputation as a lesser degree of success, but still successful in that it restores him to a relatively functional, satisfying life, then the patient and the surgeon and other members of the amputee clinic team have been successful."[7]

Once the decision to amputate has been determined by both the surgeon and the patient, the surgery should be carried out as readily as possible. Delay in amputation often fosters depression, suicidal urges, and universally a fear of death.

POST-OPERATIVE CONSIDERATIONS

In approaching the process of psychological rehabilitation of the amputee, before further consideration is directed toward the postoperative element, one must have a concrete perception of the basic human needs that must be satisfied in every individual's life in order to maintain the necessary system of balance for daily existence. These human needs in parallel with the rehabilitation process, may also be divided into two interrelated categories, and may be classified as either biological or environmental in nature.

Those needs which are labeled biological are genetically determined at birth, and are generally viewed as survival mechanisms such as hunger, thirst, avoidance of pain, and sexual gratification. On the other hand, the environmental needs are generally acquired through societal views such as the need for achievement, respect, and status: needs must be incorporated into one's daily regime. Although one may assume that these two areas are separate, they are interrelated. In that failure to meet the needs in one category can cause an imbalance in the opposite and/or affected category. Since the amputee is in fact human, it is imperative that he maintain equilibrium in both categories. When focusing on the amputee, it becomes evident that, as a result of the amputation surgery, an obvious imbalance in each category results, varying in degree from

one individual to the next. Because of the physiological permanence of amputation surgery, one must be aware that restoring equilibrium is a seemingly insurmountable process, but one which can be successfully accomplished through motivation in a rehabilitation program.

Keeping in mind that the basic human needs of the amputee have been disrupted as a result of amputation surgery, several postoperative issues may now be considered. In order to achieve the most effective state of equilibrium, prosthetic devices must be provided in order to restore appropriate function and appearance. Postoperatively, use of rigid dressings protects the wound site and may also serve as a socket for an immediate postoperative prosthesis.* Ernest Burgess, M.D. states the following advantages to immediate and early prosthetic fittings:

> "Physical and psychological advantages are attributed to this functional immediate prosthetic system. The patient does not undergo a limbless time interval. Some degree of functional restoration begins immediately. Established pathways of neuromuscular control are less likely to fade with early limb use. Residual limb pain is described as being seen far less in the patient who has a rigid dressing immediately after surgery than with the conventional soft tissue management. The time for the limb maturation and overall amputee rehabilitation, including hospitalization, is reported to be considerably shorter with this system. The general physical and mental state of the patient is benefitted by early general physical activity as well as physiological limb function."[9]

Sidney Fishman, Ph.D., further stresses the psychological benefits of an early prosthetic fitting:

> "Immediate and early prosthetic fitting procedures have major psychological values in reducing the extent of the actual and perceived disability and consequently of the psychological trauma associated with it. This is possible since the patient is never (or for a very short period) without a limb (albeit an artificial one). The immediate availability and wear of a prosthesis may legitimately tend to reduce the extent of the defensive reactions required. This in turn tends to facilitate the process of acknowledgement and adaptation."[10]

Burgess concludes and reinforces the views on immediate postoperative fittings of the prosthesis** by stating:

> "The rapid transition from limb loss to function bespeaks hope. This motivation can make the difference between effective rehabilitation and failure."[12]

Although not always successful, the ideal goal of immediate postoperative prosthetic fittings is to enhance the emotional psyche of the amputee by restoring function, thus speeding the recovery time. It is not, however, designed to evade the issue of amputation. It is imperative that the amputee work through this issue in order to reestablish a normal psychological outlook.

STAGES OF ADJUSTMENT

Losing an extremity is very similar to losing a loved one. Dr. Elisabeth Kubler-Ross in her book *On Death and Dying* explains several stages an individual will go through in attempting to work through their own death explaining, "the harder they struggle to avoid the inevitable death, the more they try to deny it, the more difficult it will be for them to reach this final stage of acceptance. . . ."[13]

*the postoperative fitting is immediate if the prosthesis is applied before the sutures are removed, and early if it is applied after removal of the sutures but before the patient is ready for permanent fitting.[8]

**Berlamont (Berk Plage), in the services of professor Deberyre, started using this technique in 1958. In 1963 Weiss reported this method of myoplastic amputation and immediate postoperative fitting of the prosthesis (I.P.O.F.P.) at the Sixth International Prosthetic Course in Copenhagen. The same year he visited the University of California, San Francisco Medical School, and the U.S. Naval Hospital, Oakland. Following this visit an I.P.O.F.P. war started at the U.S. Naval Hospital, Oakland and a Veterans Administration Project to investigate I.P.O.F.P. was given to the Prosthetic Research Study Group in Seattle.[11]

Similarly, Lawrence Friedman, M.D. states in *The Psychological Aspects of Amputation Surgery* that:

> "The finest reaction to the amputation is more or less acceptance of the fact and regarding it as something to be overcome. This provides the foundation for prosthetic use success and success in meeting life's goals. If, however, the amputee uses the amputation as a means of justifying his dependency needs or as a means to avoid competition, then the secondary gain derived from these feelings assures that the patient always complains about the prosthesis and blames all of his personal inadequacy and failures on the lack of perfect functioning prosthesis. . . . I feel that most amputees never totally accept their loss, but learn to deal with it, and this is true irrespective of the type of treatment that they have received."[14]

When dealing with the psychological adjustment of the amputee it is important that the proper perspective be maintained as to what the goal of the rehabilitation process actually is. It may be postulated that most amputees rarely accept their loss such that, the goal of amputee rehabilitation should more realistically be adaptation of the loss. Fink imposes a theoretical approach to the psychological rehabilitation of individuals with a handicapping conditions by describing four sequential stages of adjustment: (1) shock, (2) defensive retreat, (3) acknowledgment, and (4) adaptation.

Shock

> "Essentially, shock is the patient's initial response to a threat to self-preservation, leaving the individual emotionally and intellectually numb and manifested by disruption of organized thinking. The individual has no plan of action and is essentially without psychological resources. The reality of the situation is too much to handle, resulting in overall helplessness."[15]

Lawrence Friedman, M.D. indicates that telling "a patient that he will not be helpless and dependent if he participates in a rehabilitation program is what is most important."[16] Preoperative discussion of shock does help the patient deal with it postoperatively. It should be noted that during this stage suicidal impulses are prevalent and should be handled accordingly. If the patient is just talking about suicide, take note of the issue but do not overreact, as it is usually just an attention getting device based on self pity and despair, indicative of a search for self worth. If, however, the patient has a clear cut, premeditated method of carrying out the act, then it is suggested that the patient be removed from the continued care ward and placed in a psychiatric care unit so that closer observation can be provided. Shock is most severe when seeing the residual limb for the first time, especially since phantom* sensation often prevails. Similarly, "seeing the scar for the first time is always a traumatic experience."[18] Both are continuous reminders of the disfigurement of amputation surgery.

Defensive Retreat

> "As the patient's resources begin to mobilize, this phase of the adjustment process is prompted by anxiety reduction, and energy is therefore invested in keeping circumstances under control. The phase is characterized by a clinging to the past through the use of avoidance mechanisms (fantasy, denial, magical, and rigid thinking)"[19].

One way in which the amputee denies the amputation is via overcompensation through excelling in recreational activities or working excessively hard. Friedman refers to these patients as being "professional amputees" and comments that "these people deny that any disability exists. They engage in sports and many other activities of the nonamputee and, in fact, may spend considerable time proving how well they can function as amputees.

*psychiatric theories tend to relate the phantom to wish fulfillment resulting from the denial of the loss of a part, and pain is explained as resulting from denial of effect associated with the loss.[17]

These people demand treatment from others as nonamputees."[20]

Acknowledgment

> "This is a period of renewed psychological stress resulting from breakdown of the prior defenses because of lack of reinforcement of these defense mechanisms resulting from inadequate satisfactions. During this period the patient usually recognizes changes in his physical self, thus provoking a period of stress characterized by depression and mourning. At the same time there are the beginnings of intellectual and emotional reorganization which proceeds in a unique and variable pattern for each patient."[21]

Once the patient desires to implement the use of a prosthesis, the disability is reduced such that he finds it easier to adapt to the fact that a disability exists. Friedman feels that the patient is "less shy and more gregarious. They react better to people, either in or outside of the therapeutic situation. Their relationships with their families improve since they do not feel themselves as dependent and frustrated."[22]

Adaptation

> "The extent to which the patient succeeds in this reorganization process depends on his growth needs to develop a renewed self-respect, productivity, achievement, and social acceptance. This phase of adjustment is optimally characterized by the patient's willingness to take the necessary physical and psychological risks normally associated with the rehabilitation process."[23]

Similarly, Sidney Fishman concludes that "rehabilitation may be said to be successful when the amputation and its related considerations are no longer the central adjustment problem for the individual. As the ability to use the prosthesis more automatically, or subconsciously increases, as the client's awareness of being physically different becomes less threatening, and as the amputation becomes a minimal source of interference in his/her life activities, the elements of successful rehabilitation have been approached."[24] If the definitive prosthesis cosmetically appears to resemble a normal extremity the individual will feel normal, however, the patient must realize that "the provision of a prosthesis is but one step in a long journey that started before amputation, and will continue for a prolonged period after the prosthesis is received. The prosthesis is not an end in itself, but a means to the end of returning the patient to his maximum attainable place in society."[25] Once the patient is able to effectively deal with the internal issues, successfully adapting to life as an amputee, he may then attempt to resolve issues involving other individuals.

