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Volume 39
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Orthotics and Prosthetics

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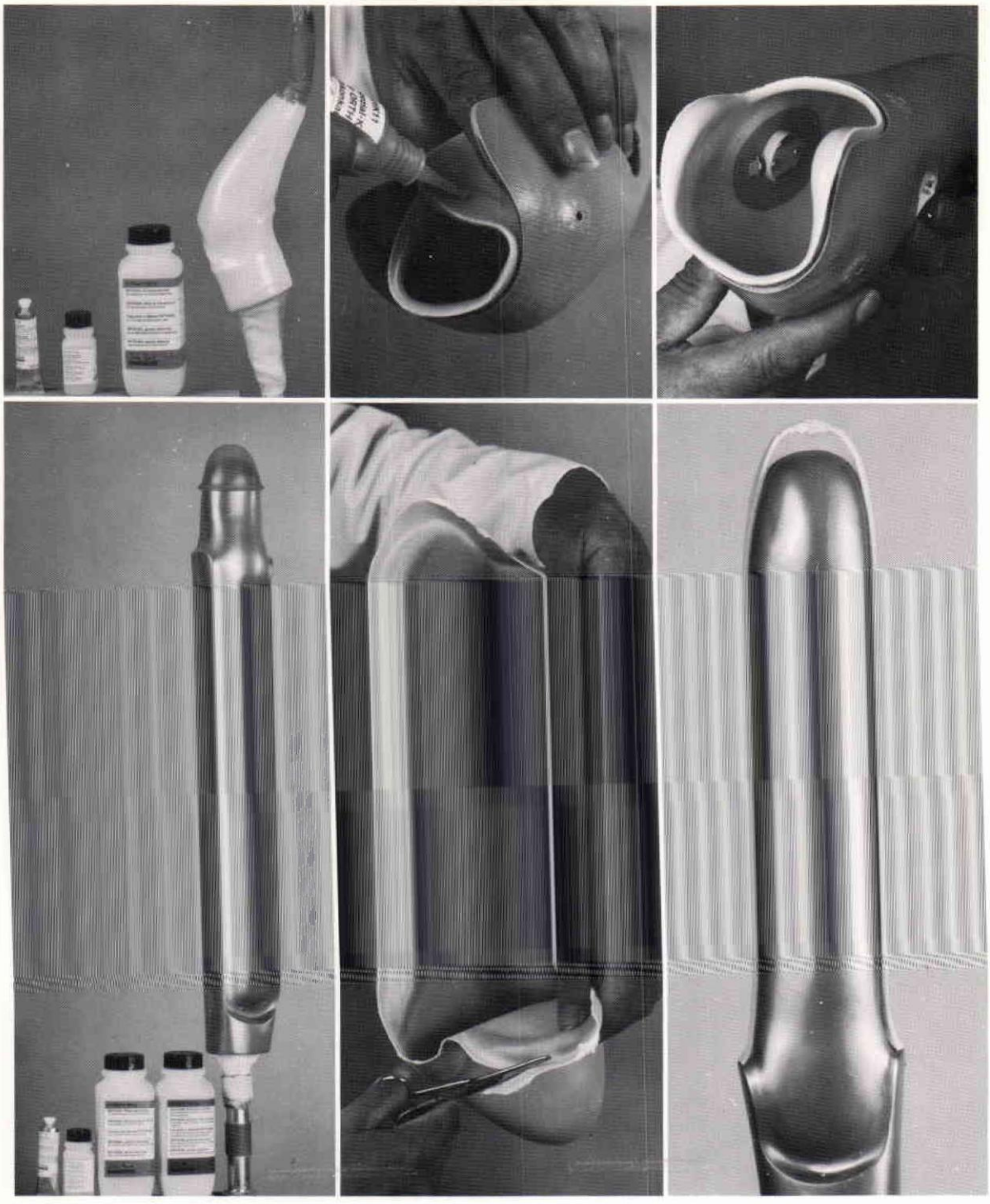

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Autumn, 1985 **Volume 39, Number 3**

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1985

October 15–20, AOPA Annual National Assembly, Town and Country Hotel, San Diego, California. Contact: AOPA National Headquarters, 703-836-7116.

October 22–24, Second International Conference on Rural Rehabilitation Technologies, University of North Dakota, Grand Forks, North Dakota. Contact: ICRRT Headquarters, Box 8103, University Station, Grand Forks, North Dakota 58202; tel. 701-777-3120.

October 31–November 1, The 1985 National Sports Prosthetics/Orthotics Symposium, Bayview Holiday Inn, Santa Monica, California. Contact: Tim Staats, CP, UCLA POEP, Room 2246, Rehabilitation Center, 1000 Veteran Avenue, Los Angeles, California 90024; tel. 213-825-6341.

November 2, Midwest Chapter of the Academy Fall Continuing Seminar.

November 2–3, Lower Extremity Prosthetics Update, Holy Cross Hospital, Fort Lauderdale, Florida. Contact: Esther S. Durbano, Program Coordinator, Physical Medicine and Rehabilitation Services, Holy Cross Hospital, 4725 N. Federal Highway, P.O. Box 23460, Fort Lauderdale, Florida 33307; tel. 305-771-8000.

November 8–9, A Lower Limb Prosthetic Symposium Clinical Frontiers, Featuring Ivan Long, CP; Dale Berry, CP(C); John Michael, CPO. Sponsored by Duke University Medical Center, Department of Prosthetics and Orthotics. Contact: John Michael, CPO, Director, Dept. of Prosthetics and Orthotics, Box 3885, DUMC, Durham, North Carolina 27710.

November 13–15, Hosmer Electric Components Seminar/Workshop Dallas. Contact: Catherine Wooten, Hosmer Corp., 561 Division St., Campbell, California 95008, Telephone (408) 379-5151.

November 15–16, American Academy of Orthotists and Prosthetists Continuing 5-85, "Powered Limb Prosthetics," Downtown Holiday Inn, Atlanta, Georgia.

November 15–17, Medithon '85, multidisciplinary seminar devoted to running injuries, Hotel Intercontinental, San Diego, California. Contact: Medithon '85, P.O. Box 89, Jackson, Michigan 49204.

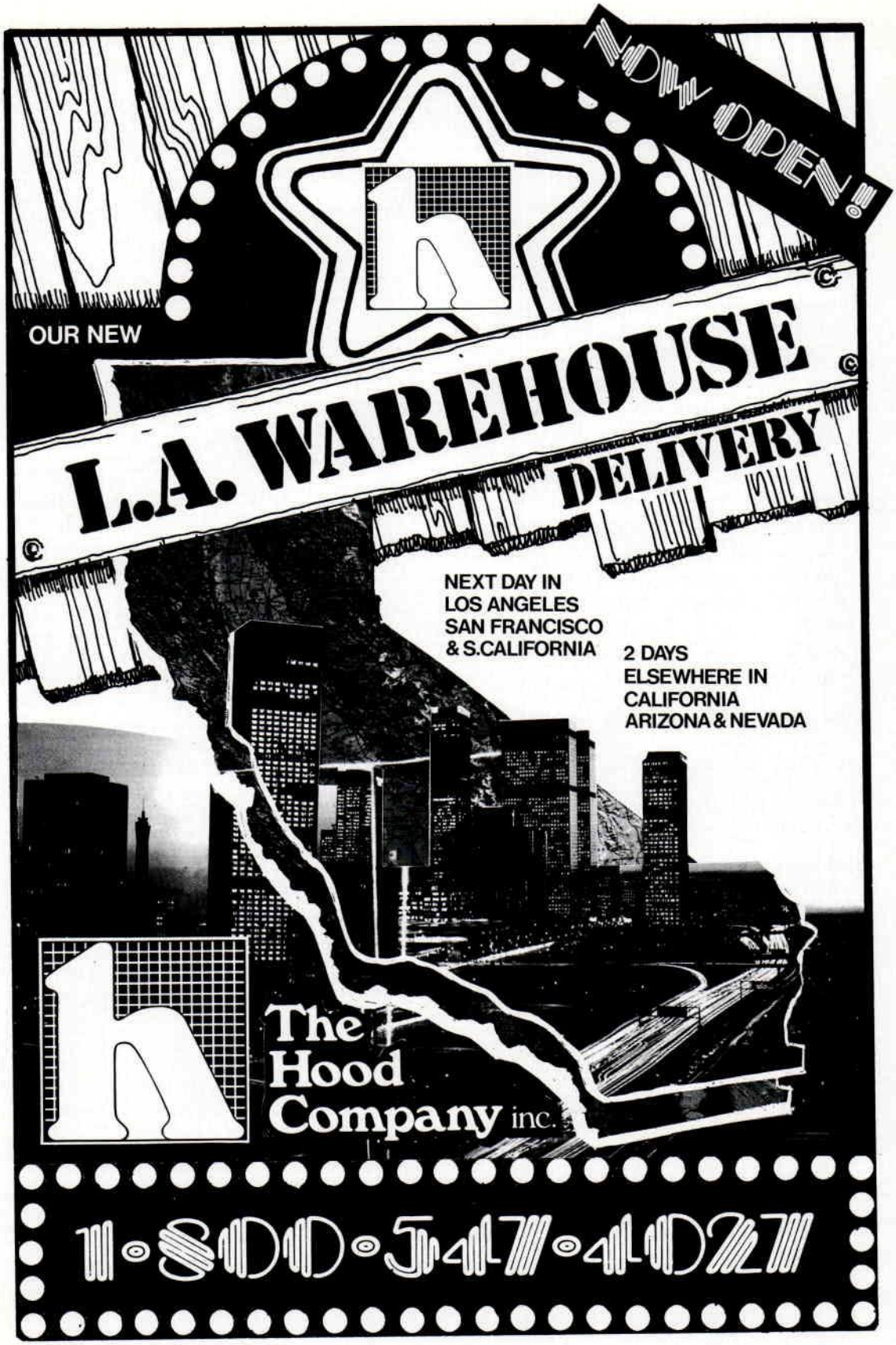
November 18–19, Second European Conference on Research in Rehabilitation, Dusseldorf, Federal Republic of Germany. Contact: Conference-Secretariat Prof. K.A. Jochheim, Rehabilitationszentrum der Universitat zu Koln, Linderburger Allee 44, D-5000 Koln 41, Federal Republic of Germany; Tel. 02 21-4 78 50 12.

December 3–6, "Credentialing Revisited Practical Approaches to Familiar Problems," Nat'l. Comm. for Health Certifying Agencies, 9th Annual Meeting, Marriott Marquis Hotel, New York, New York.

December 6–8, "The Geriatric Foot: A Multi-Disciplinary Approach," Dept. of Family Practice, Div. of Podiatry, Univ. of Texas Health Science Center at San Antonio. Contact: Med. School Continuing Ed. Services, UTHSCSA, 7703 Floyd Curl Drive, San Antonio, Texas 78284; tel. 512-691-6295.

1986

January 20–26, HANDEX '86, China's First National Care for the Handicapped Exhibition, Military Museum, Beijing, People's Republic of China. Contact: Harry Lepinske, Internatioal Marketing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January 27–February 2, Academy Annual Meeting and Scientific Seminar, MGM Grand, Las Vegas, Nevada. Contact: Academy National Headquarters: 703-836-7118.

February 20–25, American Academy of Orthopedic Surgeons Annual Meeting, New Orleans, Louisiana.

March 2–5, 3rd Israel-Scandinavian Rehabilitation Seminar, "ISRASCAN: Work for Disabled Adults," Eilat, Israel. Contact: Israel Rehabilitation Society, 18 David Elazar Street, Tel Aviv 61901, Israel.

March 13–15, American Academy of Orthotists and Prosthetists Continuing Education Conference 1-86, "Spinal and Seating Orthotics," Birmingham, Alabama.

April 8–11, Pacific Rim Conference, Intercontinental Hotel, Maui, Hawaii.

April 9–12, Ambulatory Surgery in 1986—What's Happening Now. Freestanding Ambulatory Surgery Association, Boston Marriott Copley Place, Boston, Massachusetts. Contact: 703-836-8808.

April 10–12, New England Chapter of the Academy Spring Seminar, Dunfey Hotel, Hyannis, Massachusetts. Contact: E. Janulaitis, CPO, tel. 617-586-7700.

April 12, Midwest Chapter of the Academy Spring Continuing Education Seminar/ Social Event.

April 17–20, AOPA Region IV Annual Meeting, Orlando, Florida.

May 16–17, American Academy of Orthotists and Prosthetists Continuing Education Conference 2-86, "Disarticulation Prosthetics," Ann Arbor, Michigan.

May 28–30, S.M. Dinsdale International Conference on Rehabilitation, "Towards the 21st Century," hosted by the Royal Ottawa Regional Rehabilitation Centre, 505 Smyth Road, Ottawa, Ontario K1H 8M2. Contact: Education Dept. tel. 613-737-7350, ext. 602.

May 29–June 1, AOPA Region V Annual Meeting.

June 6–8, AOPA Region IX, COPA, and the California Chapters of the Academy Combined Annual Meeting, Newport Beach Marriott, Newport Beach, California.

June 11–14, AOPA Regions VII, VIII, X, and XI Combined Annual Meeting, Alameda Plaza, Kansas City, Missouri.

June 19–22, AOPA Region VI and Academy Midwest Chapter Combined Annual Meeting, Lakelawn Lodge, Delavan, Wisconsin.

July 18–19, American Academy of Orthotists and Prosthetists Continuing Education Conference 3-86, "Spina Bifida," Cincinnati, Ohio.

August 5–7, Canadian Association of Prosthetists and Orthotists bi-annual national convention, World Trade Centre, Halifax, Nova Scotia, Canada. Contact: Novia Scotia Rehabilitation Centre, Orthotics/Prosthetics Unit, 1341 Summer Street, Halifax, Nova Scotia B3H 4H4, Canada.

September 19–20, American Academy of Orthotists and Prosthetists Continuing Education Conference 4-86, "Powered Limb Prosthetics," Newington, Connecticut.

October 24–25, American Academy of Orthotists and Prosthetists Continuing Education Conference 5-86, "Lower Limb Prosthetics," Kansas City, Missouri.

November 4–9, AOPA Annual National Assembly, Marriott's Orlando World Center, Orlando, Florida. Contact: AOPA National Headquarters, 703-836-7116.

1987

January 22–27, American Academy of Orthopaedic Surgeons, Annual Meeting, San Francisco, California.

February 15–22, Academy Annual Meeting and Scientific Seminar, Hyatt Regency Tampa, Tampa, Florida. Contact: Academy National Headquarters, 703-836-7118.

July 5–10, International Conference on Disability Education, Jerusalem, Israel. Contact: Israel Rehabilitation Society, 18 David Elazar Street, Tel Aviv 61901, Israel.

July 12–16, International Conference of Rehabilitation Journalists, Jerusalem, Israel. Contact: Israel Rehabilitation Society, 18 David Elazar Street, Tel Aviv 61901, Israel.

September 21–27, AOPA Annual National Assembly, Hyatt Regency Hotel, San Francisco, California. Contact: AOPA National Headquarters, 703-836-7116.

1988

October 25–30, AOPA Annual National Assembly, Sheraton Washington Hotel, Washington, D.C. Contact: AOPA National Headquarters, 703-836-7116.

1989

October 2–8, AOPA Annual National Assembly, MGM Grand Hotel, Reno, Nevada. Contact: AOPA National Headquarters, 703-836-7116.

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Reader's Forum

It is with some embarrasment that we here at *Orthotics and Prosthetics* must disclose that we are at fault for the recent confusion regarding the article published in this journal (Vol. 38, No. 3), "A New Orthosis for Fixation of the Cervical Spine—Fronto-Occipito-Zygomatic-Orthosis."

After communication with Messrs. Nakamura, et. al., it was learned that indeed a bibliography was submitted, yet was not included at the end of the published article. The bibliography, while submitted with the manuscript, was somehow overlooked and not published. This is an unfortunate error, and, thankfully, a rarity. I would at this time like to make a formal apology to Messrs. Nakamura, et. al. and Dr. Rubin, et. al.

We at *Orthotics and Prosthetics* would like to pledge our renewed efforts to prevent any further ommissions and to present a more error-free journal in the future. The omitted bibliography appears to the right.

The Editor

References for "A New Orthosis for the Fixation of the Cervical Spine—Fronto-Occipito-Zygomatic-Orthosis," *Orthotics and Prosthetics*, Volume 38, Number 3:

[1]Edmonson, A.S.: "Spinal Orthotics," *Orthotics and Prosthetics*, 31, 31–42, 1977.

[2]Johnson, R.M., et al.: "Cervical orthoses," *J. Bone and Joint Surg.*, 59, 332–339, 1977.

[3]Rubin, G., et al.: "An occipito-zygomatic cervical orthosis designed for emergency use," *Bulletin of Prosthetics Research*, 10–29, 50–64, Spring, 1978.

[4]Wilson, C.L., et al.: "A new non-invasive Halo orthosis for immobilization of the cervical spine," *Orthotics and Prosthetics*, 32, 16–19, 1978.