Speck feels that the manner in which the hospital staff deals with the conceptual aspect of disfigurement and surgical loss will have an effect on shaping the "patient's reaction and that of the family. It is not unusual to find a patient who has done well in the hospital regress when he returns home, because the family is not psychologically prepared to continue the rehabilitation. The family is an integral part of the rehabilitation team and should seek out educational opportunities to effectively take part in the process."[26] In general, our society tends to be obsessed with the ideal human form, such that any individual who may deviate from this flawless imagery, is labeled as 'different.' Because Americans are so caught up with this accepted norm, they fail to realize the overwhelming emotional impact of being confronted with the destruction of body image through amputation. Not only does the amputee have to learn to get along without the extremity and adapt to using some type of prosthesis, which never compares with the body portion that it replaces, but must also deal with many tangentially related psychosocial issues,[27] such as sexual dysfunction. Once the amputee has adapted to amputation, the main focus of rehabilitation then is reintegration back into as normal a life style as possible

It is very important that the topic of sexuality be considered. Ultimately, we are

dealing with a very sex-oriented society, and since the amputee is very much a part of our society, he shares the same rights to this human need. Limb amputation often presents difficulties between partner relationships, resulting in the need for support and reassurance from those individuals who have undergone similar surgery. Problems encountered may result from disruption in preestablished patterns of coital behavior, interference with balance, and phantom pain occuring at orgasm. Very little has been written on the sexual aspects of rehabilitation, primarily because of the unrealistic concept of 'asexual aging' in our society. During the rehabilitation process it is vitally important to encourage sexual function, to the degree the amputee feels comfortable. Concealing the amputation often presents serious psychosexual difficulties, basically due to the fact that, at some point during intimacy, the amputation must be revealed.[28]

DISCUSSION

The psychological aspects of amputation surgery yields several major problem areas that must be approached in a perceptive manner. As an outsider, one must intuitively realize that life for the amputee has been severely disrupted in a multi-faceted manner, in that he loses much more than 'just a limb' as result of amputation surgery, specifically, the right to be considered a 'normal human being.' "The psychological consequences of having an obvious disability reflect not only the patient's sense of loss and shame, but also society's evaluation of what disability is and acceptance of disabled individuals. Unfortunately, society still too often wrongly considers the amputee a useless cripple."[29] The amputee becomes a victim of social prejudice, a public spectacle of awe, bewilderment, and chastise. Marriage becomes a mirage of hope for those amputees who have not yet married, and divorce becomes an inferno of reality for those who have. Similarly, being able to maintain one's previous vocational interests, not to mention the obstacle of being forced to make alternative career choices are prevalent issues concerning the individual who has undergone amputation surgery. These are problems that must be solved by all of society, not just the amputee alone. Lawrence Friedman upholds that "this is the challenge to all of us. How amputees are treated in the future reflects on our civilization and on our concept of rehabilitation: our actions today will be tomorrow's history."[30]

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Triceps Pronation-Supination Orthosis

Daniel P. Cole, C.O.
Paula J. Clarkson, COTA/L

INTRODUCTION

The Triceps-Supination Orthosis* was designed for a patient with flexion contractures of the right elbow and limited pronation and supination secondary to a C6 spinal cord injury (Fig. 1). It is also designed to dynamically extend the elbow while still permitting active elbow flexion, pronation, and supination (Fig. 2 and 3).

During rehabilitative hospitalization, emphasis was on increasing right elbow extension and functional use. A series of six inhibitive serial casts* was applied to obtain gradual elbow extension. Active range increased approximately 8–10° with each successive casting, but gains in this area were not maintained following removal of the cast.

The patient's functional activities were impaired due to a soft tissue contracture of the right elbow, and active forearm pronation and supination were nonfunctional. Upon admission, active right elbow extension measured minus 70° with passive extension measuring minus 35°. Spasticity was noted when active pronation and supination were attempted. The left nondominant upper limb, being most functional, had a good tenodesis grasp with passive range of motion being within normal limits.

*a series of plaster casting to release contractures or spasticity through neutral warmth with prolonged stretch in a submaximal range.

INDICATIONS

The utilization of a triceps pronation-supination orthosis should be considered for individuals with elbow contractures or spasticity along with limited active pronation and supination. In addition to spinal cord injured individuals, this orthosis would be beneficial for patients with closed head injuries and Guillain Barre' with long term disabilities. The orthosis is applicable for spasticity that ranges from mild to severe after other therapeutic methods have been attempted to decrease spasticity.

Active elbow extension of minus 45° and passive pronation and supination are prerequisites for fitting. The orthosis will actively extend the elbow to minus 10° depending upon the severity of spasticity, and will permit full range in pronation and supination.

The patient's personality and educational background play a significant role in training the individual in orthotic use, regardless of the success of fitting of the actual orthosis. The individual who lacked motivation before his disability should not

be expected to be dynamic and motivated after the onset.

ORTHOSIS DESIGN

The triceps pronation—supination orthosis incorporate adjustments regulating the amount of tension and force applied at the mechanical elbow and radio-ulnar joints. These adjustments enable the orthotist or therapist to balance the orthosis against the active opposing musculature.

The adjustable extension assist elbow

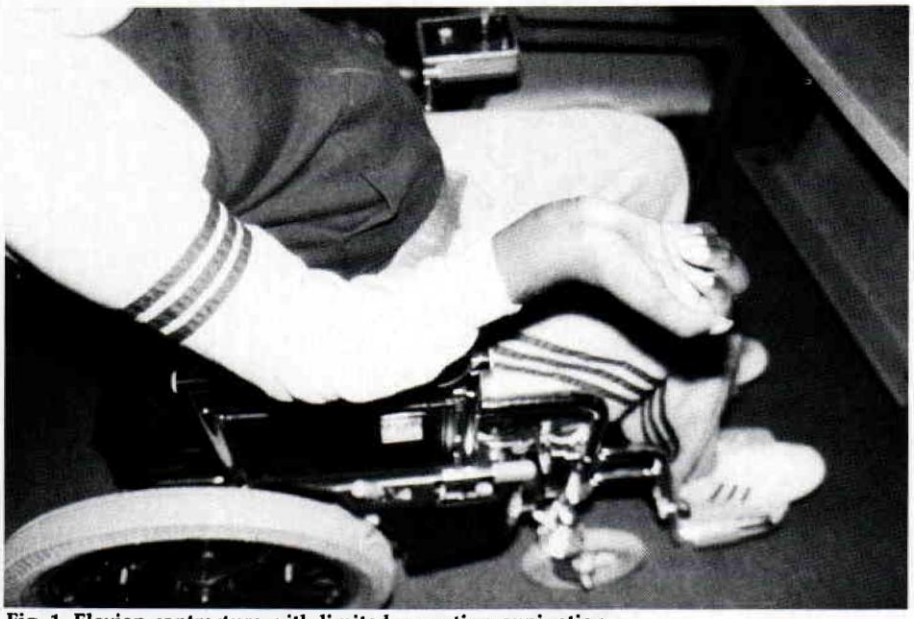

Fig. 1. Flexion contracture with limited pronation-supination.

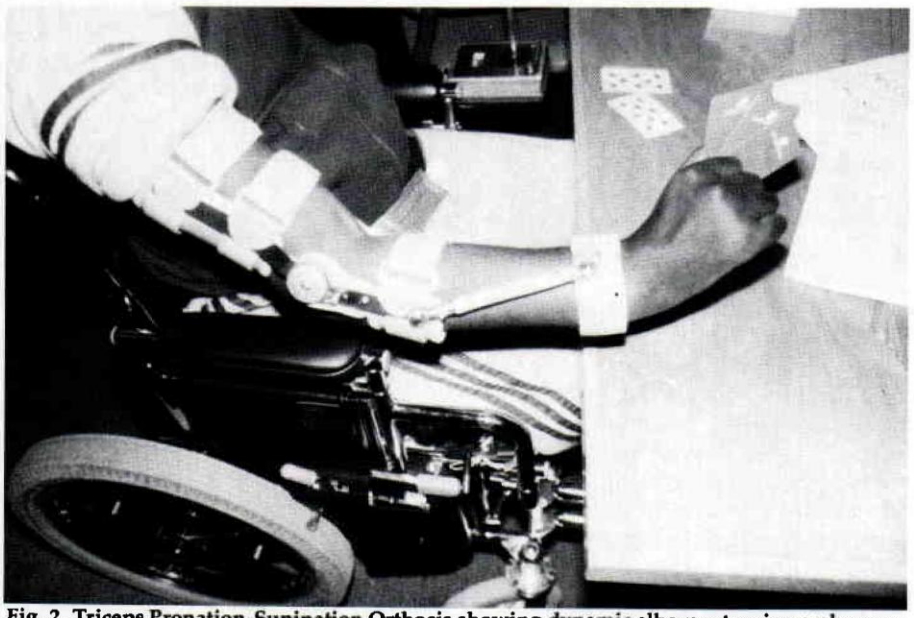

Fig. 2. Triceps Pronation-Supination Orthosis showing dynamic elbow extension and pronation.

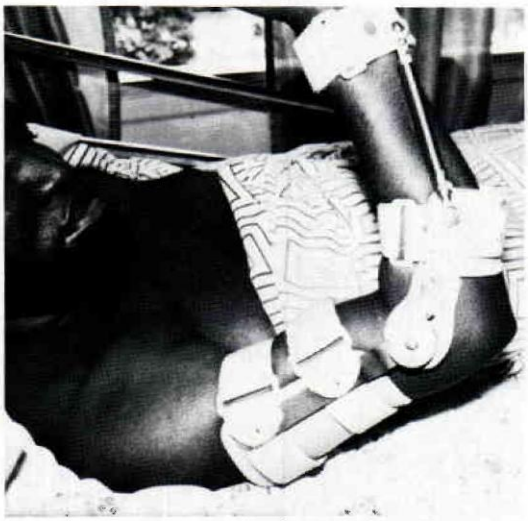

Fig. 3. Patient actively flexing the elbow and supinating the hand.

joint (Fig. 4) was originally designed as a flexion assist, but a modification to the coiled spring was made to obtain the extension forces used to simulate the triceps. Clockwise-counterclockwise rotation of the spring's mounting allows adjustment of tension forces, either increasing the amount of force by rotating the spring clockwise, or decreasing it with counterclockwise rotation. Adequate elbow extension can be achieved only when functional passive range of motion has been established.

The forearm is composed of the radius and ulna and its articulating surfaces which consists of the proximal radio-ulnar joint and the distal radio-ulnar joint, both classified as pivot joints. The primary movement permitted is rotation, and the joint is therefore monoaxial. The pivot axis extends diagonally from the proximal head of the radius to the distal head of the ulna, the forearm rotates around this axis, which results in supination and pronation.

During pronation, the radius crosses the ulna diagonally (Fig. 5).

In order to simulate supination-pronation of the hand with an orthosis, similar characteristics must prevail. Rod end bearings are used to mimic the radio-ulnar joints. Proximally, the rod end bearings are riveted to the forearm band (Fig. 6) and distally to the polypropylene wrist cuff (Fig. 7). Stainless steel linkage rods simulating the radius and ulna are threaded and rotate in the sleeve of the proximal rod-end bearing. This rotation, coupled with the intrinsic pivot action of the bearing, enables the orthosis to imitate pronation and supination. Distally, the

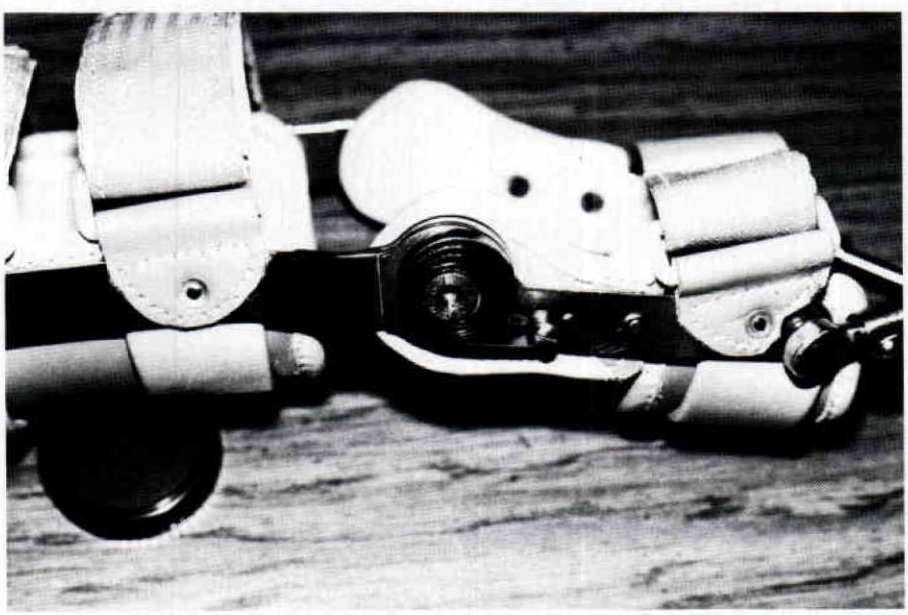

Fig. 4. Dynamic elbow extension joint (cover removed).

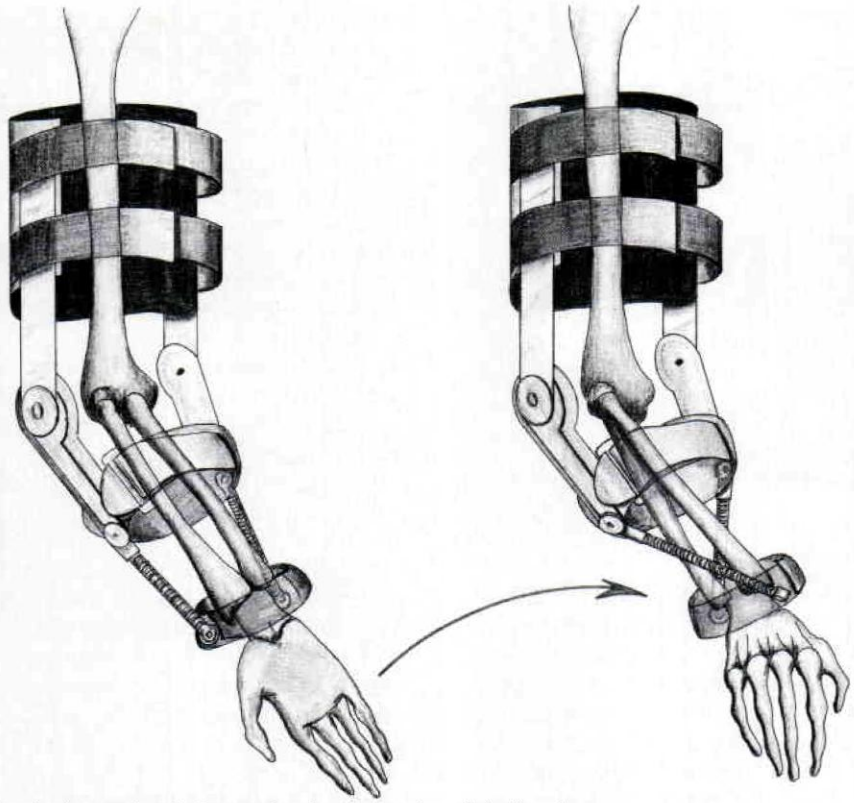

Fig. 5. Orthosis shown simulating supination-pronation of the hand.

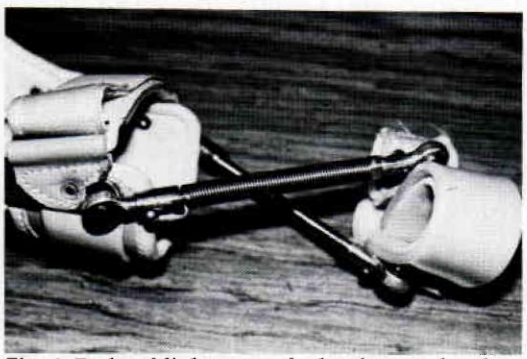

Fig. 6. Rod end linkage attached to forearm band.

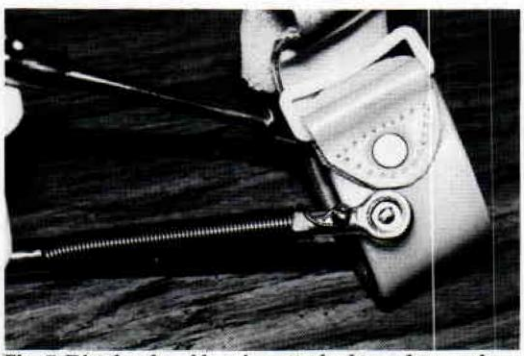

Fig. 7. Distal rod end bearing attached to polypropylene wrist cuff.

steel rods are statically attached to the rod end bearings.

In order to dynamically assist the hand into pronation, a torsion spring was incorporated over the radial stainless steel rod (Fig. 8). The torsion spring is wound in a counterclockwise direction for right hand pronation, and clockwise for left hand pronation. The torsion spring provided the necessary force to passively advance the hand into pronation. Proximally, the spring is attached to an outer adjustment sleeve. This sleeve allows the orthotist or therapist to vary the amount of force transmitted to pronating the hand. An additional spring can be added to the ulnar stainless steel linkage rod if more force is required to pronate the hand.