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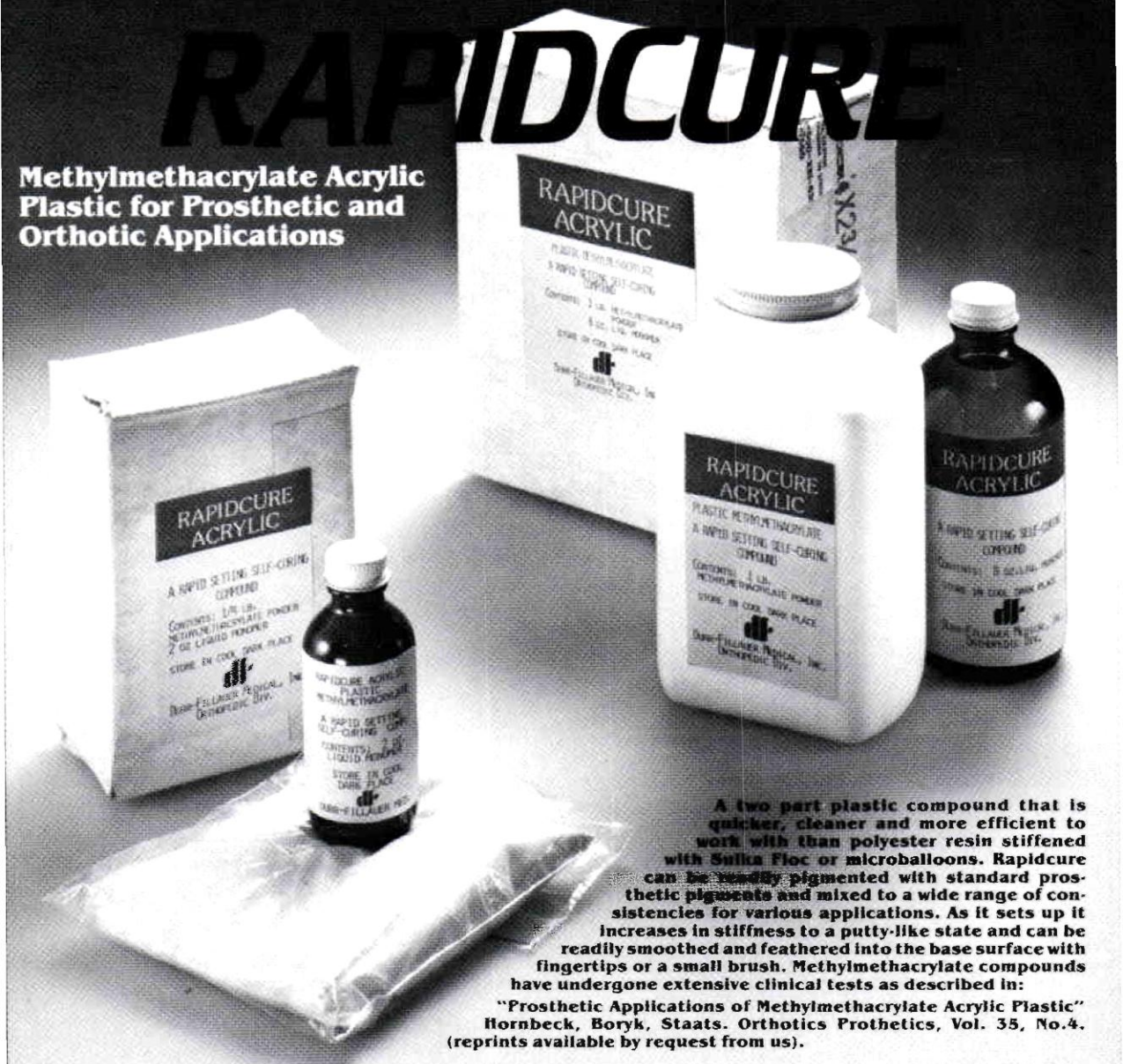

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   b. Original drawings or charts

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Orthotics and Prosthetics, Vol. 39, No. 3, pp. 14–20.

New Orthosis for Treatment of Hemiplegic Shoulder Subluxation

Joseph Brudny, M.D.

INTRODUCTION

Hemiplegia, resulting from stroke, head trauma or cerebral palsy, constitutes the leading cause of chronic disability and financial hardship in the United States. Over 500,000 new cases of stroke are reported each year, and at least one-third of these patients are wage earners. Effective rehabilitation of motor deficits related to brain insults is obviously an important problem facing health professionals.

Ambulation in hemiplegia usually depends on stability of the foot and ankle. In this respect, the orthotic contribution of restoring mobility in hemiplegic patients is a most significant one. The ankle-foot orthosis (AFO) stabilizes the weight-bearing part of the lower limb and makes ambulation possible, in up to three out of four patients.

In stark contrast, only one out of five hemiplegic patients ends up having any use of the upper limb, frequently because of loss of shoulder function. The function of the shoulder joint is to precisely position the arm in space in order to allow self-care and manipulation of the environment by the forearm and hand.[1] When shoulder subluxation, present in more than one-third of hemiplegic patients, complicates the course, the recovery rate drops to zero as a rule.

HEMIPLEGIC SHOULDER SUBLUXATION

The subluxation of the shoulder in hemiplegia is due to a decrease of cerebral control over the patterned and coordinated interaction of muscles controlling the position and movement of the scapula and humerus, with the result that spastic muscles tilt the scapula laterally and paretic muscles contribute to unseating of the humeral head from the glenoid fossa. Pain and reflexive spread of spasticity invariably result from attempted movement, and the recovery of shoulder function lags behind that of the elbow and wrist.[2]

Conventional therapy is usually of little use. Most patients, therefore, are advised to wear a shoulder sling, which, in fact, does not reduce the subluxation nor relieve pain and, if anything, perpetuates the limb's pathological synergy position.[3]

The Functional Shoulder Orthosis (FSO),† described in this article is a product of years of clinical and orthotic research. In radical contrast to available alternatives, the FSO reduces shoulder subluxation, eliminates pain, prevents spreading of spasticity, places the arm in a phy-

†Camp International, Inc.
109 W. Washington Street, Box 89
Jackson, Michigan 49201

siological position of function (abduction, flexion, and external rotation), and allows freedom of motion of forearm, wrist, and hand, with an opportunity for their retraining.

FUNCTIONAL SHOULDER ORTHOSIS

The FSO is made of modular parts, which interact dynamically with each other.

A stainless steel ball-and-socket joint (not unlike the glenohumeral joint) is externally interposed between the chest and arm and is attached to the torso by a comfortable and sturdy foundation of pelvic and thoracic bands and uprights. A grooved steel rod threads into the ball and is similar in its role to that of the humeral shaft in man. The ball can be made mobile in the socket, giving the humeral rod a range of motion comparable to that of the humerus. The ball can also be locked in any position with the humeral rod assuming the desired degree of flexion, abduction or extension (Figure 1).

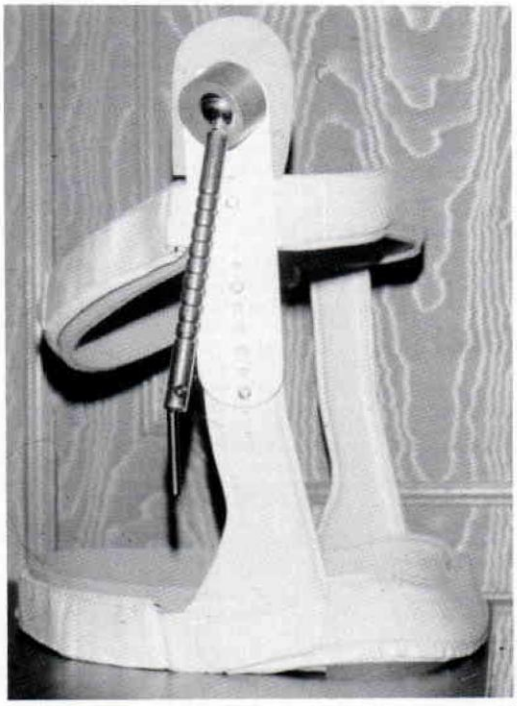

Figure 1. The ball-and-socket joint of the Functional Shoulder Orthosis, with humeral rod.

A pair of cuffs, humeral and forearm, attach to the limb above and below the elbow, respectively. These are connected by medial and lateral hinged bars forming an orthotic elbow joint with options of full or partial range of motion or stability at any desired angle. An aluminum block attached to the humeral cuff moves vertically over the humeral rod and also rotates around it, completing the assembly of the FSO (Figure 2).

When the elbow joint of the orthosis is prevented from extending beyond 150° by a stop lock, and the block is selectively elevated on the rod and fixed by a locking bolt in one of its grooves, a constant pressure is exerted against the upper ulna by the forearm cuff. This pressure, transferred axially to the humerus, repositions the humeral head into the glenoid fossa. The locking bolt, when further tightened in the selected groove, will stabilize the arm at any desired degree of rotation (Figure 3).

The orthosis is completely modular in design, is available in different sizes, and its fit and assembly by the orthotist are simple and minimally time consuming.

STUDY OF USEFULNESS OF THE FSO

The FSO, in its various prototype and final stages, was tested on eight chronic hemiplegic patients with unilateral, nonfunctional upper limbs with shoulder subluxation. All of the patients reached a limit in their conventional physical therapy program, and all were discharged with advice to wear a shoulder sling permanently.

Their ages ranged from 40 to 69. Five were men and three were women. Five patients were afflicted on the right side and three on the left. The duration of their illness ranged from one and one-half years to four and one-half years. The degree of shoulder subluxation in a standing position ranged from 22mm to 8mm, as determined by palpation and, in some, by X-rays. All patients had pain and exhibited

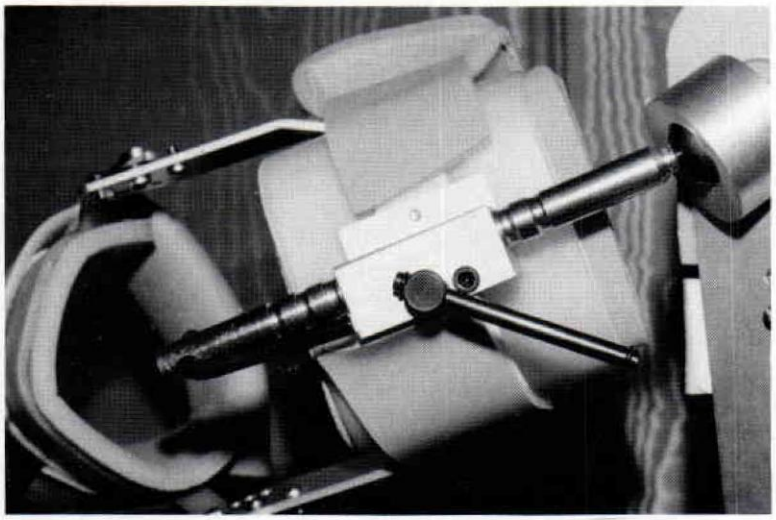

Figure 2. Hinged forearm and humeral cuffs are attached to a block which moves vertically over the humeral rod and also rotates around it.

spasticity with synergies and no voluntary control.

With the FSO in place, the reduction of subluxation was immediate and complete, and provided total relief from pain, with prompt lessening of spasticity induced flexion synergies. Such response, in all patients, allowed a course of neuromuscular re-education, or training of the patient for volitional control over dysfunctional muscles.[4]

The first phase of training was conducted in the office and was usually augmented by sensory EMG feedback from attempted or evolving movement.[5] Over a course averaging 20 treatments of 30 to 45 minutes each—given twice a week—all patients developed the ability to flex and extend the forearm in a coordinated fashion, with extension aided by the forearm cuff counter-pressure. They also learned to relax volitionally the spastic wrist and finger flexors. Two left hemiplegics with marked perceptual motor difficulties and poor motivation declined further training.

The remaining six patients were provided with the FSO and continued its use as a training aid at home with no further sensory augmentation. Their spouses or aides received a brief office demonstration of proper FSO fitting and were instructed regarding the extent and duration of a daily self-executed exercise program at home. This phase of training lasted four months

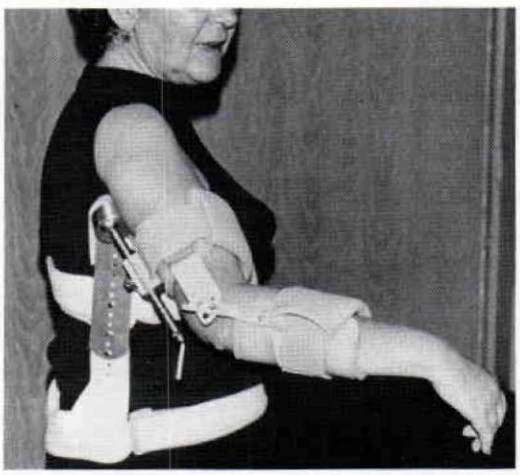

Figure 3. The humeral head is maintained in glenoid fossa by pressure exerted against upper ulna by forearm cuff and transferred axially to the humerus.

on the average, with the patients being followed-up in the physician's office at monthly intervals.

RESULTS

One patient with left hemiplegia did not progress beyond the initial stage and discontinued the training. Two patients with right hemiplegia developed bulk, power, and response to volition in previously paretic muscles of the shoulder girdle. This led to elimination of shoulder subluxation with the ability to flex and abduct the arm

without the use of an orthosis. They also retained the ability to flex, extend, pronate and supinate the forearm, and one acquired the ability for prehension and release of variously sized and shaped objects. Three patients with right hemiplegia who were not able to achieve control of the shoulder without wearing the FSO similarly learned acquisition and release of objects with full forearm mobility. These three patients have continued using the orthosis daily for a number of bimanual activities of daily living, not possible otherwise. The therapeutic usefulness of the FSO can be best illustrated by the response of one of these patients.

CASE HISTORY

Mary M., age 51, a right handed registered nurse, was first seen two years after onset of right hemiplegia and global aphasia caused by cerebral hemorrhage.

She received three months of physical therapy in a hospital affiliated with a medical school and returned home capable of mobility with assistance of a lower limb orthosis and cane. Her totally non-functional upper limb with subluxation of shoulder was placed in a sling, and she was advised to use it permanently. In the next six months, there was return of speech and comprehension, but no change in the status of the upper limb, despite continuing physical therapy.

On initial examination, marked subluxation at the right shoulder was noted (Figure 4). The hemiparetic-spastic motor deficits were evident by atrophy of limb muscles, increased DTR's, flexion of fingers, presence of cortical thumb, and clonus of the wrist. Superficial sensation to touch and pinprick was decreased distally, but position sense was well preserved, including the wrist and fingers.

X-rays of her right shoulder confirmed the extent of subluxation and at the same time demonstrated the downward rotation of the glenoid fossa contributing to the subluxation mechanism (Figure 5).

Pain at the shoulder was constant, limiting her attempts at any isolated voluntary

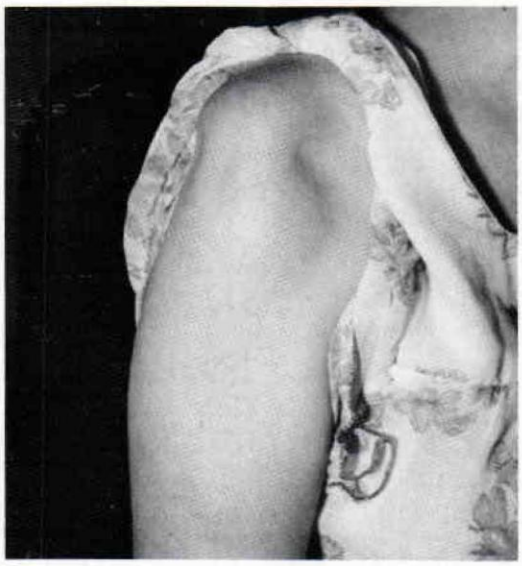

Figure 4. Considerable shoulder subluxation in hemiplegic patient.

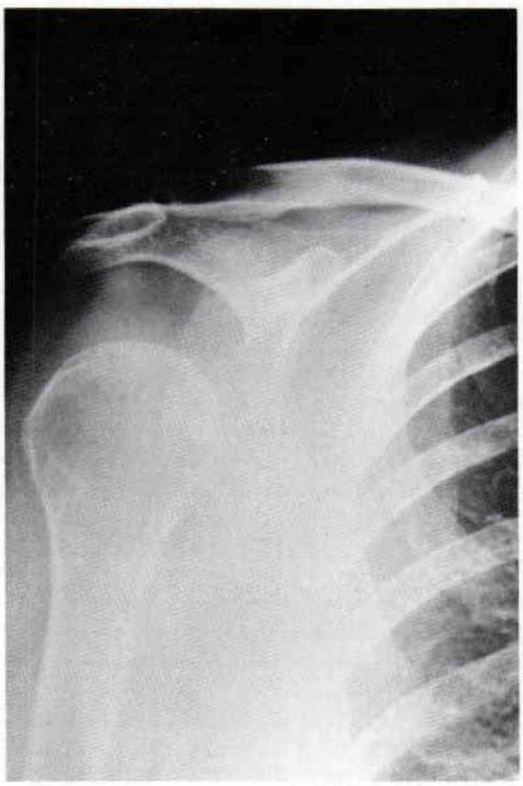

Figure 5. X-ray of patient in upright position demonstrates the degree of shoulder subluxation.

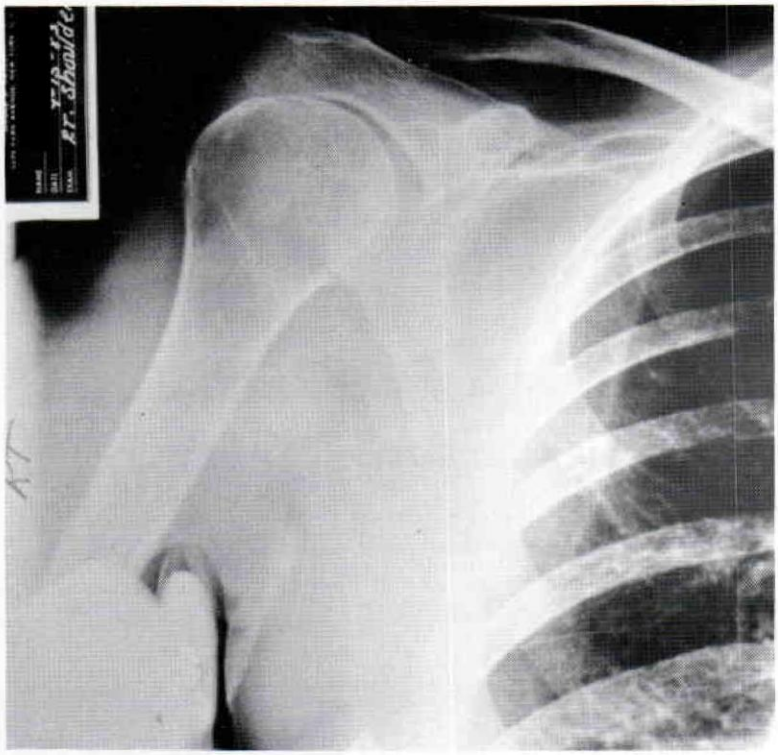

Figure 6. Same patient with FSO attached demonstrates complete reduction of shoulder subluxation.

movement. However, when a prototype of the FSO was attached, pain was instantly eliminated and subluxation was reduced (Figure 6).