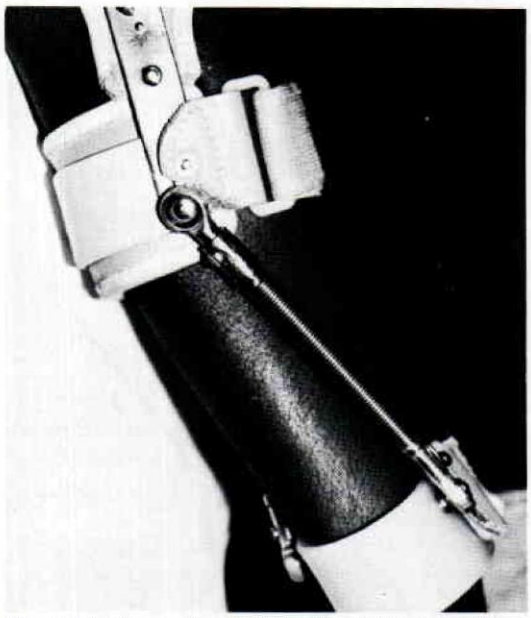

Fig. 8. Torsion spring assisting hand into pronation.

Fig. 9. Triceps Pronation-Supination Orthosis increases patient's ability to self-propel a manual wheelchair.

Functional Benefits

The following functional activities can usually be carried out with the triceps pronation—supination orthosis after training and practice.

- **Increased Range of Motion.** The orthosis dynamically extends the elbow and permits active elbow flexion while assisting with active pronation—supination.
- **Increases Active Functional Forearm Rotation.** The orthosis assists with writing skills, card playing, and ability to pick up objects.
- **Wheelchair Mobility.** The orthosis increases the ability to reach wheel rims for self-propelling a manual chair (Fig. 9) and provides the range of motion for reaching the control on an electric wheelchair.
- **Feeding Skills.** Utilizing quad cuff utensils, patients can actively and functionally feed themselves, pick up a cup, and cut food with a rocker knife.
- **Light Hygiene.** The orthosis increases the ability to comb hair, brush teeth and apply deodorant.

ACKNOWLEGMENTS

The authors would like to thank Bob Wilson for the technical illustrations.

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*U.S. patent pending

Technical Note:

Golf Club Holding Devices For Upper Limb Amputees

Ram P. Bhala, M.D.
Charles F. Schultz, C.P.

ABSTRACT

A device for playing golf by an upper limb amputee will be described. Medline search as far back as 1966 reveals that such a device has never been described in the biomedical literature. The device is interchangeable with a hook or hand, fits into a standard prosthetic arm and can be used by a right or left above elbow or below elbow amputee. The device is inexpensive and can be readily made in a machine shop.

INTRODUCTION

The game of golf requires the player to swing a club downwardly through an arc in order to strike a golf ball sitting on a tee or lying on the ground. While it is possible to successfully swing a golf club using one hand, for the average person greater accuracy and power are obtained by holding the club grip with both hands, and employing both arms in the back stroke, the down or power stroke, and the follow-through. For the able-bodied average player the making of a golf swing with both arms and both hands is a natural act that requires practice and excellent coordination for consistently good results.

However, where a person has lost one hand or part of the arm, until now there has been no practical device reported in the prosthetic literature to allow the person a normal two-handed golf swing. Such amputees, in some instances, may have developed considerable skill in swinging a club with their one remaining hand, but their inability to offer the coordination and power of a two-handed stroke has left them handicapped as opposed to an able-bodied player.

There is thus a need for a prosthetic device that can be used by the average golfer, handicapped by the loss of one hand or part of the arm, a device that will allow such a golfer to make a relatively normal golf swing. The prosthetic device described here and developed by one of our amputees is intended to satisfy the need of many patients with arm amputations.

DESIGN DESCRIPTION

The device is made of brass pipe, steel, and polyurethane rubber, and has three main parts. (Fig. 1 and 2)

A. *The Distal Portion or the Head (Fig. 1-A and Fig. 3)*—A piece of metal pipe, such as brass, 2-¼" × 1" with ⅛" thick wall (A-1) is brazed onto a solid piece of steel (A-2) at an angle of 10°. The opening of the metal pipe is tapered with a steel plug so that at its proximal end it is slightly larger in diameter than at its distal end to accommodate the tapered grip of the golf club. One side of the pipe is cut open longitudinally to allow an opening ⅝" in width for placement of the golf club into the device. A thumb screw (A-3) is installed through the head to lock the golf club in place and prevent it from twisting while playing golf.

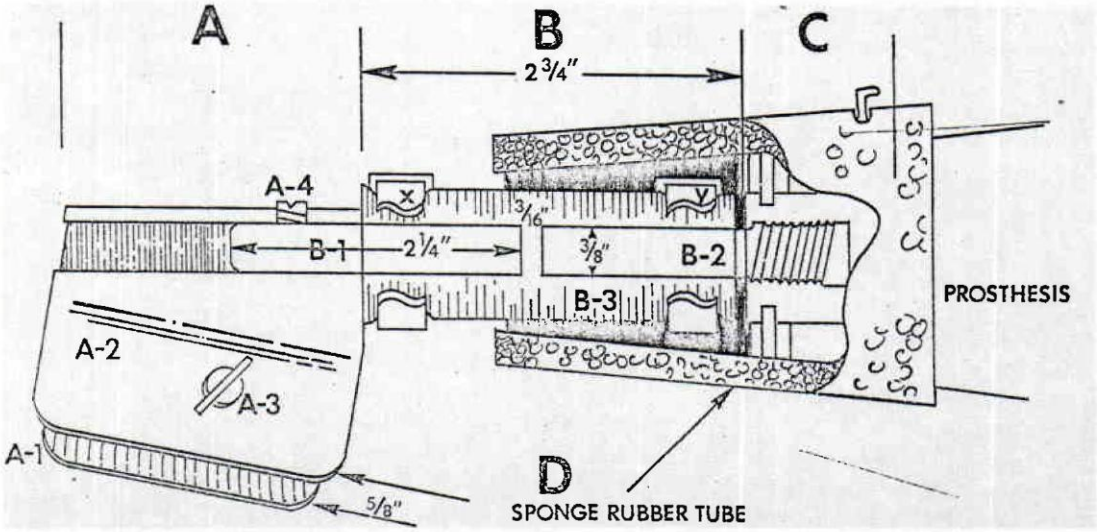

Fig. 1. Diagrammatic representation of the various components of the prosthetic device.

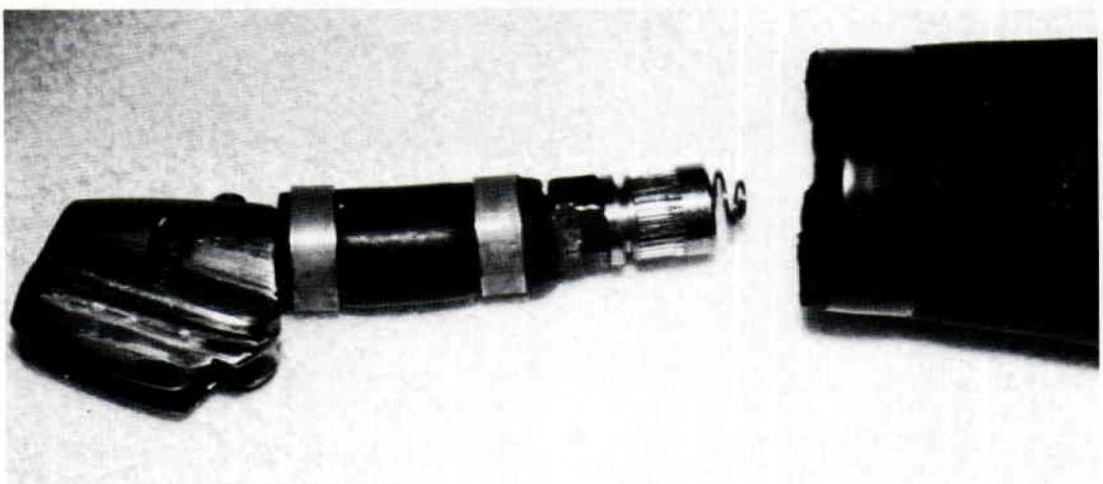

Fig. 2. Assembled device with sponge rubber sleeve.

B. *The Middle Portion or the Wrist (Fig. 1)*—This has semi-rigid structure and consists os two solid steel rods (B-1 and B-2), each 2-¼" × ⅜" inserted tightly inside a polyurethane rubber tube (B-3), which is 2-¼" long and has an outside diameter of 1" and inside diameter of slightly less than ⅜". The steel rods are held in place inside the rubber tube with two metal clamps, x and y, (Fig. 2). There is a 3/16" gap between the two steel rods at the center of the polyurethane rubber tube to allow the necessary wrist movement during back swing and follow-through while playing golf. The distal rod (B-1) is locked in place through a drill hole in the steel head (A-2) with an Allen set-screw (A-4). The length of the device can be adjusted to suit the amputee by sliding the steel head up or down over the distal steel rod and locking it in place with the set-screw. The proximal steel rod (B-2) is threaded (½" × 20) at its upper end to accommodate the proximal portion of the device called the wrist insert.

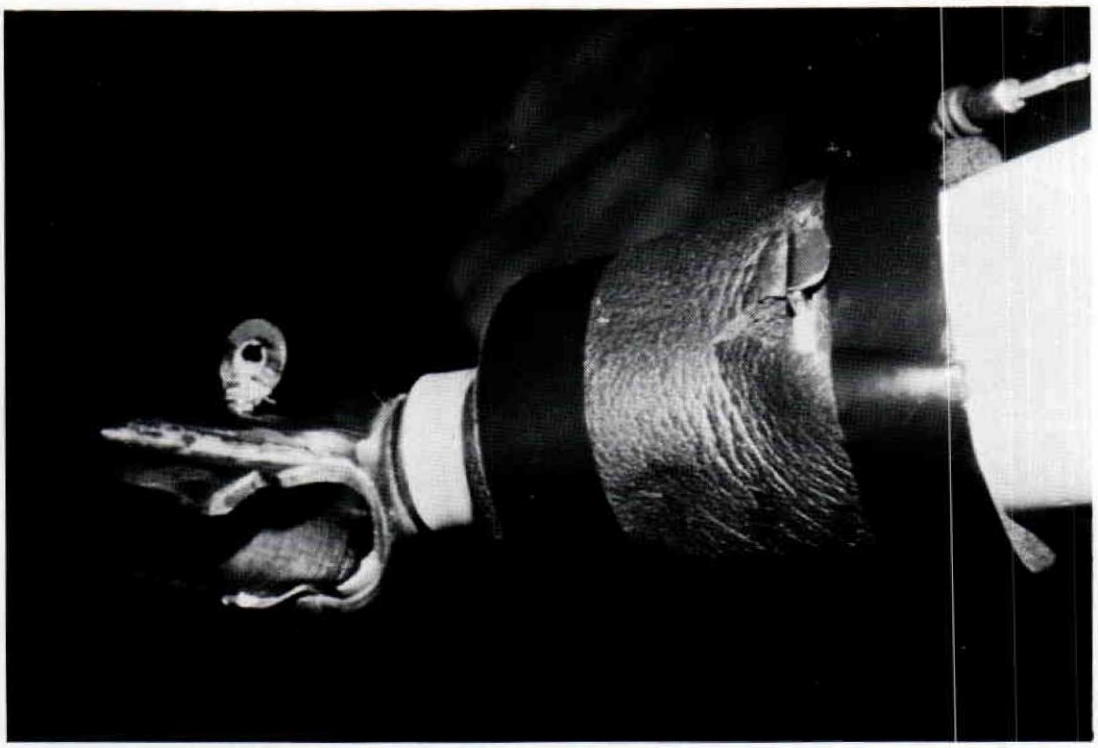

Fig. 3. Prosthetic device locked in place in a below elbow prosthesis.

C. *The Proximal Portion or the Wrist Insert (Figure 1-C)*—This is a standard insert used by prosthetists for an FM quick-change wrist unit. This part of the device allows the amputee its quick attachment and removal from the prosthesis.

In addition to the components described above, a piece of inexpensive sponge rubber tube (Fig. 1-D and Fig. 2) such as the one used for covering air conditioning pipes, measuring 3-¼" × 1-½" (internal diameter) is used over the proximal portion of the device and the distal portion of the prosthesis as shown in Figure 3 and 4 to protect the sound hand from injury during back swing or follow-through. The upper section of this covering has an opening for the quick release tab installed on the prosthesis.

The prototype described above weighs 15-ounces and will hold any standard size golf club. It is readily interchangeable with a hook or hand and is easy to install or remove from any standard prosthesis. The device is inexpensive and can be readily made in a machine shop.

CONNECTING AND DISCONNECTING THE DEVICE FROM THE PROSTHESIS

The amputee disconnects and removes the hook or hand from the prosthesis and inserts the sponge rubber covering (D) over the distal prosthesis allowing the quick release tab on his prosthesis to project through the opening in the rubber covering as shown in Figure 3. He then inserts the golf device into the prosthesis until the wrist insert unit locks in place. Since the prosthetic cable is not attached to the device, it is left disconnected. The golf club is then inserted into the head of the device through the longitudinal opening (Figure

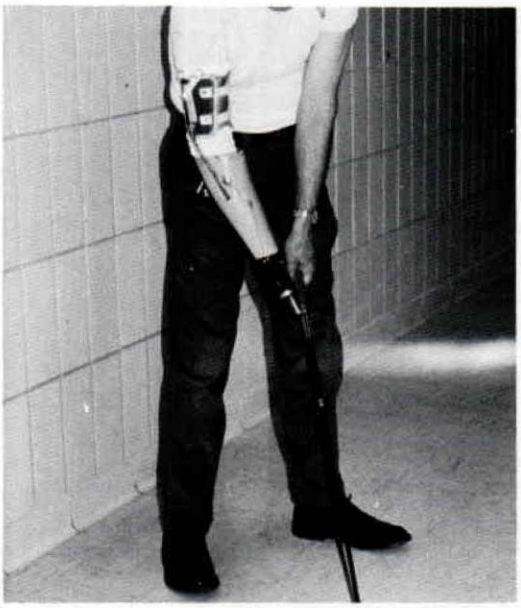

Fig. 4. A below elbow amputee holding the golf club in locked position in the prosthetic device.

1, A-1) and the device is slid up the shaft of the golf club onto the proper grip position and locked in place with the thumb screw. When the golf club is properly held in place, the sponge covering over the distal part of the prosthesis not only allows a comfortable grip of the club with the sound hand, but it protects the sound hand of the amputee from injury during swing (see Fig. 4). This is not a problem for the left arm amputees, as their sound right hand grips the golf club at a position distal to the prosthetic device. One of the most important features of this device is that its wrist unit, which is made of polyurethane rubber tubing with two steel rods in place and separated with a slight gap, is flexible enough to allow the required wrist action during swing of the club, i.e. extension during back swing and flexion with some rotation during follow-through. In order to remove the device from the prosthesis the amputee reverses the procedure.

PROSTHETIC MODIFICATIONS

Most amputees will not require any special modification to their prosthesis to use the described prosthetic device. However, there are two wrist units on the market which require special mention:

A. The FM quick-change wrist unit must be installed on the prosthesis with the quick-change tab in an *anterior* rather than medial position. This is necessary because if installed in a medial position the pressure from the sound hand on the quick-change tab could cause the tab to depress, thereby accidentally unlocking and releasing the device during the swing.

B. The F.W. flexion-friction wrist unit cannot be used with the described device because the control button must be located on the medial aspect of the wrist unit for proper operation of the wrist.

SUMMARY

A prosthetic device for playing golf by an upper extremity amputee is described. Medline search as far back as 1966 revealed that such a device has never been described in the biomedical literature. The device is readily interchangeable with a prosthetic hook or hand and fits into any standard prosthetic arm. It can be used by a right or left handed, above or below elbow amputee to confidently hold any standard size golf club made of any material. The device is inexpensive, weighs less than a pound and can be readily manufactured in a machine shop. One of the most important features of this device is that its wrist unit is flexible enough to allow the necessary wrist hovements required to play golf.

ACKNOWLEDGMENT

The authors are very grateful to Mr. Earl Puhl for his valuable comments and for sharing his experience in the use of this device. An application has been filed by Mr. Puhl with the U.S. patent office in Washington, D.C. for patenting this device. Mr. Puhl can be contacted at 3807 S. 18 St., Milwaukee, WI 53221, phone 414-645-2936.

Dr. Bhala is Associate Professor, Medical College of Wisconsin, Milwaukee, Wisconsin. Mr. Schultz is Chief Prosthetist, ACME Laboratories, Milwaukee, Wisconsin.

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Medical College of Wisctnsin
St. Luke's Hospital
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Milwaukee, WI 53215

Technical Note:

Shoeing the Deformed Foot: A Method For Fabricating Molded Sandals

Albert L. Howe, C.P.O.

Custom-molded footwear is essential for the weight-bearing comfort of patients with severe, non-operable foot deformities. Such footwear, however, is expensive and time-consuming to make and equipment for its construction is not available in the standard orthotics laboratory. The need for durable, easily fabricated molded footwear for the large number of veterans with post-traumatic and degenerative foot deformities prompted us at the Veterans Administration Hospital in Nashville, Tennessee, to develop a molded sandal which can be readily fabricated in any orthotics laboratory.