During the very first session, with the aid of the FSO, Mary was able to show fairly isolated voluntary flexion of the forearm, with marked decrease of reflexive spasticity in the entire limb.

After initial course of training in the office she continued using the FSO during the four month home phase of training and then as a permanent aid in activities of daily living. She learned rapid and fully coordinated flexion and extension of her forearm, with spatio-temporal facilitation and inhibition of the agonist-antagonist muscle interaction, as documented by multi-channel EMG recordings. Supination and pronation of the forearm have become functional.

She learned volitional relaxation of finger and wrist flexors and combined such with dorsiflexion of the wrist for functional two- and/or three-point tenodesis pinch. This allowed her to acquire and release spherical, cubic, and cylindrical objects in a functional manner, including foot items, so that she could feed herself with her right hand (Figure 7).

With the FSO, she carries out bimanual activities that add to her independence as a homemaker; for example, she is able to slice vegetables (Figure 8), and pick up and carry bimanually various objects, such as pots and pans (Figure 9). In performing these motor tasks, she demonstrates individual joint movement with coordination, and thus could be rated as stage VI on the Brunnstrom Scale, while upon initial examination she was rated as stage II, showing spasticity with synergies and no voluntary control (Brunnstrom, 1970).[6]

BENEFITS OBTAINED FROM USE OF A FSO

Based on the outcome of this preliminary study, certain conclusions seem evident:

- The reduction of shoulder subluxation immediately eliminates pain and the

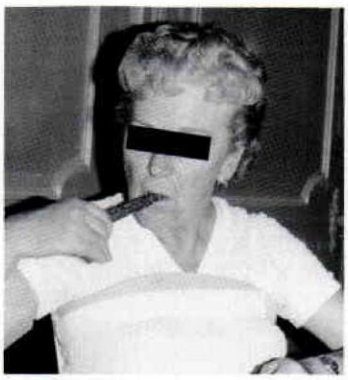

Figure 7. Patient with FSO in place is capable of increased independence in activities of daily living, for example, feeding herself.

Figure 8. Bimanual activities such as slicing vegetables are possible with aid of the Functional Shoulder Orthosis.

Figure 9. Bimanual lifting and carrying of large and heavy objects, such as pots, is possible with aid of the Functional Shoulder Orthosis.

spread of reflexive muscles' spasticity on attempted movement, providing comfort to the patient.

- The physiological positioning of the arm in abduction, flexion and, usually, external rotation, promotes stretching and elongation of spastic muscles of the scapula and arm and gradually decreases their detrimental activity while at the same time prevents elongation and further weakening of the paretic and unresponsive muscle groups. In time, the latter may become more responsive and functional, reversing the very mechanism of subluxation and causing its reduction.
- The elimination of pain and the spread of spasticity offer an opportunity for acquisition of voluntary movement of the limb. The patient can concentrate first on facilitation and inhibition of a key agonist muscle activity such as biceps, with acquisition of its motor control. In time, the patient can learn to coordinate simultaneously, in an orderly manner, the facilitation and inhibition of agonist-antagonist muscles, such as biceps and triceps.
- The physiological position of the upper limb, with freedom to pronate, supinate, flex, and extend the forearm, helped some of the patients to concentrate on and master more peripheral functions such as the volitional relaxation of spastic fingers and wrist flexors with simultaneous volitional wrist dorsiflexion. The result of this was a crude, wrist tenodesis controlled, ability to acquire objects. In one patient, finger extension and thumb abduction, adduction, and opposition were also achieved, offering more skilled prehension and more rapid release.
- The use of an FSO at home over extended time periods stresses the concept of self-help, offering to the patient the opportunity of many of hundreds of thousands of proper movement repetitions, which are essential for repatterning of movement to occur.
- In many patients, the Functional Shoulder Orthosis as a training device may be needed for an extensive time, but eventually discontinued at some point. In others, its more permanent use (comparable to that of the ankle-foot orthosis) is acceptable, considering the benefit of functional use of forearm, wrist, and hand, and bimanual activities, which would not otherwise be possible. The acceptance of the FSO, including the cosmetic aspect, was uniform, and no skin pressure was noted even with prolonged wear of the device.
- Success derived from use of an FSO seemed to be directly related to motivational drive, ability to handle information, the involvement of the dominant limb, independent ambulation, and a supportive environment.

• The FSO offers an opportunity to materially alter the non-functional status of upper limb in many patients with hemiplegic shoulder subluxation. With proper patient selection, professional supervision, family education, and orthotic support, the numbers of such patients can be considerable, while the psychological and socioeconomic benefits are most gratifying.

OTHER USES FOR THE FSO

Loss of shoulder function is of serious consequences in any illness or injury and limts the use of the entire limb, resulting more often than not in permanent disability of the afflicted individual.[7] The FSO can, therefore, also be a valuable aid where traumatic, inflammatory, and degenerative diseases have affected the shoulder joint and temporarily compromised its crucial function of self-care and control of environment. The Functional Shoulder Orthosis can be used in conservative treatment of postsurgical phase of fractures of humeral neck and head, rotator cuff tears, and posterior shoulder dislocations; in incomplete brachial plexus lesions (C5, C6); in frozen shoulder and shoulder/hand syndromes; and in the postsurgical phase of total shoulder joint replacement. With the shoulder securely stabilized and the arm kept in a physiological position of function, the forearm and hand can be used functionally during the often lengthy period of the needed shoulder immobilization.

CONCLUSION

Orthotists have historically played a unique role in interacting between professionals (physicians, physical and occupational therapists) and patients, often educating the former while always serving the best interests of the latter.

Concerning the hemiplegic patient, orthotists have contributed significantly to restoring the main function of the lower limb, i.e. mobility. The introduction of the Functional Shoulder Orthosis has opened up a vast area of new orthotic input towards a more meaningful rehabilitation of the upper hemiplegic extremity as well.

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The Open Brace Ring Halo Orthosis

Karl Fillauer, C.P.O.

INTRODUCTION

Today both the management and orthotic care a patient with a severe cervical injury receives have changed. The recent entrance of orthotists in the management of this area has allowed for improved designs and application techniques. Five years ago orthotists were usually not involved with management of a patient with a severe cervical injury. These patients were treated by traction and bed rest, placed in a plaster Minerva jacket, or had a cervical fusion, and then maybe were fitted with a cervical orthosis.

In the Knoxville, Tennessee area, physicians listed as their main reasons for the limited use of the halo orthosis the inconvenience in procuring the device, and the time and difficulty in applying the orthosis to the patient. They, in general, did not see much advantage in using halo orthoses.

HISTORY

The first halo orthoses were used for the management of massive paralysis of the neck muscles. The halo system consisted of a plaster cast and metal superstructure. Soon the halo system was applied to patients with cervical fractures. In 1972, the "low-profile" halo system was introduced by Loutkin and Levine.[1] Our involvement with a halo system was initiated in 1979, when the staff at Duke University asked if Durr-Fillauer would consider designing a system. The intent was to improve on the currently available designs and make the application easier and less time consuming. The average time required to apply a halo orthosis was 1½ hours. The first halo vest orthosis of the new design was fitted six years ago in Knoxville, Tennessee. The University Hospital had an orthopedic residency program at that time and the physicians were very helpful.

The hospitals in the area all stated that the use of a halo orthosis was very limited and they did not expect many applications. The expectation was not so much to stimulate more work but to obtain experience in the management of cervical injuries. Orthotists have commonly dealt with mild cervical injuries with various designs such as the four poster cervical orthoses, S.O.M.I.® and other similar items, but stayed clear of serious injuries to the cervical spine because they had little to offer the physician.

After several fittings of the prototype versions, the conviction grew that not only could the design be improved, but the orthotist could function as a valuable assistant to the physician during the application. This assistance prompted other physicians to try the halo system because of the availability of the hardware and the technical help. Today five to six Halo vests per month are being supplied in the Knoxville area. This is a dramatic change from five years ago, when there were only two to

three fittings per year. This initial train of development has led to the basic Durr-Fillauer Halo vest, which has been in clinical application for six years now.

DESIGN OBJECTIVES

Working with the basic D-F halo in addition to other designs and noting the drawbacks helped to determine design objectives that would be incorporated into the current open back halo ring. The evolution of this design has occurred over several years. It was noted that most of the patients followed a similar series of events. First, patients are placed in some type of traction. Then, in some cases, they undergo cervical fusion, and finally are placed in a halo orthosis.

One of the first goals was to design a system that could be used for traction and surgery, yet later be integrated with the halo vest. The ring needed to have the posterior section open so that the patient's head would lie on the bed without rocking or loading of the pins from the weight of the head. This configuration would also afford the surgeon maximum access to the posterior structures of the neck and skull. The ability to use either the standard or the spring loaded self-adjusting skull pins was important as well (Figure 1). Another objective was to eliminate all components that were not essential to the structural integrity of the system. It was felt that there were some areas of the halo vest that could be removed without detrimental effects.

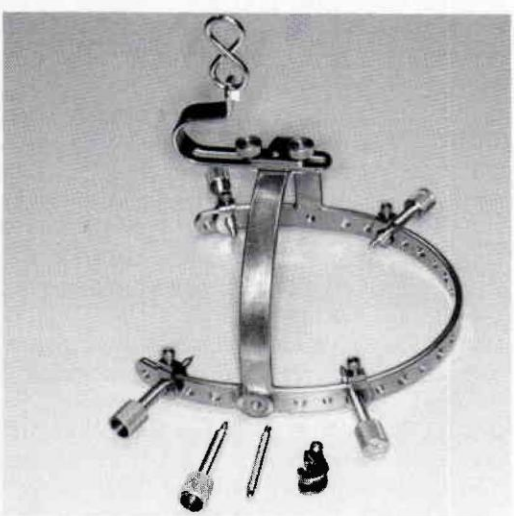

Figure 1.

CURRENT DESIGN

The above work has culminated in the most recent halo system design. The word "system" is used for the components which serve three functions (Figure 2). The first is for traction, in place of the widely used Gardner-Welles tongs. The ring has an over-the-head loop that serves as an attachment point for a traction rope or traction outrigger.

The second use is in surgery for cervical fusion. The patient's head is held firmly in position by the halo ring, which is connected to the surgical table by an adapter. This idea was suggested by a local neurosurgeon who objected to the then current procedure of removing the Gardner-Welles tongs or equivalent, placing the patient in the Mayfield head positioner, and, after surgery, applying a halo. This gave the patient up to nine pin sites and potential scars during the management of his injury.

Third, the system can be used for a halo orthosis as in the original design. The components of the system fall into three categories. These are: the ring, the vest, and the superstructure that connects the ring to the vest. All three component categories come in a range of sizes.* The vests and superstructures are the same as used with the conventional head ring. This allows for the ability to fit all patients from infants to large adults. The youngest patient fit to date was 18 months old, and the oldest was 90 years old.

GENERAL PRINCIPLES

The purpose of a halo orthosis is to stabilize the cervical spine. This is achieved by immobilizing the skull relative to the chest with an orthosis. A rigid metal band

*Available from Durr-Fillauer Medical, Inc., Orthopedic Division, 2710 Amnicola Highway, Chattanooga, Tennessee 37406.

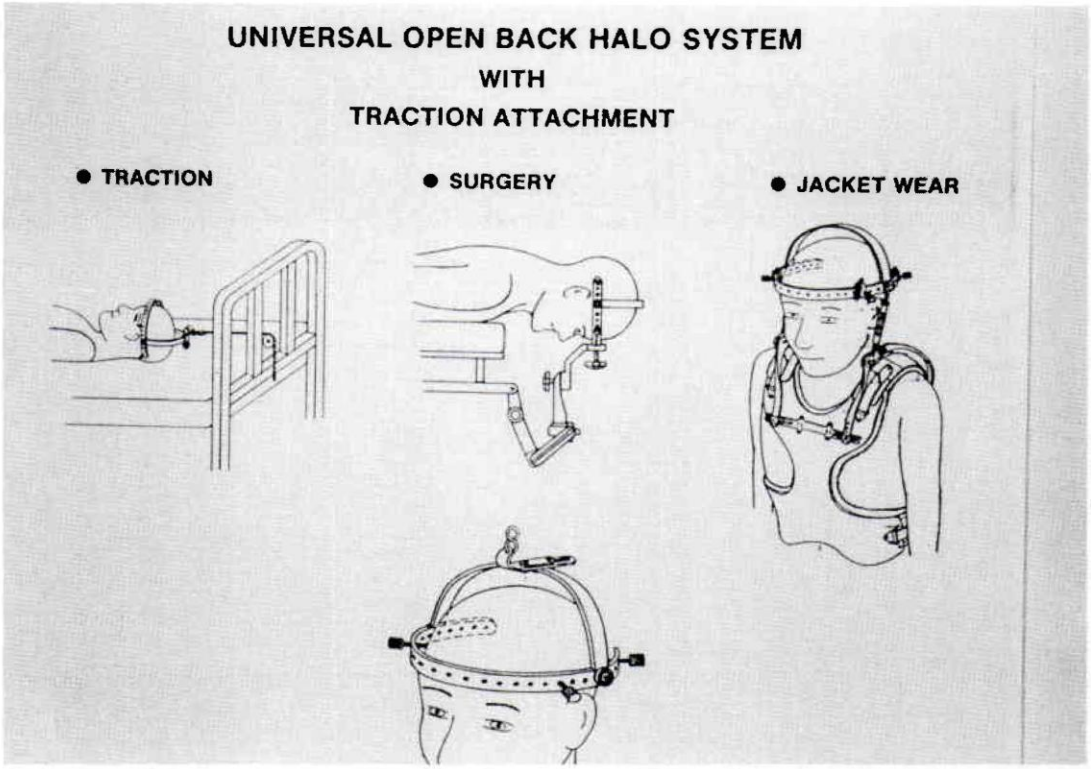

Figure 2.

is held in place by four skull pins and connected to a chest section by two turnbuckles. The advantages of the halo jacket system are:

- Early mobilization of the patient is possible.
- Better pulmonary care is permitted.
- Hospitalization time is shortened.
- Use of the arms is unrestricted.
- Aluminum parts do not interfere with x-rays.
- In case of cardiac arrest, the jacket can be removed quickly.

This new system has been designed to make application as easy and foolproof as possible. However, meticulous attention to detail is still required if good results are to be obtained, and due to the possibility of further injury from inexperienced application of the device, care must be taken to insure proper attachment of the system.

The most recent change to the vest has been the removal of the plastic shoulder sections. In place of the plastic, there is a Velcro® strap that connects the anterior and posterior sections. We have now applied ten halos with the new vest modifications. The reasons for the change are to increase cosmesis and, in some cases, to eliminate lateral pressure on the neck. No problems have resulted from this modification of the vest.

GENERAL APPLICATION TECHNIQUE

The patient may remain in his hospital bed or be transferred to a surgical table for the procedure. The use of a head positioning fixture greatly aids in safety and time reduction (Figure 3). Only two tools are needed to apply the halo orthosis with spring loaded pins. They are a $^{7}/_{16}$" open end wrench and a $^{5}/_{32}$" Allen wrench.

The steps in the procedure are straight forward and easy to follow with the aid of the Durr-Fillauer Halo manual.[2] The man-

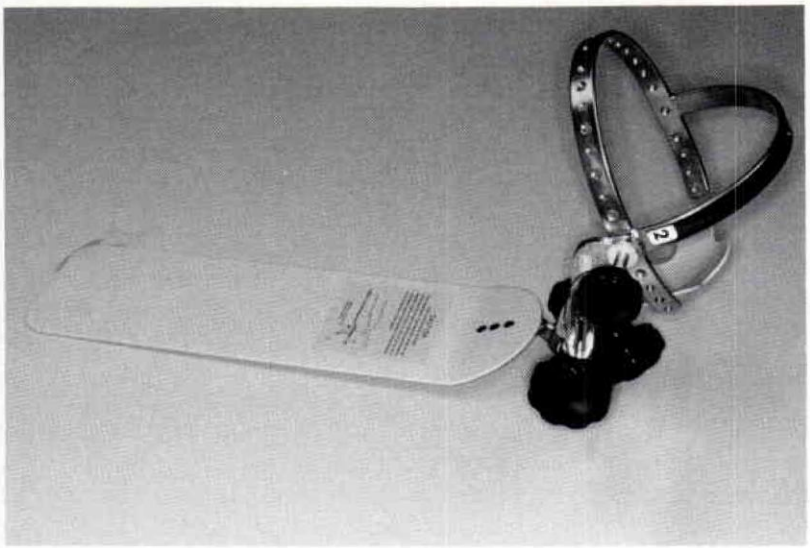

Figure 3.

ual lists all of the available sizes of components to assist in proper selection of components.

The ring and skull pins must be flash sterilized for at least three minutes. The patient must be moved so that his head is free of the mattress and supported by the head positioner. Adjustments are made to position the neck and cervical spine in flexion or extension, as directed by the surgeon. During the procedure of moving the patient forward, the posterior section of the vest is slid into place (Note: the positioning fixture is on the outside of the vest).

Application is routine with the aid of at least three assistants. The physician should hold the patient's head during this step. The ring is positioned by either using the ring positioning attachment (Figure 3) or by someone holding it by the head loop. The ring should be about ½" superior to the eyebrows and should not touch the ears. The doctor prepares the skin in the area of the pin insertion sites. Hair in the area is shaved and Betadine solution is applied prior to the infusion of a local anesthetic, usually Xylocane 1%.

The pins used most frequently are the self adjusting type, which do not require a torque wrench. If the smaller ¼" non self-adjusting pins are used, tighten them to approximately six inch-pounds. The self-adjusting pin set has two spring-loaded pins and two fixed pins. The two "like" types of pins are kept on the same side of the ring, and their position in the ring should be kept symmetrical. The pins are tightened alternately in pairs obliquely on the ring. They are turned together until the small metal rod on the spring-loaded pin protrudes approximately 1mm. When satisfied with the torque, apply a yoke clamp to each pin (Figure 3).

Now the anterior section of the vest is applied, and the four Velcro® straps are fastened. Attach the two over-the-shoulder bars to the vest first by rolling the patient slightly to one side and then the other. The posterior attachment point of the over-the-shoulder bar slides easily into the slot in the horizontal bar attached to the vest. The anterior attachment point is then secured.

The turnbuckles are now installed, which connect the head to the over-the-shoulder bar. When the proper flexion/extension attitude is attained, tighten the four 7/16" nuts, two per turnbuckle. Before sitting the patient, double check the tightness of all screws. It is recommended that an x-ray be taken while the team is still present in case changes in alignment are required.

PRECAUTIONS

Though the system is simple, there are several technical considerations to remember. If the jacket selection is improper, especially too large, adequate good purchase in the chest may not be obtained, and thus excursion of the unit after application may occur. In addition, if the over-the-shoulder bars do not fit properly, the vest antero-posterior diameter may be forced wider or narrower.

Spreading the vest may allow motion, and narrowing the anterior-posterior dimension might cause a pressure sore. A proper fit is obtained when the over-the-shoulder bars just slightly compress the vest. The bars are of malleable aluminum and should be adjusted by hand.

Double check all screws for tightness before leaving, and explain to the patient that there should not be any loose nuts or bolts. If it is decided to place the skull pins laterally, it is recommended that four self-adjusting pins be used. It is possible to create a three point fixation system instead of a four point due to the danger of misjudging the tightness of one of the non-springloaded pins, even though both spring-loaded pins indicate proper compression. Wide placement of the pins is encouraged, but we do apply them laterally very often ourselves.

SUMMARY

In the six months prior to the writing of this article, 40 universal open back ring halo systems have been used. All team members have been pleased with the function and ease of application. Though there are four sizes of rings, the number "two" size seems to fit 90 percent of the patients. It is recommended that all of the various sizes of components be maintained in stock so that the physician can be offered trouble free assistance.

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The Denver "T" Ankle-Foot Orthosis: A Unique Orthotic Approach in Selected Hemiplegic Patients

Catherine Britell, M.D.
John Hayes, C.P.
Randy Sherbon
Margo Williams, C.O.

INTRODUCTION

In many spastic hemiplegic patients with functional equinovarus deformities and ankle instability during ambulation, conventional in-the-shoe ankle foot orthoses (AFO's) when fabricated to provide good mediolateral stability, cause excessive flexion moment at the knee at heel strike, causing knee instability. They also often limit dorsiflexion enough to result in exacerbation of the problem of genu recurvatum at toe-off. On the other hand, if the orthosis is fixed to the shoe externally, stimulation of the ball of the foot will often cause excessive extensor spasticity, resulting in increased energy expenditure and more difficult gait.

The Denver "T" AFO, developed in the Orthotics Laboratory at the Denver Veteran's Administration Medical Center, is a custom-molded orthosis which provides excellent mediolateral stability while allowing relatively free ankle dorsiflexion. It provides mild to moderate dorsiflexion assist which may be varied according to patient requirements, but does not provide excessive plantar flexion resistance at heel strike. Precise trimming posterior to the metatarsal heads prevents excessive stimulation of extensor spasticity, and the polyethylene material from which it is fabricated is extremely light in weight and flexible, causing the orthosis to be well-accepted by patients.

This orthosis is most effective in those hemiplegic patients who exhibit some toe and ankle dorsiflexion as part of a mass flexion pattern, but who cannot control this dorsiflexion throughout the gait cycle, and who may have equinovarus pattern at stance phase and/or ankle instability. It is also of use in those patients who have some limited dorsiflexion, but lose this as they become fatigued. It has generally not been useful in patients who have no ankle dorsiflexion, and should be used with caution where there is insensate skin.

DESCRIPTION OF TECHNIQUE

Patients are evaluated by the Orthotic Clinic Team, consisting of a Rehabilitation Medicine Physician, Orthotist, and Physical Therapist prior to the prescription of the orthosis. Criteria for trial of this orthosis are as follows: The patient has or has nearly achieved maximal neuromuscular function through optimal rehabilitation. The patient exhibits some ankle dorsiflexion in or out of mass pattern. Skin sensation is not totally absent. Moderate to severe spasticity is not a contraindication to use of this orthosis. If possible, gait is evaluated using a pre-fabricated "T" orthosis of appropriate size.

After marking bony prominence and tendons, a negative mold is made in a sitting position with the knee and ankle at 90° and the foot flat on the floor. A positive mold is poured and a ¾" pipe with vacuum hole is inserted. Modifications include relief over the malleoli and other bony prominences and extensor tendons. The positive mold is then sealed and prepared for vacuum-forming. A sheet of 3/16" Vitrathene® is cut to proper size, heated to approximately 190°C, and vacuum-formed over the mold using approximatey 20" Hg negative pressure. Edges are brought together to form a seal in the anterior midline.

After curing at room temperature for 24 hours, trim lines are marked as shown (Figures 1 and 2). Overall height of the orthosis is 2.5" above the superior border of the medial malleolus. The posterior cutout extends from two inches below the top of the orthosis to the apex of the calcaneus, and laterally to ½" behind the posterior edges of the malleoli. The anterior trim line extends from the cuff section posterocaudally to the anterior borders of the malleoli, mid-lateral aspect of the foot, and plantar surface posterior to the metatarsal heads. The plantar surface is carefully beveled for comfort and even pressure distribution. The orthosis is finished with a 1½" Velcro® strap and Chafe-keeper (Figure 3). This may be adapted for various upper extrem-

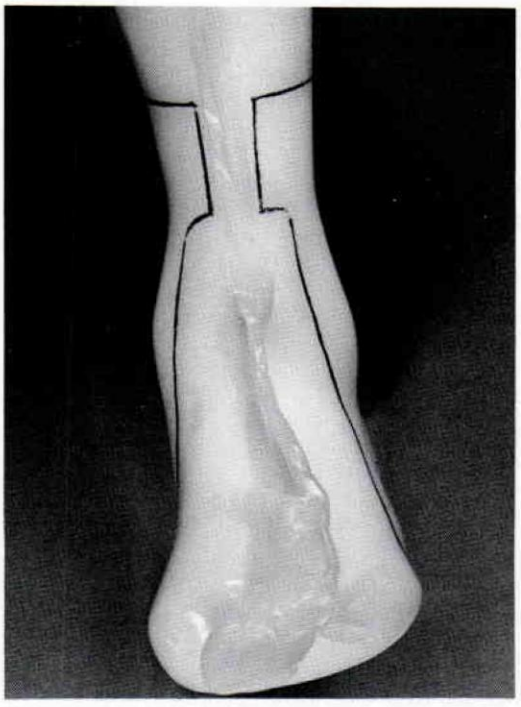

Figure 1. Anterior trim lines.

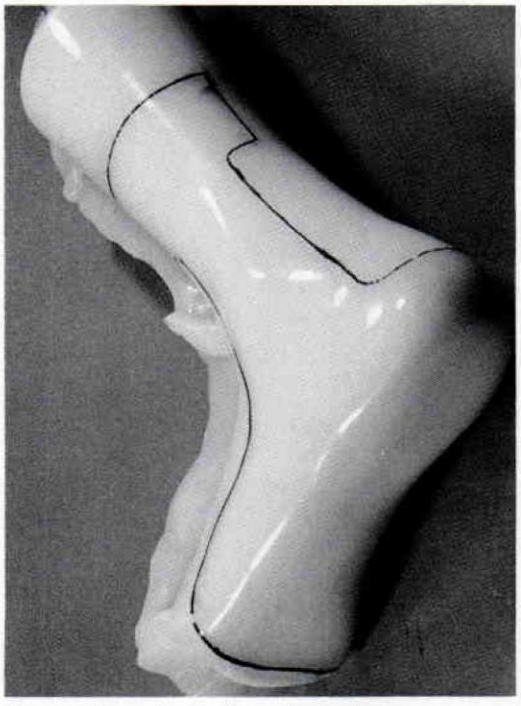

Figure 2. Posterior and lateral trim lines

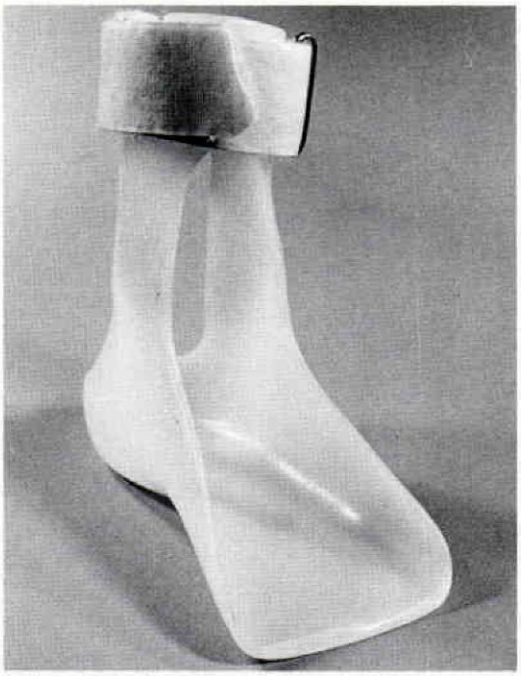

Figure 3. Finished orthosis.

ity disabilities. The patient will generally require shoes one size wider than his normal width to accommodate the orthosis.

A small to moderate increase in dorsiflexion assist may be achieved by increasing the height of the orthosis and/or increasing the width of the vertical side portion. The posterior cuff, which is usually split (Figure 4) to increase flexibility and ease of donning, may be left solid if more dorsiflexion is needed. In cases of severe spasticity, a Bobath toe spreader has occasionally been used with the Denver "T" AFO with excellent results.

The orthosis is fit over the patient's normal stocking, and checked for adequate relief of pressure over bony prominences and tendons (Figure 5). The patient then wears the orthosis for a short time, after which the orthotist checks for skin problems and makes necessary adjustments. If there is an alteration in skin sensation, the patient is instructed to check the skin at regular intervals and gradually increase wearing time over the first two weeks of use. Telephone followup has been done at six weeks, three months, and six months, and patients are told to contact the orthotist if they experience any problems with the orthosis.

DISCUSSION

This orthosis was evaluated at the Denver Veterans Administration Medical Center with 17 hemiplegic patients for three to 20 months. Sixteen of the patients were successful users, while one, who had a concomitant nerve injury and insensate foot, discontinued use due to skin breakdown. All patients who had previously used double upright orthoses or polypropylene AFO's found the Denver "T" ankle foot orthosis superior in comfort, convenience, light weight, and stability to their previous orthoses. Clinical gait evaluations showed improvement of gait in all patients evaluated. Formal biomechanical analysis of the orthosis is planned, and application of these principles to other orthotic problems is being explored.

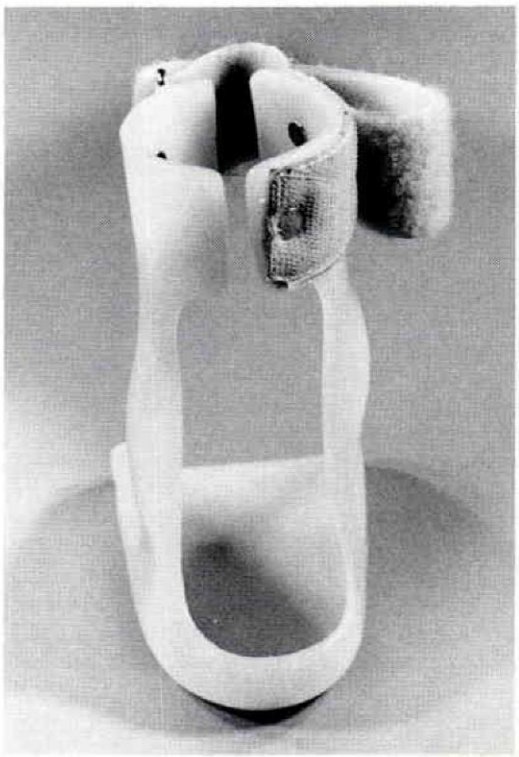

Figure 4. Finished orthosis.

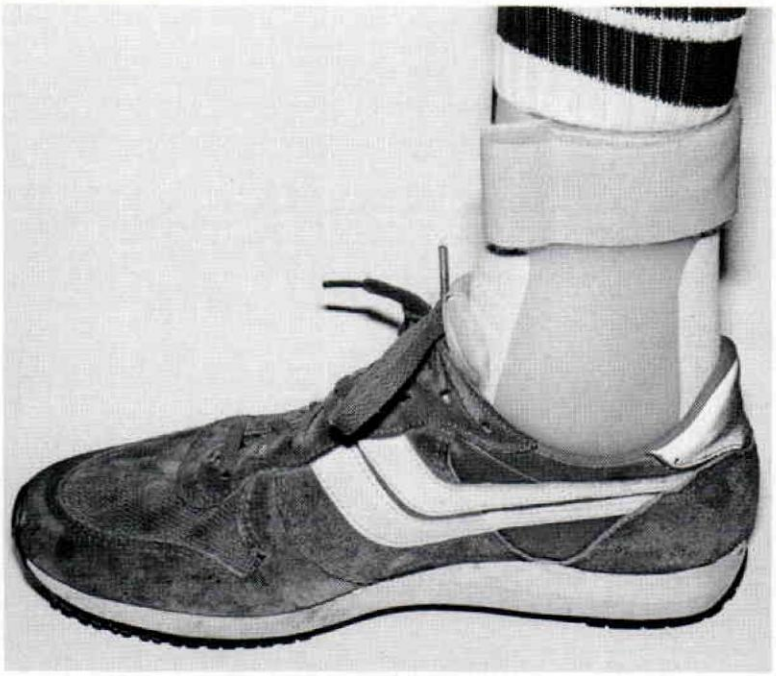

Figure 5. Orthosis is worn over regular stocking inside patient's choice of shoe.

CONCLUSION

The Denver "T" ankle-foot orthosis represents an effective new approach to the problem of functional equinovarus deformity and ankle instability in selected hemiplegic patients. It is designed to make use of neurodevelopmental principles to maximize gait efficiency, and is exceptionally well-accepted by patients.

AUTHOR

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Orthotics and Prosthetics, Vol. 39, No. 3, pp. 30–34.

A New Bed-Frame Device to Minimize Halo Malalignment

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Paul E. Stang, B.S., PA-C

INTRODUCTION

The halo orthosis evolved in the 1950's in response to an increasing number of cervical spine injuries and operative procedures. The previously available body cast provided an insecure grasp of the body and head, thus limiting their effectiveness in stabilizing the cervical spine. Despite extremely careful application and molding, the body cast (Minerva jacket) limits the motion of the cervical spine but does not fix it in a given position, nor does it offer any distraction of the vertebral column.

Head fixation soon became a troublesome problem. The thin scalp and skull tolerates only minor force without skin breakdown or pain. The cranial roundness provides a less than optimal surface for attaching fixtures.

Hoen[3] in 1936 introduced skeletal traction via paired wire loops. His system was soon replaced by Crutchfield tongs, which had been described three years earlier, since the tongs were technically easier to apply.[2] Modifications of the tongs by Vinke[5] and Barton[1] reduced the slippage inherent in the original device. However, all of these systems were limited to single-plane fixation, thus limiting the amount of positioning that the staff and patient would be able to exercise. The halo orthosis was a fusion of many well-known fixation devices, including Bloom's facial body traction. Its prototype, the halo-plaster body cast, was first described by Perry and Nickel in 1959[4] and has subsequently evolved into the plastic and metal orthosis known to us today.

The halo orthosis, unlike other cervical traction devices, offers six distinct advantages:

- precise positioning in all three planes
- adjustable longitudinal traction
- simple application
- minimum patient discomfort
- relatively inflexible stabilization
- fewer complications from surgery or prolonged confinement to bed

These advantages may be negated by forces within the halo orthosis itself,[6] or by poor positioning of the patient in the conventional hospital bed. The subsequent text reviews our experience with the halo orthosis, its advantages, and a particular fault in positioning that may be remedied by a simple footboard device.

DISCUSSION

The Department of Neurological Surgery at Stony Brook University Hospital (New York) is a regional center for the acute

treatment and stabilization of patients with cervical spine injuries and their associated neurologic deficits. Our therapy consists of rapid stabilization of the fracture/subluxation in hopes of minimizing permanent neurologic involvement. After sufficient stability is achieved, the patient is transferred to a rehabilitation facility.

Although our patients do include those who are ambulatory, the majority are not. In either case, the halo orthosis has been the appliance of choice, for it maintains proper cervical alignment and distraction while offering the mobility for both in-house physical therapy and subsequent transportation to the rehabilitation facility and further therapy.

Initially, the patient's cervical spine is stabilized in Gardner-Wells long traction on a Roto-Rest Kinetic Treatment Table.™ When proper reduction of a fracture/subluxation site is realized, and the patient is medically stable, the patient is placed in the halo orthosis and transferred to a standard hospital bed.

After their transfer to the hospital bed, patients characteristically complain of 'tightness' in the distal anterior aspect of the thoracic jacket. This may also be accompanied by added difficulty in breathing and pressure on the spinous process of the scapula. In addition, the cervical spine x-rays show deterioration in alignment. Initially, these symptoms were attributed to greater mobility of the patient during therapy and in the hospital bed. However, reducing the patient's activity did not appreciably reduce these symptoms. Further adjustments in the fit of the jacket failed to relieve the symptoms as well.