Using commercially available foam foot impression blocks (Foam-art), a negative mold of the plantar surface of the foot is made. This is done with the patient partial weight-bearing to allow nearly full spreading of the forefoot and partial flattening of the longitudinal arch. The toes are manually pressed into the foam to assure that the full length of the foot has been impressed. A positive plaster mold is then cast. Modifications of the positive cast include (1) extending the toe-plate approximately one-half inch to insure that the toes do not extend beyond the anterior edge of the sandal, (2) filling in the toe sulcus, (3) leveling the weight-bearing areas of the heel and ball to the same plane and (4) constructing reliefs for any plantar protuberances.

A Pelite and thermal cork insole is then formed on the positive mold using a vacuum apparatus. The Pelite interfaces with the foot. Pelite is used rather than leather for the foot contact surface because it is more washable, more durable, adheres better to the cork mid-sole and is easier to form.

Successive thicknesses of thermal cork adhered with Master Cement are applied to build up the sole and fill in the area under the longitudinal arch. The plantar surface and sides of the insoles are ground flat and the edges trimmed almost flush with the Pelite insole. Layered smooth crepe can be used to construct a rocker bottom. Crinkly crepe provides a non-skid cushiony sole. Heavy-weight elkhide makes strong but flexible straps. Strap design is accommodated to the foot deformity. Double transverse straps over the metatarsals are comfortable and easy to don (Fig. 1). Fastenings of one-inch Velcro®, lapped back on itself through a keeper ring, allows easy strap release for arthritic patients with little use

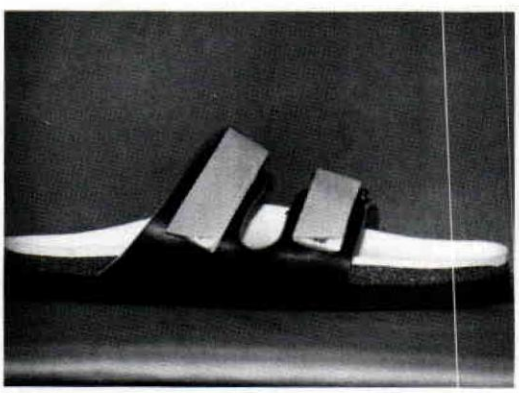

Fig. 1

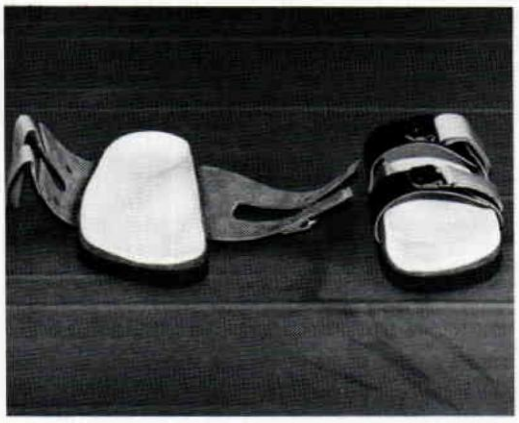

Fig. 2

of their hands and allows the fastenings to be fully opened to accommodate severely deformed feet (Fig. 2).

The completed sandal is comparatively light-weight. The total time required for fabrication is less than six hours. This sandal has been used successfully during the past two years on patients with rheumatoid arthritis, severe subluxation of the metatarsal heads, degenerative arthritis, painful callosities and hallux valgus. All of these patients have worn their sandals for more than two months and report them to be comfortable during weight-bearing for extended periods.

It is hoped that this work in the development of simple molded footwear will give impetus to further effort in this area.

ACKNOWLEDGMENTS

Dr. Harry J. Bugel, M.D., Chief, Rehabilitative Medicine Service, Veterans Administration Medical Center, Nashville, Tennessee.
Dr. Cynthia A. Schneider, M.D., Orthopedic Resident, Vanderbilt University Hospital, Nashville, Tennessee.
David L. Norris, Orthotist, Orthotics and Posthetics Laboratory, Veterans Administration Medical Center Nashville, Tennessee.

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Reviews

by Charles H. Pritham, C.P.O.

Handbook of Externally Powered Prostheses for the Upper Extemity Amputation

John P. Spaeth, M.S., and John S. Klotz, C.P.O., Charles C. Thomas, Publisher, 2600 South First Street, Springfield, Illinois, 62717 107 pages, four appendices, glossary, references, annotated bibliography, and index. $29.75, Spiral (paper). 1981.

This is a laudable attempt to gather together and summarize in one book a great deal of information. The goal, as described by the title, is to present a manual describing general principles and specific details of interest to practitioners involved in treating upper extremity amputees. It sketchily reviews the developmental history and describes components available, concentrating mainly on those that have had the greatest clinical application in North America. Specific criteria for prescribing for various levels of amputation are presented and illustrated with case histories. Principles involved in training and therapy are covered by two occupational therapists. Garvin Marty has contributed a most interesting chapter entitled "Business Procedures." In it he directly addresses many of the issues involved with cost that are oftentimes ignored. He reviews the practical considerations to be taken into account by the prosthetist and in doing so provides other practitioners with some insight into the problems.

While this book contains a good deal of information of practical value, particularly in the appendices that list sources of information, training, and components; overall it is somewhat disorganized, repetitious, and would have benefited from better editing. It would also seem that the authors were working with incomplete reference materials. Use of suction socket above elbow sockets is suggested, but specific reference to the article by Pentland describing such sockets is not made. The classification system of Frantz and O'Rahilly is described with reference to an article from 1961. No reference is made to later discussions describing modifications on the classification system. While the work of IBM is covered in some detail, the equally interesting work in the years from 1900 to 1945 is not mentioned.

In any event, the author here made a praiseworthy effort in assembling clinically relevant material, in a readily accessible format, of interest to clinicians. For someone looking for an overview of the topic or an introduction to it, this book should prove to be of interest.

Common Orthopedic Problems In Children,

Jacob F. Katz, M.D., Raven Press,
1140 Avenue of the Americas, New York, New York, 10036.
210 pages, Glossary, Bibliography, and Index. $22.50

This book is primarily intended for practicing pediatricians and others involved in the routine treatment of children and is written by a professor of clinical orthopedics. Stress is placed on diagnosis, clinical course, and natural history. Treatment is described in very general terms with an avoidance of detail. It opens with an anatomic survey of the body, describing various conditions that affect a certain segment of the body; and concludes with a discussion of broad disease categories.

The book might best be considered as a source book for those confronted by an unfamiliar diagnosis in the notes or report of an orthopedic consultant and responsible for discussing the diagnosis and its implications with the concerned parents. While possibly useful in such terms, the absence of detailed description of treatment methods is a drawback from the prosthetist/orthotist's point of view.

Orthopedic Mechanics, Procedure and Devices

Vols. 2 and 3. edited by D.N. Ghista and R. Roaf,
Academic Press Inc. (London) Ltd.,
24-28 Oval Road, London NWL 7DX, England.
1981: Vol. 2, $82.50, 308 pages. Vol. 3, $57.00, 207 pages.

As described in the forwards, these two books in conjunction with vol. 1 are intended to provide orthopedic researchers and biomechanics students with background information necessary for research and development. The editors specifically state that the reader will have considerable knowledge of mathematics and engineering theory. Among the various topics considered are: the mechanics of the spine; scoliosis; design considerations of endoprostheses, and measuring the strength of bond non-invasively.

From the preceding it can be concluded that these two books are not the average prosthetist/orthotist's cup of tea. However, there are at least two articles of passing interest. One describes the design philosophy of **Torqueheels,** and the other describes the Salford (England) swivel walker, for paraplegics. A third, of less direct relevance by Pedotti and Ghista, discusses gait analysis.