A subsequent review of patients has indicated that the position of the bedframe pivot joint for torso elevation on the standard hospital bed is not located properly for the average adult, especially those in the halo device. When the average adult is positioned customarily in bed, the break in the mattress at the pivot joint of the flexed bedframe is located at the mid-thoracic re-

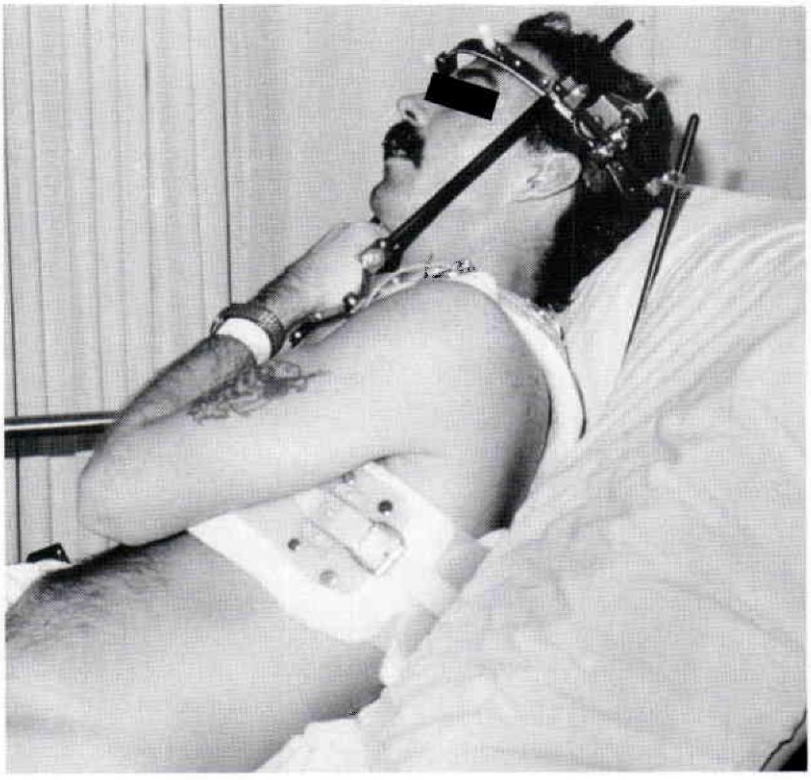

Figure 1. Halo patient in hospital bed in flexed position. Note break in bed at thoraco-lumbar area of spine.

gion instead of the anticipated sacro-gluteal region. Consequently, the patient is forced into a flexed thoracolumbar position (Figure 1).

In this situation, since the halo thoracic jacket extends only to the mid-torso, the thoracic spine is flexed, forcing the anterior distal aspect of the jacket against the lower ribcage, causing excessive distal anterior pressure and difficulty in breathing, as described by most patients. Posteriorly, the scapular spinous process is exaggerated and protrudes against the proximal posterior aspect of the jacket. This flexion appears to extend into the cervical spine itself, thereby disrupting alignment and stabilization that was purportedly intact. This flexion of the cervical spine may be substantiated by x-rays of patients in neutral (Figure 2) and flexed-bed position (Figure 3), where the distal pelvic girdle rests on the mattress, allowing the entire torso to lie against the elevated portion of the mattress.

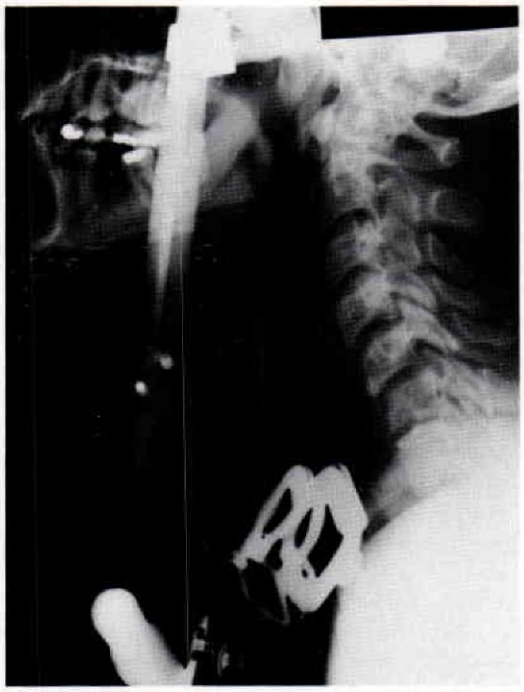

Figure 2. Cervical spine x-ray of halo patient in neutral position afforded by bed-frame device. Note alignment.

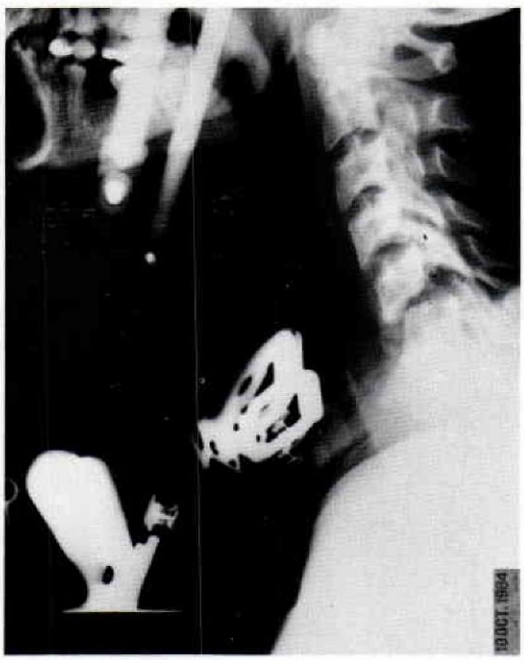

Figure 3. Cervical spine x-ray of patient in flexed bed without proper positioning in bed. Note anterior subluxation of spine at lower cervical area.

DEVELOPMENT

Despite proper positioning by the staff, patients were unable to maintain that location but instead, migrated toward the foot of the bed. A positioning device was constructed to maintain the proper pelvic position at the mattress fold. The device consists of two 2′ × 1′ half-inch thick pieces of plywood covered with leatherette and attached to a Z-type frame of $1\frac{1}{4}$″ by $\frac{3}{16}$″ steel strapping.

The long arm of the frame lays along the mattress while both upright bends serve as attachment bars for the wood platforms (Figures 4 and 5). One platform rests against the footboard of the bed, while the other serves as a foot rest. The surface of the foot rest has Velcro® hook material attached to it to accept the Velcro® pile material of positioning boots worn by patients to prevent footdrop (Figure 6).

After patients were properly positioned in bed using this new footboard device, complaints and alignment problems were virtually eliminated. Figure 7 shows the patient in proper alignment with the posi-

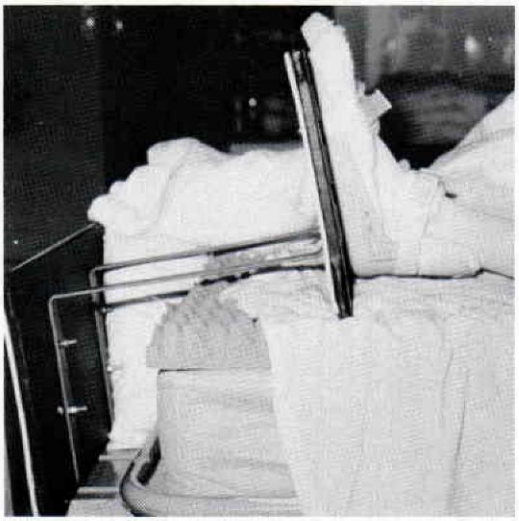

Figure 4. Bed frame device with positioning boots in place.

Figure 5. Positioning boots and bed frame device. Note Velcro® attachments on footboards.

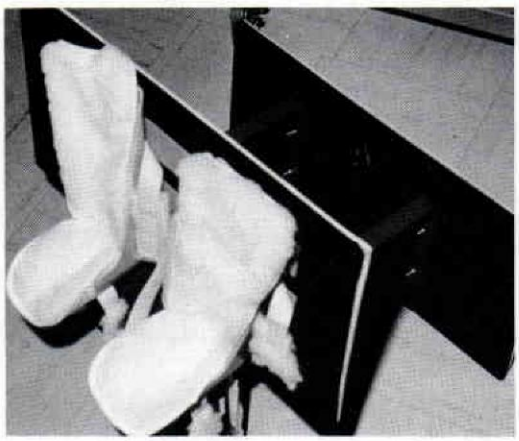

Figure 6. Bed frame device shown with positioning boots. Unit is easily removed and stored by nursing personnel.

tioning device. Note that this unit was made specifically for this patient's height and leg length. However, adjustable length units are easily constructed for general positioning purposes.

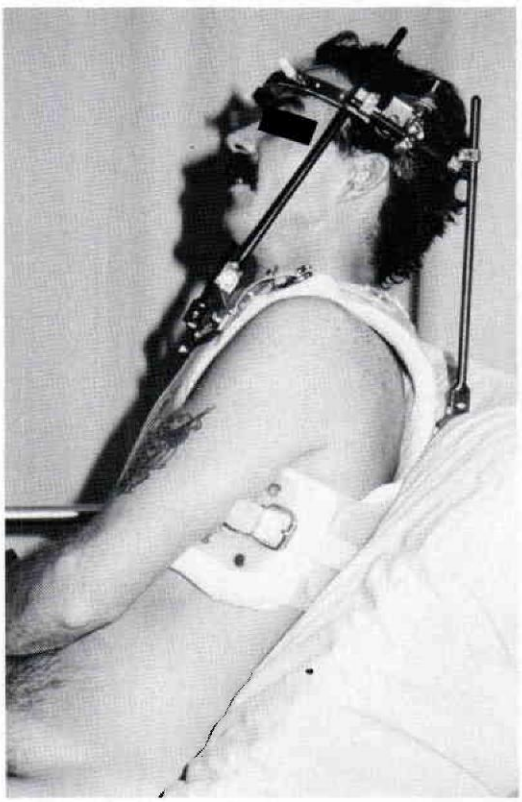

Figure 7. Halo patient properly positioned in bed with flexion at the hips and pelvis.

CONCLUSION

Clearly, the proper positioning of a patient in a standard hospital bed is a significant contributing factor to proper orthosis alignment and maintenance. Proper alignment cannot be maintained unless the hospital staff and patient are alerted to positioning criteria. In addition, a positioning device should be employed to attain and maintain the desired result.

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Tuli's—A Dynamic Heel Cup Which Effectively Reduces the Shock of Heel Strike

M.R. Davidson, D.P.M., F.A.C.F.S.
Richard E. Quint, B.S.

INTRODUCTION

It is the intention of the authors of this paper to introduce a revolutionary new foot device which may be employed as a primary or adjunctive method of treatment for a myriad of painful foot and leg conditions. The TULI's dynamic heel cup is the culmination of three years' developmental research and clinical experimentation directed towards reducing the phenomenon of shock at heel strike.

During the evolutionary process, primates underwent numerous physiologic changes in a relatively short period of time. In an arboreal existence, body locomotion is distributed to both the upper and lower extremities, often with the former playing the dominant role. As primates evolved to a terrestrial existence, bipedism replaced quadripedism. "Thus, with the entire function of body locomotion transferred upon the lower extremities, not only were they [the lower extremities] required to assume all of the stress of body weight, but also they had become adapted to maintain the vertical posture of the body in stable equilibrium over a greatly reduced area of ground support."[1]

The numerous musculo-skeletal functionally-adaptive changes that took place in the foot, leg, pelvis, and spine, may in no uncertain terms be attributed to the reactive forces of gravity and the perfection of locomotory advantage. We are all aware of the body's effort in its marvelous adaptation to reduce the forces of shock transmitted through the lower extremities during ambulation. These adaptations range from the development of accentuated muscular deceleration to sub-talar joint pronation, and flexion at the knee. But the amalgamation of these evolutionary adaptations in human locomotion are ineffective, and most certainly compromised in modern civilization's unyielding walking surfaces.

The lower extremity was designed neither to be placed into restrictive stockings and shoe gear, nor to ambulate on miles of concrete, asphalt, tile, and hardwood floors. It is no surprise that orthopedists, podiatrists, and general practitioners are seeing increasing numbers of patients with musculo-skeletal complaints. It is our contention that the vast majorities of these conditions, which we shall discuss briefly, are intimately related to one particular aspect of the gait cycle, this being heel strike.

No matter how effective the musculature of the anterior and posterior groups is in limb deceleration, or the sophistication of its joints in their locking and unlocking mechanism to reduce shock, micro-trauma

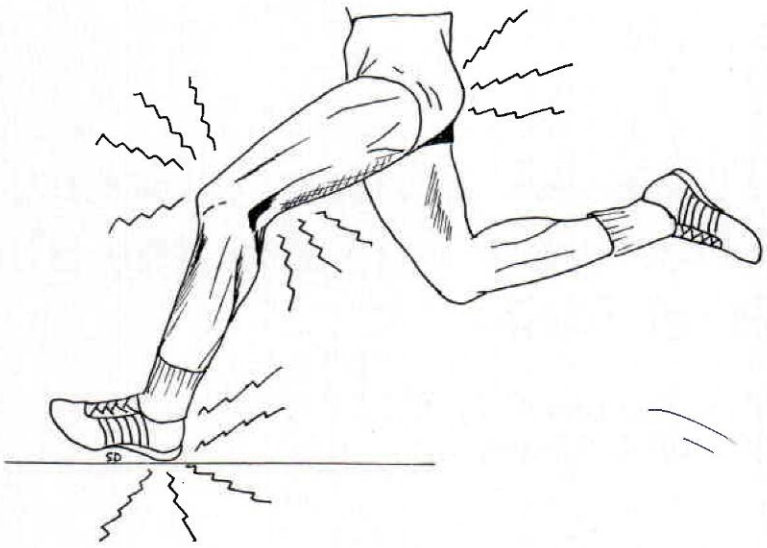

Figure 1. Lower extremity during heel strike. Arrows indicate various segments of the lower extremity: heel, subtalar joint, ankle, knee, hip, and lower back.

occurs and will continue to occur on unyielding surfaces unless protection is offered at the point of contact. This is especially true in the case of athletes who are subject to far more stress than the individual engaging in normal activities. It has been estimated that the force exerted at the point of heel contact in jogging on a level terrain is approximately 3 G's, while it may be increased to 4 G's on a downhill course.[2] Assuming that 4 G's equals four times the body weight and the average man weighs 150 lbs., then the force exerted upon heel strike is 600 lbs./sq.in. Furthermore, the heel strike occurs an estimated 1600 times in the course of one mile, producing 960,000 lbs. pressure at the point of contact over an average jogging time of eight minutes.

The tremendous force of shock during heel strike is dissipated proximally to the sub-talar joint, ankle, knee, hip, and lower back (Figure 1), and is contributory in producing many of the following conditions:

1. Calcaneal apophysitis—(children 8-13 years). Also known as Sever's disease. This condition, according to Tachdjain, is not an osteochondrosis. It is an "irregularity of ossification and sclerosis of the apophysis and is a normal roentgenographic finding."[3] O'Donogue disagrees and states that apophysitis of the calcaneous is aseptic necrosis of the calcaneal epiphysis. *"Faulty circulation is manifested by sclerosis of the epiphysis, frequently accompanied by fragmentation, but the condition is self-limited and usually does not demand drastic treatment. Symptomatically, there is pain at the posterior point of the heel, usually somewhat below the actual attachment of the tendo-Achilles. Pain is elicited by a forcible activity, so that the adolescent can usually go about his regular activity without trouble, only to have recurrence of pain if he starts to run or jump or violently exercise his foot."*[4]

2. Heel spur—an exostosis of the plantar calcaneal tuberosity, the etiology of which is attributed to plantar fascial strain often associated with abnormal pronation.[5]

3. Heel neuroma—perineural fibrosis of the medial calcaneal nerve as described by Davidson is the result of microtrauma. This condition can be extremely painful and neurectomy is the treatment of choice.[6]

Other conditions which are related to the shock of heel strike are disturbances of the forefoot such as metatarsalgia, plantar fascial strain, shin splints, chondromalacia, and hip and low back pain. In the past we have treated the aforementioned conditions with numerous conservative, mechanical, and surgical methods. There are times when surgery is indicated, e.g., chronically symptomatic calcaneal spurs, nerve entrapment syndrome, heel neuroma, knee pain due to a torn meniscus,

etc.; however, surgical intervention is no panacea and certainly no substitute for aggressive conservative treatment.

In our 15 years of clinical experience in shock absorption, we have tried numerous materials and combinations of materials with less than satisfactory results. These include 76 types of padding materials including felt, sponge, airfoam, polyurethane, and a variety of polymer/catalyst preparations. It was due to our frustrations in the conservative treatment and management of the aforementioned conditions that we set out to develop a "true" shock absorbing device.

In the past, primary emphasis has been placed on the biomechanical control of pronatory forces, rather than the reduction of shock at heel strike. After three years of scientific research and mechanical testing, we have developed a unique device, designed to reduce shock to all segments of the lower extremity.

The device itself resembles a heel cup. However, its key feature is a ribbed design on the plantar-posterior aspect, which effectively crushes upon impact. Constructed of a high quality natural latex rubber, it completely rebounds with 100 percent memory (Figures 2 and 3).

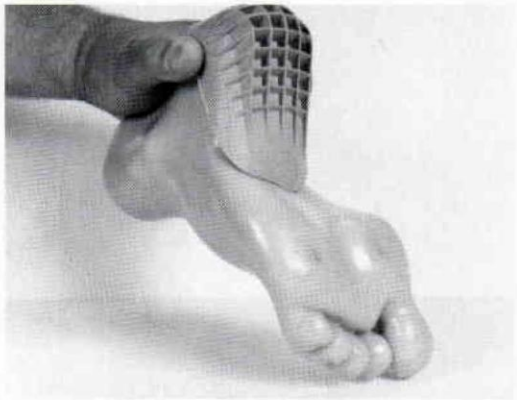

Figure 3. Tuli as applied to bottom of foot.

Figure 4. Tuli may be placed in any shoe.

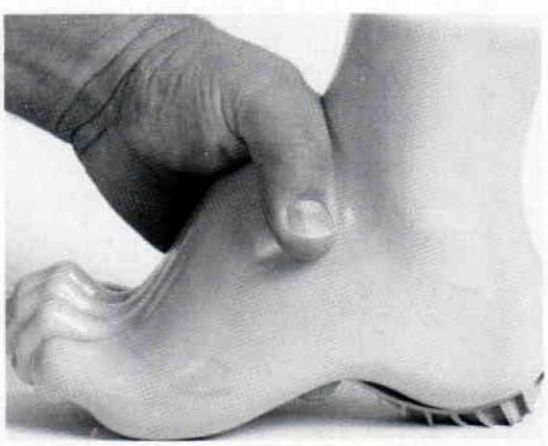

Figure 2. Demonstrating (cross section Tuli) ribs depressed in heel strike.

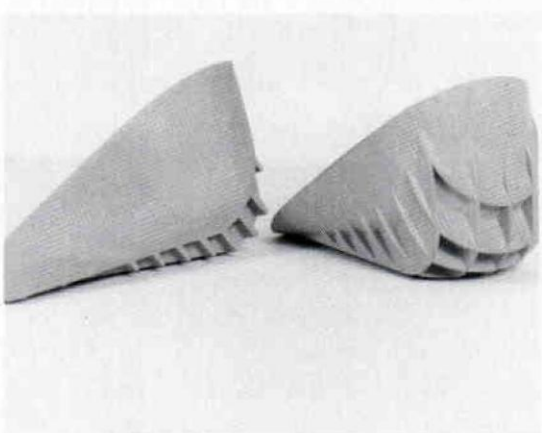

Figure 5. (left) Cross-section side view, showing Tuli rib structure. (right) Complete Tuli, back view.

Preliminary Trial

Patient	Foot Condition	Age	Wgt. (lbs.)	Sex	Duration of SX's
1. R.G.*	Apophysitis Bil.	11	89	M	2 weeks
2. A.G.*	Apophysitis Bil.	13	99	M	3 weeks
3. D.R.*	Apophysitis L	14	94	M	1 year
4. S.R.*	Apophysitis Bil.	12	93	F	3 weeks
5. M.R.*	Apophysitis Bil.	14	110	M	3 years
6. M.B.*	Heel Neuroma R	64	160	F	6 months
7. R.G.	Heel Neuroma L Heel Spur	46	250	M	2 months
8. Jog A	Shin Splints Bil.	28	165	M	1 week
9. Jog B	Shin Splints Bil.	35	135	M	10 days
10. Jog C	Shin Splints Bil.	38	140	M	1 week
11. R.G.*	Heel Faciitis Bil.	24	138	M	4 days
12. G.R.*	Chondrolamacia R	18	175	M	2 weeks

CODE:
*TULI'S Heel Cup worn continuously
Jog—jogger
R—right
L—left
Bil.—bilateral

Figure 6.

Statistics—TULI's

RESPONSE			
2 days	**2 weeks**	**2 months**	**extended**
I	C.R.S.	—	—
C.R.S.	—	—	—
C.R.S.	—	—	—
C.R.S.	—	—	—
I	I	C.R.S.	—
I	I	I	Surgical resection
I	I	I	I
P	I	I	I
I	C.R.S.	—	—
I	C.R.S.	—	—
I	I	moved	moved
P	I	I	C.R.S.

RESPONSE:
P—Poor to None
I—Improved condition
C.R.S.—complete remission of symptoms

Some shoe gear today, especially athletic foot gear, has been designed to include shock absorbing qualities. But the placement of these shock absorbing devices has been traditionally on the outside of the shoe. Interior shoe sponge materials are notoriously too hard, or have no repeated long-term memory. TULI's fit inside any shoe, against the foot, where the shock absorption is most needed (Figure 4).

We are not suggesting that the device be used as a substitute for the control of biomechanical faults, namely pronation, but rather that it be employed as an adjunctive or primary therapy. In addition, the TULI's heel cup (Figure 5) may be utilized in conjunction with a custom orthosis.

Figure 6 is a graphic representation of our preliminary clinical trials and results. The majority of our patients in this study were involved in some recreational or competitive sports activity. We feel that two findings in this study are significant:

- All patients had some improvement within the first two weeks of treatment.
- None of the children presenting with calcaneal apophysitis required casting and all returned to complete activity, including those who participated in athletic events.

When considering heel pain, however, one must not preclude systemic disorders as a causative factor. Diabetes mellitus, gout, alcoholism, rheumatic arthritis, and the use of Thiazide diuretics and other drugs have all been implicated.[7] A thorough history and clinical examination is essential in ruling out such entities.

In summary, this paper elucidates the problems of heel strike shock and discusses some of its common clinical manifestations. We have introduced the TULI's dynamic heel cup to be used as an alternate method of aggressive conservative treatment and prophylaxis.

AUTHORS

Dr. Davidson is Director of the Residency Program, Community Hospital of Phoenix. Mr. Quint was a fourth-year student, O.C.P.M., at the time of the writing.

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The Use of the Modified Boston Brace System (B.O.B.) For Back Pain: Clinical Indications

Lyle J. Micheli, M.D.

INTRODUCTION

The development of prefabricated thermoplastic orthoses to aid in the treatment of spinal deformities, especially scoliosis, is a recent phenomenon. The first such system, the Boston Brace System,® was introduced only ten years ago. The efficacy and high patient acceptance of these semirigid, closely fitting orthoses resulted in a reassessment of the use of orthoses for spinal disorders, in general.[11]

While a number of spinal orthoses were used in the past for a variety of disorders causing back pain, their use has fallen into disrepute in recent years. There appear to be a number of quite different factors responsible for this, ranging from theoretical concerns about their effect on the long term function and physiology of the back, to poor patient acceptance and compliance.

These orthoses, which included the Norton Brown, Jewett hypertension, and chairback orthosis, were most commonly prescribed for patients complaining of back pain from a number of very different etiologies.[9,10] Unfortunately, careful determination of this etiology of the back pain was most often not done, and orthoses were prescribed indiscriminately, reflecting the ignorance of both orthosis prescriber and orthosis fabricator as to the cause of pain being treated, and the expected effect of the orthosis on the spinal column and its primary disease process.

In addition, these orthoses were often prescribed without concurrent exercise programs, resulting in loss of spinal motion, strength, and, sometimes, further exasperating the back pain when the orthosis was removed.[12,13] Finally, these other orthoses were often bulky and of metal and leather construction, with a limited number of contact sites on the torso and pelvis. Wearers of these orthoses often complained of the orthosis being uncomfortable; and patient compliance was usually low.[3]

Most of the new thermoplastic orthoses developed to treat spinal deformities in children or adolescents incorporated, as a design feature, a forward flexion of the orthosis. This design helped to reduce lumbar lordosis, flatten the back, and increase the torso contact and efficacy of derotation pads placed at the convexities of the curve, or curves.

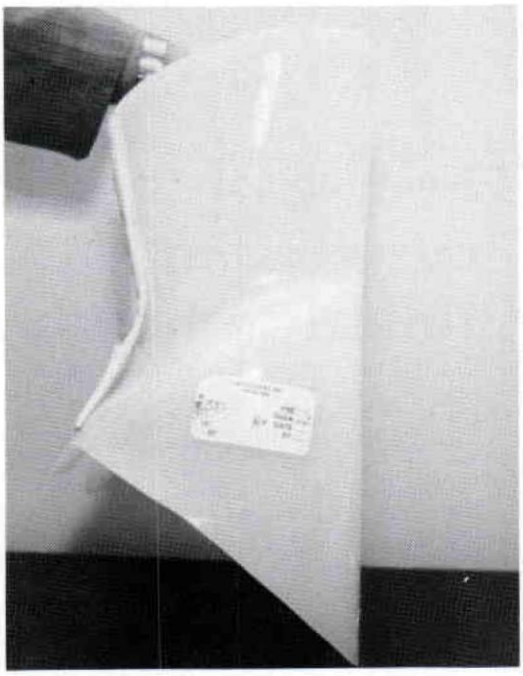
In certain cases, this anti-lordotic feature itself was used to treat children with excessive lumbar lordosis when this was a primary spinal deformity. These conditions included cleidocranial ostosis, achondroplastic dwarfism, and in some instances, idiopathic hyperlordosis. These early cases confirmed the efficacy of this orthosis design in mechanically decreasing lumbar lordosis.

Another clinical application of this anti-lordotic feature of the Boston Brace System® soon became evident. Back pain in athletically active youngsters, although due to a variety of etiologies, including spondylolysis, apophyseal fracture, disc disease, or back strain, appeared to have as a common etiology feature, hyperlordosis of the lumbar spine. This occurred either in the onset of the injury, or in its persistence.[7]

The potential for effective treatment of back pain in athletically active children and adolescents with thermoplastic orthoses was confirmed by extensive clinical trials.

In the process, certain aspects of the orthosis design were changed, and clinical indications were refined. The original orthoses were posterior opening and opening and constructed of polypropylene with semi-rigid ¼" polyethylene liners. A number of different design modifications to this orthosis were subsequently tried. The present unlined, anterior opening, polyethylene with reinforced spring steel "B.O.B. Boston Overlap Brace," is the culmination of these clinical investigations. At the present time, the orthosis is available in either polyethylene, in ¼" or ⅛" thickness, or polypropylene in ¼" thickness. The orthosis is usually prescribed unlined. The B.O.B.® is available in contours of 0°, 15°, or 30° of lumbar lordosis (Figure 1A & B).

The efficacy and high rate of acceptance of these thermoplastic orthoses for back pain in these young athletes, particularly for treatment of spondylolysis, served as an incentive for the use of thermoplastic orthoses in a variety of other back disorders, including low and upper back pain in adults.



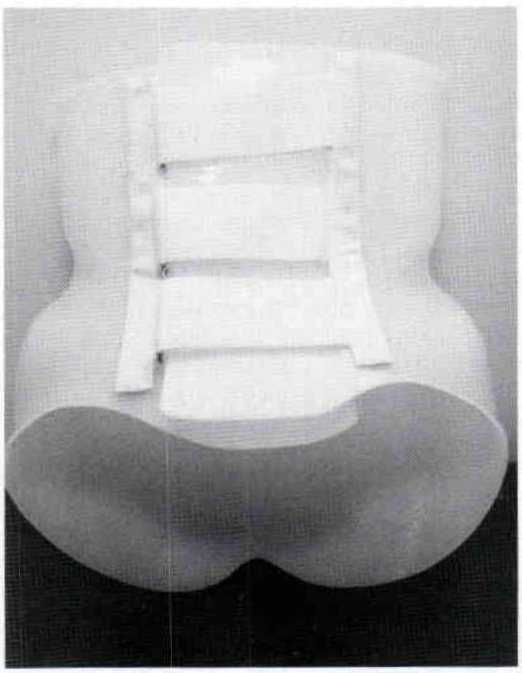


Figure 1A & 1B. The present model of the Modified Boston Brace, the Boston Overlap Brace (B.O.B.). This particular module has 0° of Posterior Lordosis and 30° of flexion of the anterior spring steel ribs.

Experience with the application of this thermoplastic total contact orthosis has proven promising. While this experience is more recent, and study is needed to determine the long term efficacy and effect on the natural history of back pain in adults, the short term observations, in and of themselves, are an adequate basis for our own continued use of this orthosis.

Use of the thermoplastic orthosis, although only one part of a comprehensive treatment regimen, can often prove decisive in restoration of function, by allowing an executive with discogenic back pain to return to work, or a geriatric woman with incapacitating arthritic back pain to resume light housework.

There are, of course, a great variety of etiologies of adult back pain. Some of these are related, as in the case of an adult with previously untreated decompensating scoliosis and secondary discogenic back pain below the curve. Other causes include spondylolysis, facet arthrosis, osteopenic deformity including kyphosis, lordosis, progressive scoliosis, or spinal stenosis. It is imperative to make a proper diagnosis as to the most probable cause of back pain in a given individual and to use orthotics as one component of the treatment regimen. Back pain due to metastatic carcinoma of the spine may indeed undergo symptomatic improvement when placed in a thermoplastic orthosis.

The definitive treatment for the primary condition requires quite different management, of course. Ascribing the source of back pain in such an instance to "mechanical" back pain and failing to do a comprehensive assessment would be tragic indeed. The adjunctive use of thermoplastic orthoses for the management of adult back pain can prove extremely useful for both patient and surgeon, but in no way replaces the careful comprehensive assessment and total management of the patient's condition.

DISCOGENIC LOW BACK PAIN

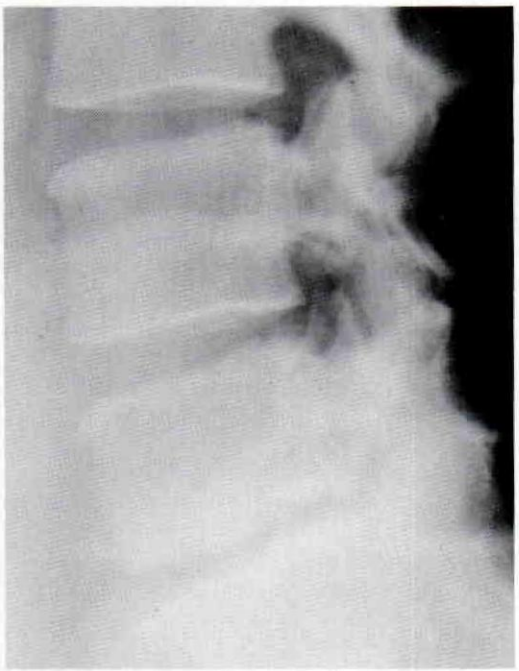
Discogenic back pain, with or without sciatica, can often be improved with the addition of a thermoplastic spinal orthosis to the treatment regimen. Analgesics, muscle relaxants, and exercises to reduce lumbar lordosis, as well as periods of strict bed rest, are time honored components of disc management.[1] The use of a spinal orthosis to not only maintain immobilization of the back, but also to help maintain an anti-lordotic posturing of the back when the patient is erect, has proven useful in many of our patients with disc pain. It is noteworthy, however, that most adults cannot tolerate the full 0° lordosis orthosis. The orthosis with 15° of lordosis has proven most helpful, and in some cases, the 30° lordosis B.O.B.® may be necessary.

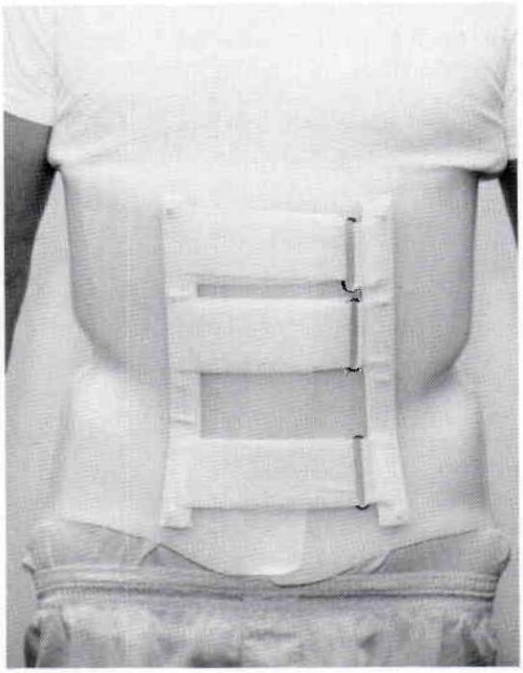
Some insight into the particular orthosis design to be used in a given patient can be gained by manually posturing the patient into more or less lordosis, while standing, and observing the effect on the back or leg pain.

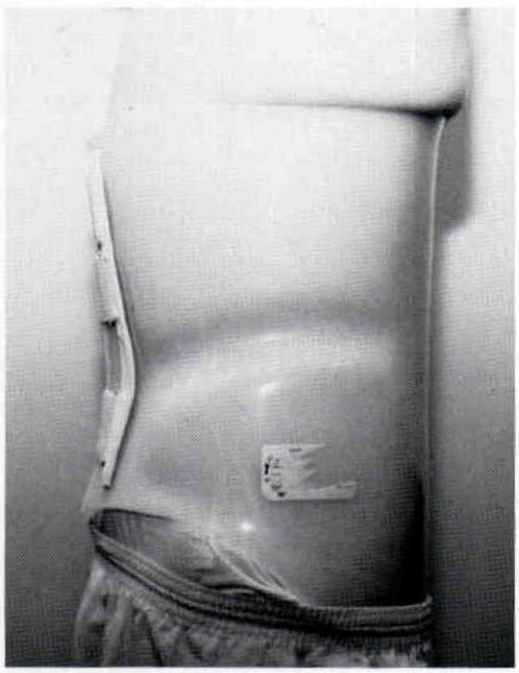
The patient with an acute, incapacitating attack of discogenic back pain cannot be fitted for this orthosis, of course, and usually must be treated with bed rest initially. However, after the acute pain and spasm have diminished, orthotic application and use can often speed return to function.

This application is often particularly useful when sciatic scoliosis is associated with the back pain, as it reduces the decompensation of the spine resulting from the sciatic scoliosis and seems to break the cycle of pain and spasm associated with it (Figures 2A, B, C, & D).

Orthosis use is continued until full painless function is restored. This may be as soon as 12-14 weeks, but a more usual period of orthotic treatment is four to six months. The use of a daily program of directed physical therapy, to restore the strength and motion of the back, is essential. If the patient attains a comfortable and functional improvement with the orthosis, but has resumption of pain when the orthosis use is tapered, further diagnostic evaluation and possibly more aggressive therapy such as laminectomy or chymopapain injection may be required.[2,6]







By experience, some patients with chronic intermittent discogenic back pain and sciatica reach the point where they have significant improvement in function and then will use their orthosis intermittently for particular episodes of back pain following strenuous activity. This will often involve use of the orthosis at night and while up and about working, for a period of two to three days.

SPINAL ARTHROSIS

Some of the most gratifying results of orthotic treatment for low back pain are in patients with extensive arthrosis of the lumbar spine. As with other arthroses or arthritis, anti-inflammatory medications are often important components of the treatment program. However, during the sub-acute period of rehabilitation and

Figure 2. This 42 year old patient has had episodic back pain with sciatica for approximately five years. Lateral radiograph of the lumbar spine (2A) shows degenerative changes and narrowing of the L5-S1 disc space. The patient attained complete relief of both back and leg pain within four weeks of full time orthosis use. A combined orthosis and exercise program was continued for six months. Front and side views demonstrate orthosis fit (2B, 2C).

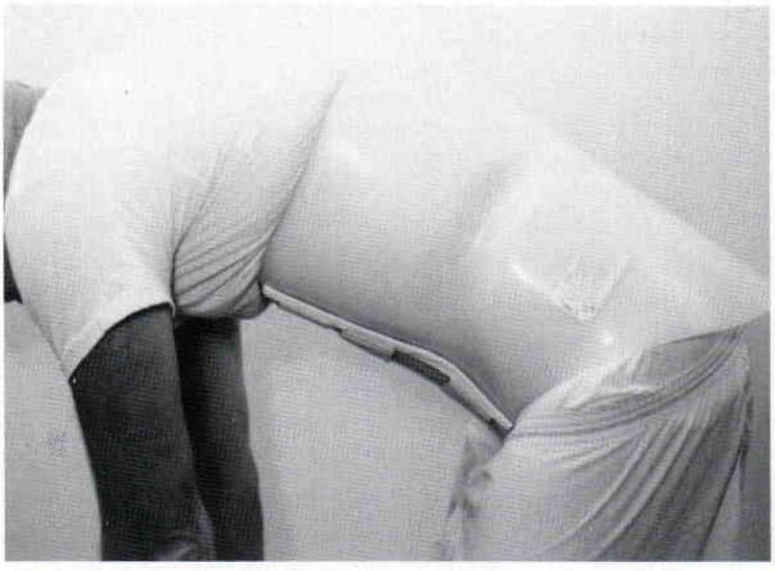


Figure 2D. The patient demonstrates range of forward bending in the orthosis.

restoration of function, orthoses can indeed be useful. Once again, the patient will not usually be able to tolerate the full 0° lordosis orthosis but can generally and most effectively treated with a 15° of lumbar lordosis orthosis.