Early Management of Acute Spinal Cord Injury

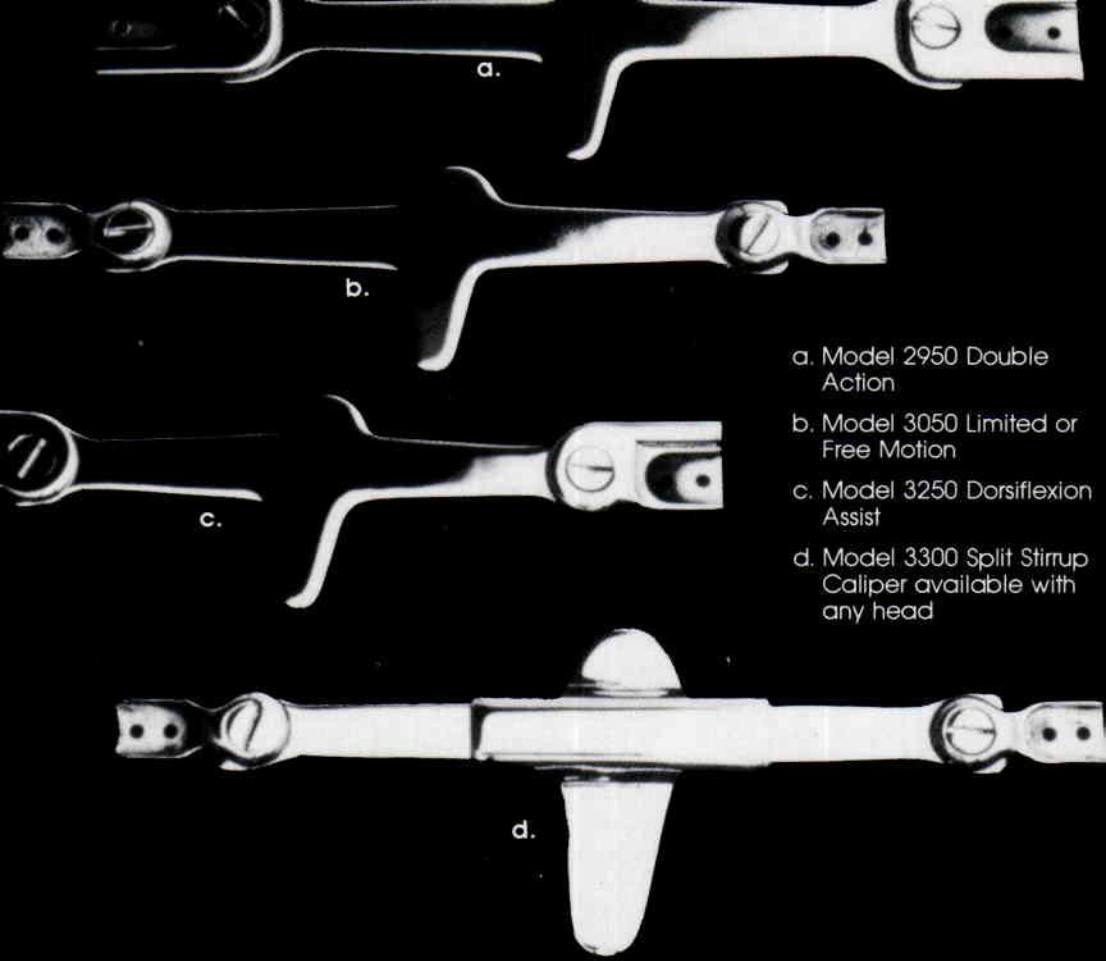
(Seminars in Neurological Surgery).
Edited by Charles H. Tator, M.D.
462 Pages, $52.00. 1982.
Raven Press, 1140 Avenue of the Americas,
New York, NY 10036.

This book is an outgrowth of a workshop dealing with the subject held in Toronto, Canada in 1980. The majority of the contributions are members of the Acute Spinal Cord Injury Unit, Sunnybrook Medical Center, Toronto and the emphasis is on management of injuries of the cervical spine. It is the avowed purpose of the book, as described by Dr. Tator, to provide physicians, nurses, and paramedical per-

sonnel with reliable up to date information about the diagnosis and treatment of individuals with cervical spinal cord injuries during the critical early days.

It discusses types of injury, mechanism of injury, radiological diagnosis, neurophysiological diagnosis, principles of treatment, urological care, surgical management, and rehabilitation. Of particular interest to orthotists are the three chapters that discuss use of Halo fixation devices. One chapter reviews the Acute Spinal Cord Injury Unit's experience in using Halo fixation treatment to reduce and maintain fractures/dislocations associated with neurological deficit. It reports on methods of treatment, problems, and outcome. The next chapter reviews the experiences of an Acute Spinal Cord Injury Unit in British Columbia in utilizing Halo-vest orthoses to treat problems of the neck without neurological deficit; principally odontoid fractures, other fractures of the cervical spine, and metastatic carcinoma of the cervical spine. The third chapter, and one of particular interest, describes management of the Halo program at the Unit in Toronto. It deals with the practical matters of applying the orthosis, maintenance of an adequate supply, and patient care of the application. It places particular stress on the role of the "Halo program coordinator," the individual at the Unit charged with maintaining stock, assisting in applying the orthosis, and subsequent follow up. Many orthotists today find themselves filling this role and the information presented should be of use to them in dealing with nurses and patients.

The book as a whole should be of use to orthotists in understanding the acute phase of spinal cord management.



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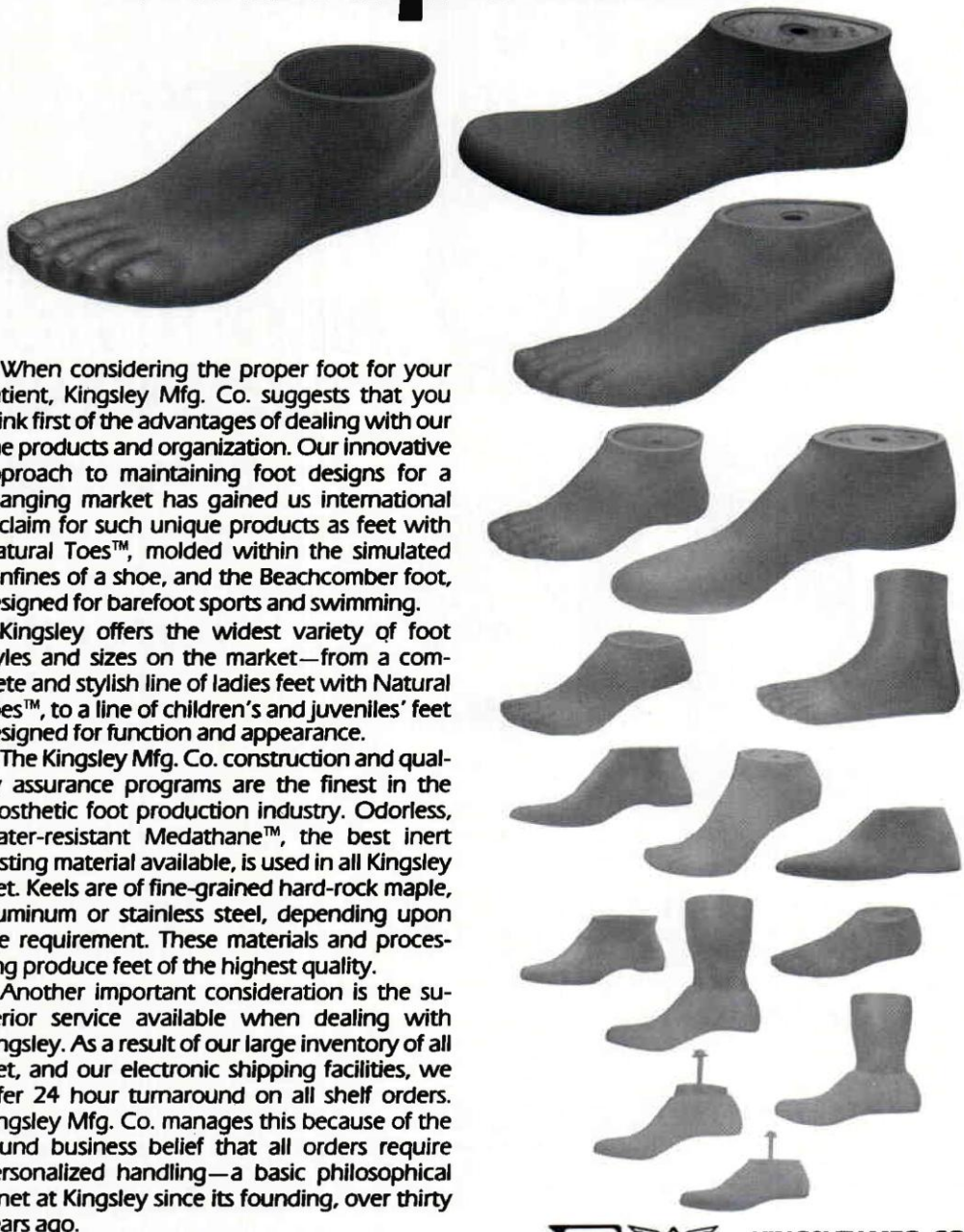