It is essential to begin a progressive exercise program in conjunction with the use of an orthosis as soon as possible. Most of these patients have dramatic tightness of the lumbo-dorsal fascia and hamstrings and must be on a good anti-lordotic and good exercise program to restore the flexion and the extension of the lumbar spine and the addition of the flexibility of the lower extremities. In these patients, William[13] type exercises alone may have to be supplemented by the McKensie flexion type exercises to restore the full range of motion and strength of the spine.

It must be explained to the patient that the orthosis is really an adjunct in the restoration of function to their back. It, once again, can be very useful for the first two to three months after an acute episode of back pain, but then is used to help support the back while instituting a progressive exercise program. In addition, it can be extremely helpful to have the orthosis on hand for recurrent episodes of back pain and spasm.

SPONDYLOLYSIS

As in the adolescent with acute spondylolysis, the adult with more chronic spondylolysis can often be significantly helped by an orthosis and exercise program. This adult often has had this condition for a number of years and has associated arthrosis and, sometimes, frank neurologic impingement at this level of the spine.[5] He or she may not be able to be placed initially in a full 0° of lordosis orthosis. We will often begin with a 15° of lordosis B.O.B.® and then contour it into 0° after two to three months.

If the patient is able to retain a very nice level of comfort and function while in the orthosis, but has resumption of back pain whenever he/she begins to wean from use of the orthosis extensively, this may be considered an indication for surgical stabilization of the spondylolysis level. Use of the anti-lordotic orthosis, in particular, seems to be useful in those patients who have a component of sciatica with a spondylitic level.

COMBINED DORSAL KYPHOSIS AND LORDOSIS

Patients with tightness of the spine in association with a dorsal kyphosis and

lumbar lordosis deformity often will have intermittent episodes of mechanical back pain localized to the mid-dorsal area of the spine, thoracal-lumbar junction, or low back.[8] The characteristic clinical picture is that of a patient who is rather dramatically tight in the low back and hamstrings and can often not get within two feet of the floor on forward bending.

Orthotic immobilization, of course, will in no way restore motion to the spine, but the use of the orthosis for the painful episode often dramatically facilitates the relief of pain and the restoration of motion. In addition, the reduction of lumbar lordosis with the 15° B.O.B.® and performing dorsal extension exercises while in the orthosis can be useful in helping to reduce, at least in part, the spinal deformity.

We have found this treatment particularly useful in post-menopausal females with osteopia as a component of a progressive deformity. In some cases, we will use an additional anterior strut to apply anterior chest pressure and help stabilize the upper back until comfort has been obtained.

The relief of pain, which is the direct result of orthosis use, can then be used to facilitate the progressive rehabilitation of the patient with exercises and activity. Then, the patient should be referred to an appropriate rheumotologist or internist to discuss possible nutritional components of the management of their primary osteopenia.[4]

However, it has been well demonstrated that one of the most important components of maintaining bone structure is restoration of exercise and function. The relief of pain and the stabilization of the spine facilitated by the orthotic treatment is often a first important step in the restoration of strength and function to the torso and spinal column.

POST OPERATIVE USE OF THE ORTHOSIS

Thermoplastic orthoses can also be used in the post-operative period in a number of situations involving spinal surgery. We use a B.O.B.® with 15° of lumbar lordosis following fusion for spondylolysis, or any low back fusion in which the basically normal contour of the spine is expected following attainment of fusion. Orthoses are not usually required following simple dissections or chymopapain injection.

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A New Approach to the Symes Amputation and Its Prosthesis

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INTRODUCTION

Though Symes amputation has stood the test of time as a surgical technique since Syme described it in 1843, it has always been a problem for the prosthetist to fit a cosmetically appropriate prosthesis to a classical Symes residual limb.

A classical Symes residual limb is bulbous, and too long to facilitate the introduction of a standard SACH foot in the space betwen the end of the residual limb and the ground in its prosthesis. The prosthesis for such a limb is bulky and consists of a self-suspending socket and foot, with or without an ankle joint. If an ankle joint is to be incorporated, the best substitute that could be incorporated is by means of hinges outside the limb, in turn further increasing the bulkiness around the ankle.

A large bulbous residual limb for end-bearing is almost "an article of faith" with advocates of classical Symes amputation. However, a surgeon's responsibility these days does not end merely with the performance of a successful operation. In addition to the amputee's functional requirements, due consideration has to be given to his aesthetic needs as well. The large ankle appearance of a conventional Symes prosthesis is unsightly for women and those who may not be able to hide the ankle inside a trouser leg. People in India have slimmer ankles than Europeans, a racial characteristic, and they often do not hide thier ankles due to the type of attire they wear.

Faced with these problems, we decided to modify the operation, as well as the prosthesis which was fabricated.

OPERATION

The modifications we used during the Symes amputation were: a smaller heel flap, the tibia and fibula cut ½" above the articular surface, and the heel pad firmly secured to the cut end of the bone by suturing it to the flap of the tibial periosteum.

The incision is made just below the tip of the lateral malleolus and goes across the sole of the foot, below the tip of the medial malleolus (Figure 1). The level of the plantar surface incision should be about 2½" in front of the point of the heel. The dorsal part of the incision joining the two malleolar points should be about 1" above the level of the ankle joint.

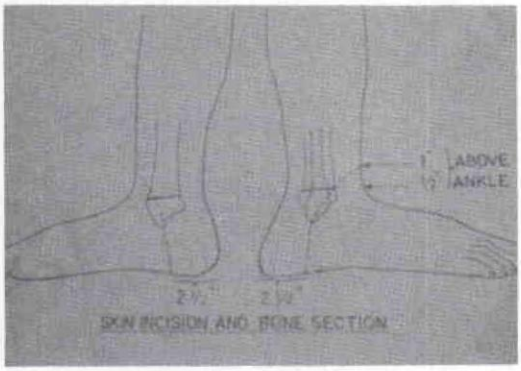

Figure 1. Skin incision and bone section.

The ankle joint is opened, and by plantar flexing the foot, both medial and lateral ligaments are cut from inside. The talus is dislocated away and the calcaneum is dissected out subperiosteally, taking care not to encroach on the fibrofatty tissues of heel pad. The tendoachilles is then divided close to the bone.

Next, the periosteum of tibia is incised at the level of the tibial section and a flap of periosteum is raised upwards. The tibia and fibula are cut ½" above the articular surface and the cut ends are smoothed with a file. After haemostasis and sectioning of the posterior tibial nerve at a higher level, the heel flap is carefully centered, and the raised periosteum of tibia is sutured with the heel flap. This important step helps in firmly securing the heel flap under the lower end of the tibia and prevents it displacement or migration later. While suturing the heel flap, the heel skin covers the anterior edge of the cut tibia. This is possible because of the original anterior incision of skin being higher. The resultant residual end is not bulbous, it is just a little wider than the lower leg above and is covered with the thick heel pad meant for weight bearing (Figure 2).

Postoperatively, we give an "elephant boot" after four weeks when the heel pad is firmly fixed to the cut bone end. Weight bearing "sets" the residual limb, and boosts the patients' morale. After another three to four weeks, the fabrication of the prosthesis starts.

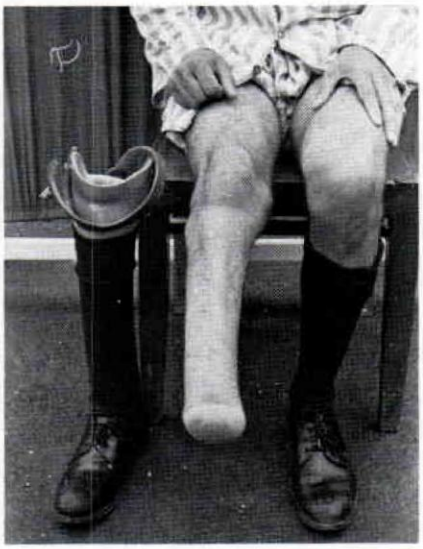

Figure 2. A modified Symes residual limb.

PROSTHETIC FITTING

The prosthesis for the Symes residual limb that we have fabricated has a plastic socket to which a SACH foot is attached. The socket has no soft liner nor any posterior or medial opening. At its proximal end it has features of a Patellar Tendon Bearing prosthesis. It is, therefore, not a total end-bearing prosthesis, but is partial end-bearing and partial proximal tibia-bearing.

To fabricate the prosthesis, a negative plaster cast is made in the usual manner, but the proximal end is molded as for a Patellar Tendon Bearing prosthesis. On the positive model, apart from the usual build-up on the tibial crest and fibular head, a build-up is also done over the distal third of the leg so that the diameter equals that of the distal end. Generally, only a slight build-up is required to make it nearly cylindrical, because the distal end is not grossly bulbous. On this positive model, a standard plastic lamination is done to create the socket of the prosthesis (Figure 3). The socket thus produced does not have any narrow section at the distal third of the limb so that the residual limb can be easily inserted and removed. The proximal portion of the socket acts as a

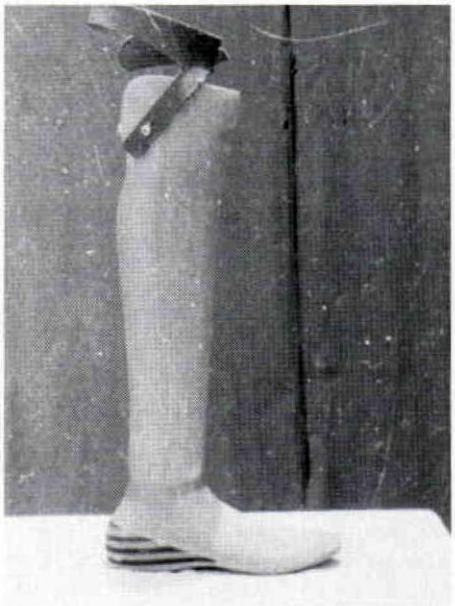

Figure 3. Our Symes Prosthesis.

Causative Agents for Amputations		
Causative agent	**No. of cases**	**%**
Mine-blast injury	58	54
Crush injury	16	15
Frost-bite	33	31
	107	100

Table 1.

Original Levels of Amputation and Subsequent Modifications		
Original level of amputation	**No. of cases**	**Surgical Procedures carried out**
Choparts amputation	46	Modified Symes amputation
Symes amputation	33	Revised modified Symes amputation
Symes amputation	28	Below-knee amputation

Table 2.

P.T.B. prosthesis and the lower end bears partial weight from the distal end.

A SACH foot is attached at the end of the socket, and the prosthesis is finished in the standard manner. The patient wears a long residual limb sock, rather like a stocking, extending up above the patella, and pushes his limb into the prosthesis. A suprapatellar leather strap is used as with the P.T.B. prosthesis to stabilize the prosthesis and act as a suspension.

CLINICAL MATERIAL

A total of 107 cases of Symes amputation have been surgically managed at this centre, of which 79 cases have had the modified operation. These cases included those done initially at this centre, and others referred to this centre after surgery which had to be redone, as they were not fit either surgically or from a prosthetic fitting point of view. Table 1 shows the causative agents for those amputations.

The large proportion of mine-blast injury and frost-bite cases seen in this series are because the majority of our patients were soldiers wounded during the 1971 Indo-Pakistan War. Table 2 shows the original level at which amputations had been done initially, and the various surgical procedures carried out thereafter.

Forty-six patients had undergone a Choparts amputation, but since their residual limbs were deformed, painful, and provided neither weight-bearing nor comfortable walking, they were converted into Symes amputation by the described tech-

nique above. Thirty-three patients on whom a classical Symes amputation had already been performed before reporting at this centre had residual limbs which were considered unsuitable for prosthetic fitting for various reasons.

Some of the residual limbs were too bulbous and long, most with projecting malleoli. Others had displaced heel pads, as a result of which the end-bearing area was covered with normal leg skin unsuitable for weight bearing. Others had depressed adherent scars. Some cases were such in which parts of the Talus and Calcaneum were left behind. In some others, due to wound infection, there was wound gaping. All such residual limbs were revised to a Symes amputation.

Twenty-eight cases were in such a state that they could not be salvaged, and thus we had to resort to amputation at a higher level. Some cases presented extensive gangrene of the heel flap, others had extensive loss of heel flap due to uncontrolled soft tissue and bony infection. In some cases, mere disarticulation at the ankle joint was performed without coverage of the terminal end of the residual limb with a heel flap. Some had terminal, adherent, painful scars, and projecting malleoli. All these cases had to be treated by below-knee amputation.

DISCUSSION

Syme originally devised this operation to provide an end bearing residual limb covered with heel skin containing the pad of fibrofatty tissues. He cut away only the malleoli after disarticulating the ankle. Elmslie (1924) modified the Symes amputation by transecting the tibia and fibula at a higher level to provide a smaller and thinner terminal end of the residual limb. His idea was to give a tapered end which would permit easier fitting of the prosthesis.

But this operation went out of practice because he made the limb too tapered by cutting too high, and by providing too small a heel pad. Thus, the end bearing qualities of the limb were seriously impaired. With the same aim, that is, reducing the bulbous terminal end, Sarmiento, et al. (1966) rounded off the bone end, but this also resulted in reduction of the weight bearing area.

In the operation described here, we have not compromised the basic requirements of the Symes amputation. The only liberty that we have taken is to reduce the bulbous nature of the distal end, to a certain extent, by fashioning a smaller heel flap, and by cutting the bone ½" above the tibial articular surface. This produces a residual limb with sufficient space between the end of the limb and the ground for introduction of an ankle joint in the prosthesis.

We did realize that by reducing the bulbous terminal end of the residual limb by our operation, we were reducing the weight bearing area of the residual limb to some extent. We compensated this objection by redistributing the load bearing forces over wider areas of the residual limb by making a prosthesis, partial end-bearing and partial proximal tibia-bearing.

Success of a Symes amputation depends upon a good stable heel pad, which is adherent to the cut surface of the tibia. To achieve stability, methods like strapping the heel pad or transfixing the heel flap with Kirschner wires have been advocated during the post-operative period for about six weeks, or until healing has fixed it to the lower end of the tibia. It is common knowledge that if post-operative supervision is neglected, the heel flap may be pushed out of place by the dressings and may get displaced over the tibia, resulting in impairment of end-bearing properties. If the heel flap is loosely attached, on weight bearing it is easily displaced to one side or the other, resulting in a wobbly or unstable heel flap. Migration of the heel flap due to pull of the Tendo-achilles is also commonly encountered.

In our technique, no post-operative fixation of the heel pad is employed. Suturing of the heel flap lined with periosteum to the periosteal flap of the tibia results in rapid and firm adherence to the cut surfaces of tibia and fibula. The only care taken is that, before suturing the heel

flap, it is carefully centered over the lower cut ends of the bones, and retained in place by ordinary conventional dressings. Suturing of the heel flap to the tough periosteal flap of tibia does not permit its displacement and, moreover, sometimes new bone forms from the tibial periosteal flap and periosteal lining of the heel flap, resulting in very firm fixation. Because of rapid fixation with this technique, weight bearing is started four weeks post-operatively.

The standard prosthesis for the classical Symes residual limb is made of molded leather, to which the foot is fixed by metal uprights. The appearance of this prosthesis with its thick ankle, uprights, and prominent laces is not satisfactory.

Development of a plastic lamination process enabled our prosthetists to design a light and durable plastic Symes prosthesis. The problem of introducing the bulbous bulky end of the residual limb through the narrower lower third portion of the socket was solved by cutting a posterior window as in the Canadian style prosthesis, or a medial window, as that of the New York University model. These prostheses, however, retained the objectionable bulky ankles, in addition to the inherent weakness of the structure at the window site. To retain window flaps, straps and buckles are employed, which further spoil the appearance of the limb.

Later, to overcome these structural defects, a closed prosthesis with an expandable inner liner had been devised (Sarmiento, 1966; Eckhardt, 1970). The inner liner was made of Kemblo rubber and Silastic foam (Romano, et al., 1972; Le Blanc, 1971; Eckhardt, 1970) which permits the bulbous end of the residual limb to go through the narrow section by expanding it. The lower third portion of this prosthesis is as wide as the distal end, giving the prosthesis a fat leg and ankle appearance. An important objection to inner liners is that in a tropical climate, it becomes uncomfortably hot, leading to excessive perspiration.

Another difficulty faced in making a plastic socket prosthesis for a classical Symes residual limb is how to fit the foot at the end of the shin. The commonly used SACH foot needs at least 2½" of space between the end of the socket and the ground.

The classical Symes residual limb does not usually have that much clearance, and thus the prosthesis becomes too long. This is compensated either by raising the heel of the shoe of the sound leg, which looks unsightly, or by hollowing out the keel of the SACH foot, which destroys the cushioning effect of the SACH heel and may also alter the gait pattern.

In the prosthesis made at the Centre (Figure 4), most of the objectionable features described above could be overcome because of our surgical technique. The residual limb created with this technique provides sufficient clearance for a foot with its ankle to be fitted at the end of the socket. Since the end of the residual limb is not bulky, and is only slightly bigger in circumference than that of the lower third portion of the leg, a more cosmetically appealing prosthesis can be fabricated. The hard socket without a window and a liner does not pose either a problem of structural weakness or of excessive perspiration in a hot climate. The finished prosthesis is also light in weight and durable.