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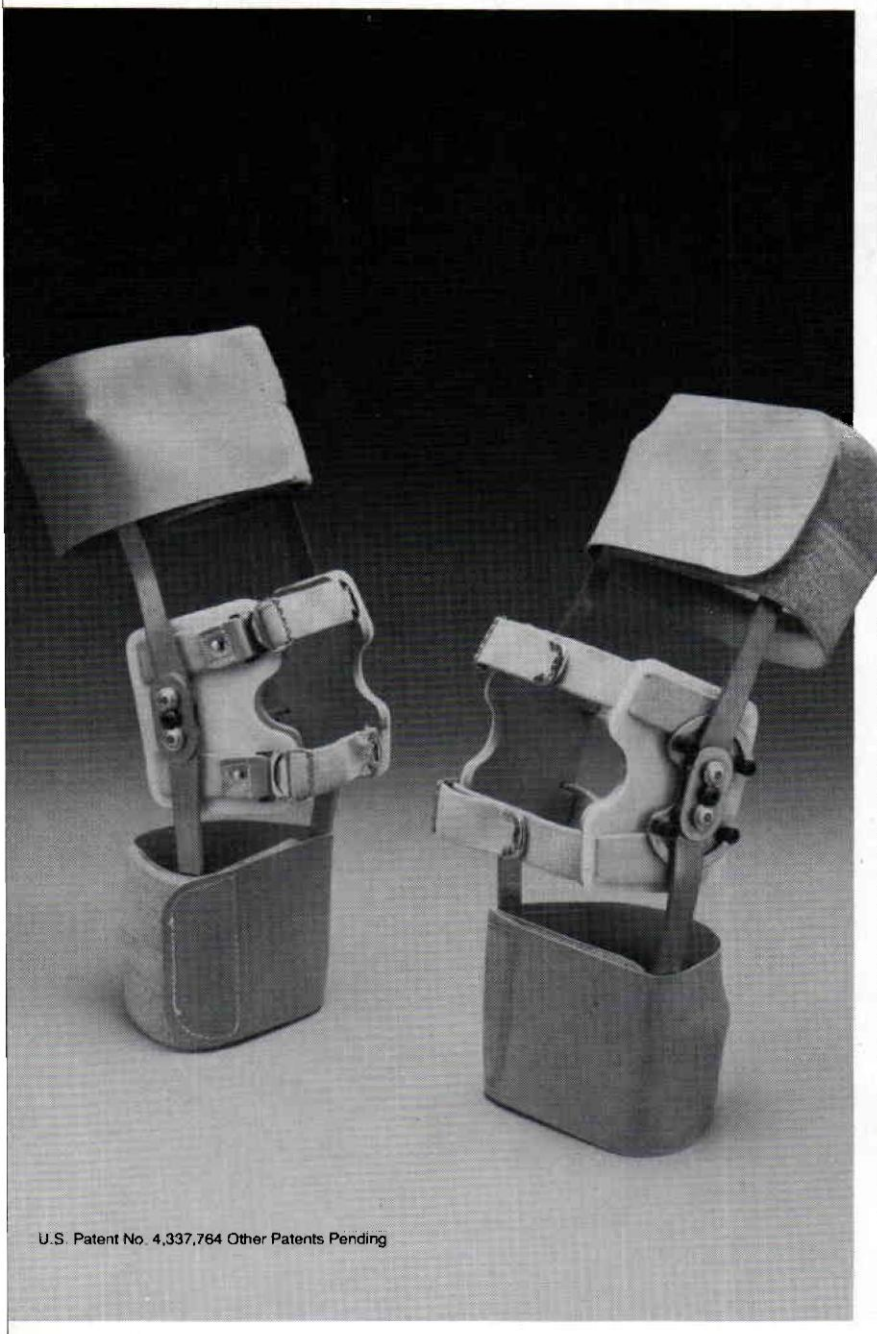

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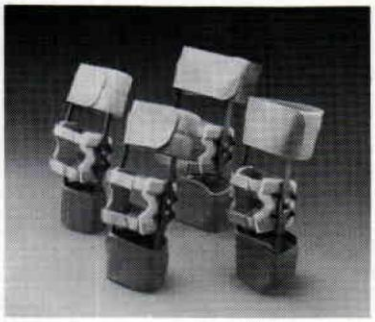

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Large - Right — A16-6RL-G000
X-Large - Right — A16-6RX-L000
Small - Left — A16-6LS-M000
Medium - Left — A16-6LM-D000
Large - Left — A16-6LL-G000
X-Large - Left — A16-6LX-L000

Free Knee Model Product Numbers:
Small - Right — A16-6RS-M001
Medium - Right — A16-6RM-D001
Large - Right — A16-6RL-G001
X-Large - Right — A16-6RX-L001
Small - Left — A16-6LS-M001
Medium - Left — A16-6LM-D001
Large - Left — A16-6LL-G001
X-Large - Left — A16-6LX-L001

USMC

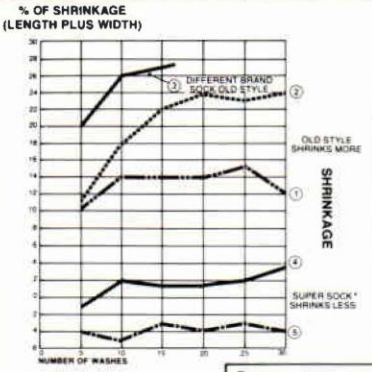
United States Manufacturing Company
180 North San Gabriel Blvd., P.O. Box 5030,
Pasadena, California 91107 U.S.A. (213) 796-0477
Cable: LIMBRACE, TWX No.: 910-588-1973

KNIT-RITE™ SUPER SOCK™ PROSTHETIC SOCK

It's CONSISTENT!

100% Fine Virgin Wool, Machine Wash and Dry

Complements the intimacy of fit, of a total contact socket.



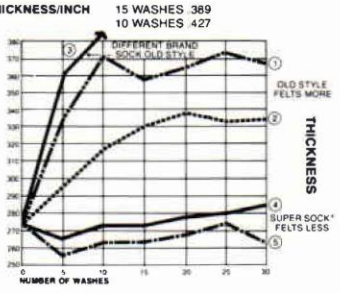
SUPER SOCK, 100% fine grade, natural virgin wool with the PLUS of, consistency, easier care, prolonged flexibility, and freedom from shrinkage and felting.

Comparison of Super Sock & Old Style Sock

MEASURED THICKNESS

	New	After 30 Wash/Dries
④ 5 Ply, Super Sock	.275"	.285"
⑤ 5 Ply, Super Sock	.275"	.265"
*① 5 Ply, Old Style Sock	.275"	.368"
*② 5 Ply, Old Style Sock	.275"	.334"

Felting and shrinkage inherent in natural wool is significantly reduced in the 100% Wool Super Sock.



① OLD STYLE SOCK — MACHINE WASH WARM WATER GENTLE AGITATION AIR DRIED NO BLEACH

② OLD STYLE SOCK — MACHINE WASH WHITE LOAD WARM WATER NO BLEACH MACHINE DRY

③ DIFFERENT BRAND REGULAR SOCK — MACHINE WASH WHITE LOAD WARM WATER NO BLEACH MACHINE DRY

④ SUPER SOCK* — MACHINE WASH WHITE LOAD WARM WATER NO BLEACH MACHINE DRY

⑤ SUPER SOCK* — MACHINE WASH WARM WATER NO BLEACH GENTLE AGITATION AIR DRIED

SUPER SOCK IS CONSISTENT 4 & 5 FLAT LINES

Different tests on the same type of knitted product will give slightly different statistical results, but the trend is constant.

FROM THE BEGINNING... and some findings

Research on the Super (wool) Sock began in the summer of 1977. Nine months passed, with many socks produced, before a sock worthy of wearing resulted. Laboratory tests preceded wear tests.

Washability tests indicated Super Sock could be machine washed and machine dried 30 times with 5% or less shrinkage. When machine washed in Ivory and air dried, the shrinkage was less than 3%. Increase in thickness fluctuated at less than .025 inch.

The Old Style socks shrank 17% when machine washed and dried 15 times. They shrank 9% when machine washed in Ivory and air dried 15 times. Thickness increase averaged .060 inch. This thickness increase is more than the thickness difference between a 3-Ply and a 5-Ply sock.

None of the Old Style wool socks were wearable after 30 wash, dry cycles using either care method of 1. machine wash, machine dry, or 2. machine wash with Ivory and air dry.

If the average amputee purchased twelve socks and wore a clean sock after each wearing, he would need approximately 30 wash-wears, from each sock, to service him for one year.

In 1978 wear tests with a small group of individuals was underway. Participants were a cross section, including office workers, farmers and professionals. They wore the test socks. We laundered the socks and kept the data. At the end of 1981, some of these socks are still on test! Socks became more pliable in the wear situation than in the laboratory test situation. Wear tests with this small group of amputees preceded development of production techniques. Testing and development continued through 1979.

By spring of 1980 Super Sock was being tested on a broader scope in the field. Several prosthetic facilities made Super Socks available to their amputee clients. These individuals were asked to evaluate the socks a year later.

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

Of those using the Super Socks, 85% washed them in the machine, half drying them in a dryer and half air drying them. Even the 15% who continued to wash their socks by hand, and air dry, were quite generous in their praise.

MORE THAN 3 YEARS OF RESEARCH

And a 100% Natural Virgin Wool Sock with the Super Plus was ready!

Super Sock was introduced in September 1980 at the National Assembly of the American Orthotic and Prosthetic Association. It is now available in 3-ply, 5-ply and 6-ply stock sizes and in all special sizes. Consult your prosthetist for the sock best suited to your individual needs.

BY KNIT-RITE™

Call Toll Free: 1-800-821-3094

KNIT-RITE, INC.

BOX 208 / KANSAS CITY, MO 64141 U.S.A. / PHONE: (816) 221-5200

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'An Exciting New Company Over 60 Years Old'

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