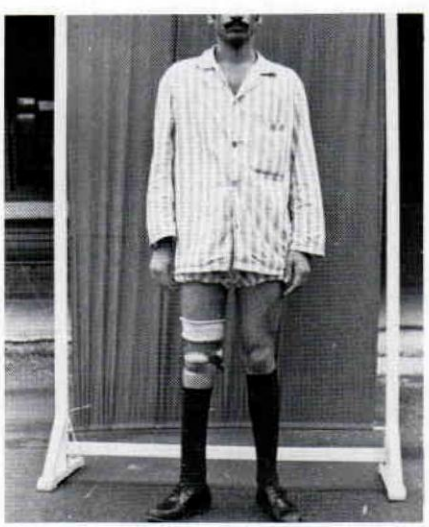

Figure 4. A Symes amputee with prosthesis.

In order to compensate for the slightly reduced end-bearing area of the residual limb, we extended the socket upwards and made it similar to a Patellar Tendon Bearing type, thus distributing some weight bearing through the proximal portion of the socket. At a rough estimate, by asking patients their subjective feeling, the weight transmitted through the end is about 75 percent, and through the proximal portion, about 25 percent.

Since this prosthesis is not self-suspending, a supra-patellar strap is provided, which provides suspension and restricts piston action. Because of the PTB type proximal portion, rotation of the residual limb within the socket is also eliminated.

The socket of the prosthesis remains in contact with the residual limb at its end and nearly the entire proximal two-thirds. Thus, propriocaptive quality is not lost. The small contact gap between the distal third and the corresponding socket wall has not been found to cause any edema of that portion of the residual limb in our series, contrary to expectations of advocates of the expandable inner liner, and total contact.

However, when indicated to achieve total contact, we advise the patient to wear a cylindrical section of sock over the narrow portion of the leg followed by the long residual limb sock on top of it. No edema of the residual limb has been noted, probably because of the usual habit of our Indian patients to remove their prostheses when not in use.

The patients operated on and fitted by our technique have been followed up for the past ten years. The residual limbs have been found healthy with good end-bearing qualities. All of them could bear weight on it, and walk indoors in an emergency without any prosthesis. No shifting or migration of the heel flap has been encountered. The patients are highly satisfied with their prosthesis both from its functional and esthetic point of view.

SUMMARY

The classical Symes amputation is a good operation, but due to the resultant bulky distal end, there are some difficulties in fitting a prosthesis. To overcome the difficulties, the surgical technique has been modified, and a functional, cosmetic prosthesis was fabricated.

The surgical technique provides a less bulbous distal end with sufficient clearance from the distal end to the floor, to enable fabrication and fitting of a cosmetically acceptable prosthesis.

Of the 107 cases of Symes amputation which were treated, 79 had the above operation and prosthesis with very satisfactory results.

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Orthotics and Prosthetics, Vol. 39, No. 3, pp. 53–56.

Imler Partial Foot Prosthesis IPFP—"The Chicago Boot"

Clarence D. Imler, C.P.

INTRODUCTION

Surgeons, because of better technology and advances in surgical technique, are now performing a greater number of distal amputations, including those of the forefoot. Consequently, a need exists for a prosthesis that allows a more functional gait pattern and is more energy conservative, with ankle motion left intact in the saggital plane and dorsi/plantor flexion unrestricted. The prosthesis needs to be light in weight, be structurally strong, provide ankle support, have an anterior lever arm, act as a shoe filler, and be cosmetically acceptable.

The Imler Partial Foot Prosthesis fulfills these needs. This prosthesis is utilized for LisFranc, Chopart, Boyd, and other difficult forefoot amputations.

The essential element of the prosthesis is the interface, consisting of a vacuum formed co-polymer† U.C.B. type insert, and a toe filler of soft foam. This interface is then inserted into a laminated, flexible rubber-epoxy-resin (Lynadure††) cosmetic sleeve that encompasses the entire foot. This sleeve extends proximally to above the malleolus and has an anterior opening. The interface is removable, and enabled the prosthetist to make necessary adjustments (i.e. alignment and/or relief). Closure is obtained by eyelets and laces for greater suspension, or Velcro® for more cosmesis.

CASTING PROCEDURE

A negative impression may be obtained using any conventional method. A midfoot amputation should be placed on a casting board or covered with a plastic bag and inserted into the patient's shoe to simulate heel height. Very little weight should be applied to avoid spreading of the foot. With a Chopart amputation, where the calcaneous is plantar flexed or rotated posteriorally, a casting board is not used. The casting in all cases is similar to the procedure used when casting for a U.C.B. shoe insert.

MODIFICATION OF THE POSITIVE MODEL

Modifications include a standard 3mm. anterior relief. A 1mm. relief for the malleolus is added, along with relief for any

†Co-polymer, Colyene: Orthotic Prosthetic Enterprises, 1316 Sherman Avenue, Evanston, Illinois 60202.

††Lynadure: Medical Center Prosthetics, 6955 Almeda Road, Houston, Texas 77021.

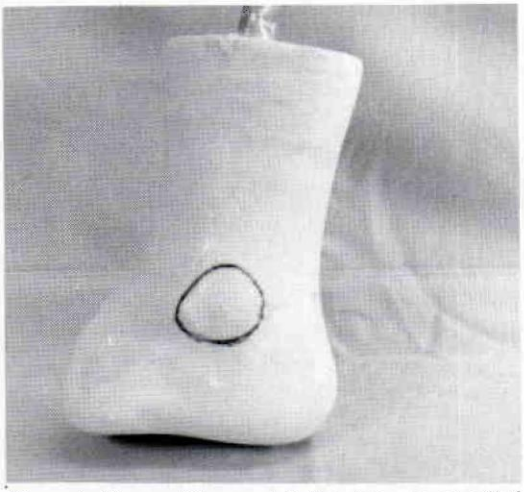

Figure 1. The positive model showing area of relief over malleoli.

bony prominence or scar tissue as needed. Remove 2mm. of plaster both medially and laterally, proximal to the calcaneous to enhance the support effect of the U.C.B. type insert. There is no relief formed for the anterior tibia (Figure 1).

SHOE INSERT WITH TOE FILLER

Over the modified positive model, thermo-form a section of 5mm. firm density Pelite,® for an anterior end pad. Trim and bevel the edges to achieve a smooth transition (Figure 2). A sheet of 3/16" Colyene is vacuum formed over the cast and end pad (Figure 3). The interface may also be laminated with either acrylic or polyester resin. The posterior trim line is proximal to the calcaneous. The medial and lateral trim lines are distal to the malleolus, and the anterior is at mid-height level. Care should be taken not to cut into the Pelite® pad as it extends above the trim line (Figure 4). The anterior toe section can be constructed by various means. Pelite® of 5mm. firm density should be added until a flat surface distally is attained (Figure 5).

It is at this juncture that adjustments, during or after fitting, are to be made. The heel cup toe filler can be bisected, and the heel cup interface rotated, to produce eversion, inversion, plantar/dorsi-flexion, toe in, or toe out. Due to the flexibility of the outer sleeve, these changes may be accommodated without the need for a new lamination.

Figure 2. Corrected positive model with Pelite® end pad.

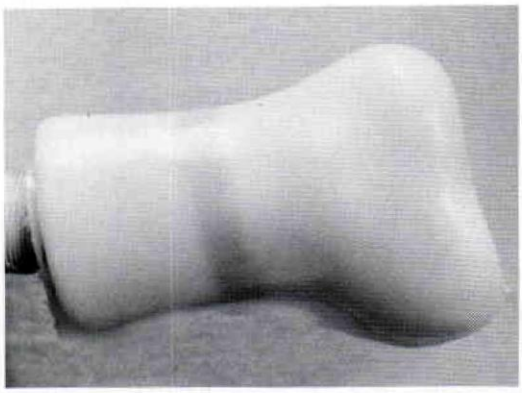

Figure 3. Vacuum formed colyene over positive model.

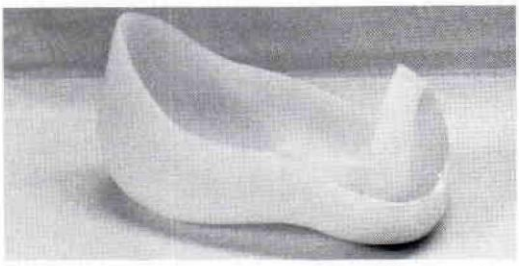

Figure 4. Trimmed heel cup with Pelite® end pad.

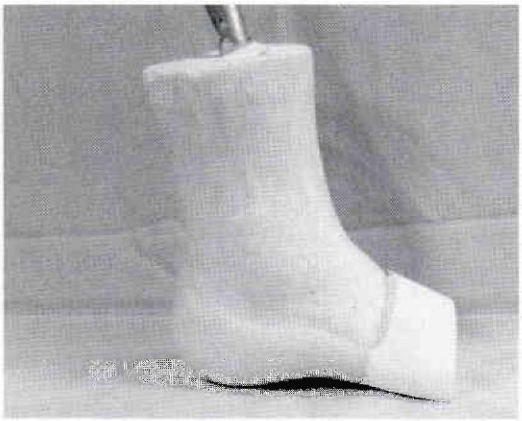

Figure 5. Heel cup with flat anterior surface created by Pelite® buildup.

The anterior toe section is constructed of 12mm. firm density Pelite,® bonded together lengthwise. This toe section is bonded to the heel cup and shaped to size. Using a mold or the patient's shoe, the toe section can be formed using a flexible foam. Additional material is removed to leave room for the outer lamination (Figure 6). The finished heel cup interface with toe filler is replaced on the cast and inserted into the patient's shoe. At this point, a final determination is made of the alignment.

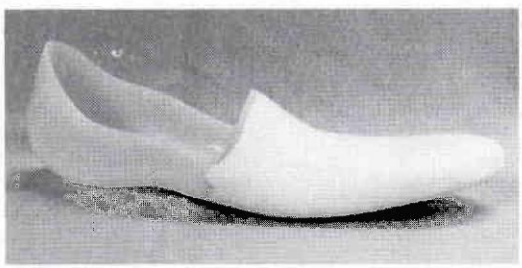

Figure 6. Heel cup with toe section.

A 1.5mm. thick strip of polyethylene is thermo-formed over the anterior surface. This will act as a separating agent, forming the tongue and overlap. A center line is drawn with parallel lines on either side, making the overall width approximately 2.6cm. The length extends from the proximal edge of the cast, to 5mm. past the proximal edge of the Pelite® toe filler. The strip is trimmed to length, and the edges beveled for a smooth transition.

The layup for the rubber epoxy sleeve lamination consists of a nylon hose covered by a PVA bag, which has been capped off and put under full vacuum. Two layers of stretch nylon stockinette are applied. The strip of polyethylene wrapped in Dynalon is sandwiched between this and four additional layers of stretch nylon and one layer of ortholon, for a smooth outer finish. A second PVA bag is applied with vacuum, and the rubber epoxy resin is introduced (Figure 7).

Figure 7. Lamination with rubber epoxy resin (Lynadure®).

Before final trimming, it should be determined if closure is to be achieved by eyelets and lace or Velcro.® If eyelets are used, make a center cut through to the polyethylene strip, with inverted T slits to the edges of the strip. Heat the laminate lightly, remove the polyethylene strip and cut the inner tongue along the medial and distal edges only. To obtain a Velcro® closure, first cut along the medial and distal edge of the polyethylene strip, remove the strip, and cut the inner tongue along the lateral and distal border. To complete the prosthesis, insert eyelets, or sew in Velcro.® Before cutting the laminate, be sure

the material has fully cured, otherwise it may fray.

Initially, the first prosthesis made extended proximally to 1/3 the length of the lower limb. This trim line has since been lowered to just proximal to the malleolus.

The I.P.E.P. weighs approximately 250 grams, depending on the shoe size. It is extremely lightweight, but very durable.

A leg length discrepancy may be accommodated for in the prosthesis by adding a Pelite® pad of the proper height, either before or after the interface is vacuum formed.

The prosthesis is thinly constructed to be used by the patient with regular shoes. There is no need for split-sized, over-sized, or extra depth inlay shoes, in most cases. Figure 8 shows the finished prosthesis in a patient's shoe.

Figure 8. Finished prosthesis in a patient's shoe.

CONCLUSION

During a two year period, approximately 50 partial foot prostheses were fabricated at a central fabrication laboratory, for facilities throughout the United States. The response of first time prosthesis wearers was mixed, whereas former wearers of other types of prostheses were very favorable in their comments. A 65 year old patient with a three year old amputation indicated that he feels there is no comparison. His previous prosthesis weighed 10 pounds and his "Imler boot" weighs 10 ounces. There is increased mobility with the ability to use the right foot when driving. A 70 year old congenital amputee with 3/4" leg length discrepancy comments that the boot is comfortable and light in weight and says she feels more sure-footed than previously.

This is not the answer to every partial foot amputation, but an alternative to the problem of fitting a difficult prosthesis.

AUTHOR

Mr. Imler is with The Orthotic Prosthetic Center, Fairfax, Virginia. He previously was in charge of the Prosthetic Department at Orthotic Prosthetic Lab Service, Evanston, Illinois, a central fabrication facility where he developed his partial foot prosthesis.

Orthotics and Prosthetics, Vol. 39, No. 3, pp. 57–59.

A Case Study: Functional Positioning Toe Restoration

Robert D. Young, B.S.Ed., C.P.

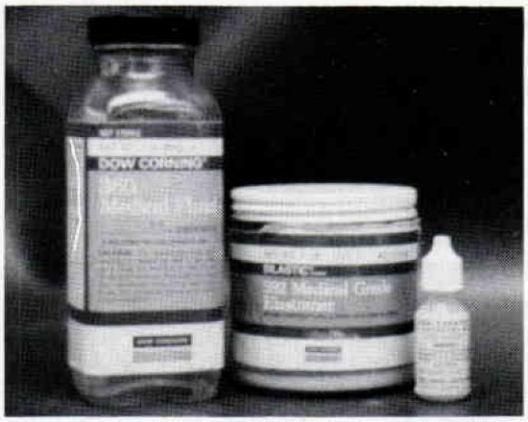

Figure 1. Dow Corning #382 Elastomer with medical fluid and catalist.

Figure 2. Dorsum of modified plaster positive.

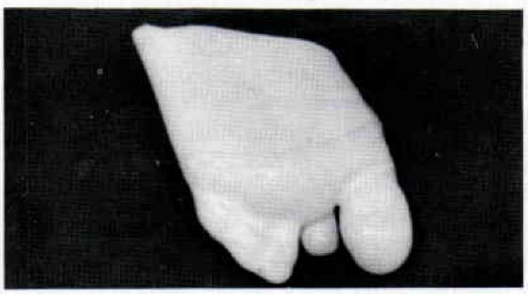

Figure 3. Plantar surface of modified plaster positive.

The case presented involved a patient with a proximal phalanx resection of the second toe. The great toe and third toe worked under the residual toe and forced it dorsally into contact with the shoe. This toe is ¾" short and is not muscularly controlled. Lengthening the toe, as well as holding it in position between the great and third toes, were requirements of the restoration.

Dow Corning #382 Medical Elastomer® (Figure 1) was the material used for this prosthesis, using conventional pigments to color the material. This material offers a soft, resilient, cosmetically acceptable prosthesis, which holds on by suction and a "ridge" fit to the plantar toe spaces.

Fabrication began with an alginate impression of the distal portion of the foot. A piece of tongue depressor was cut to hold the great and third toes apart enough to allow the alginate to completely encompass the residual toe. A piece of tape was used between the toe and tongue depressor to hold the toe in its proper location. A positive mold was then prepared and modified. Modification included reducing the circumference of the positive mold of the residual toe, to offer a snug fit in the socket

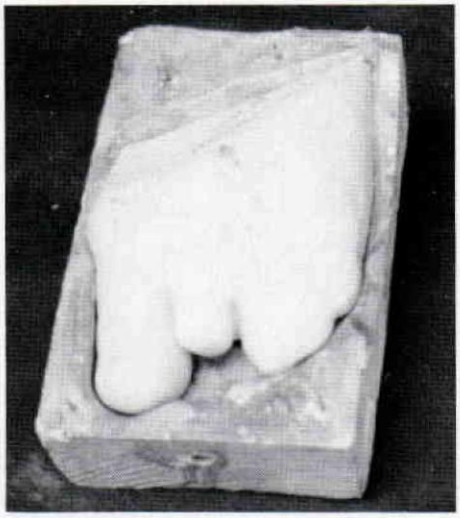

Figure 4. Positive model in base of mold.

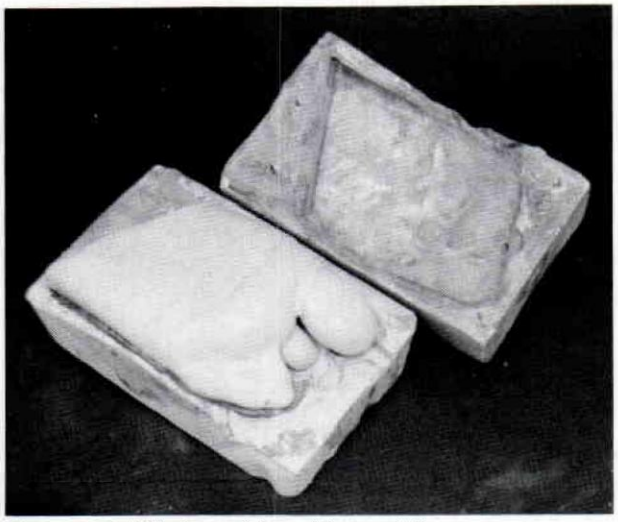

Figure 5. Mold halves with positive model.

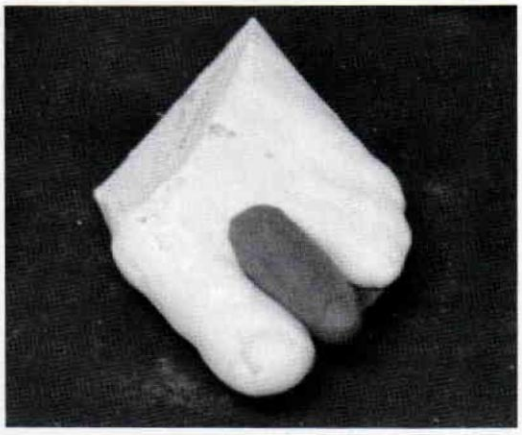

Figure 6. Dorsum of model with completed prosthesis attached.

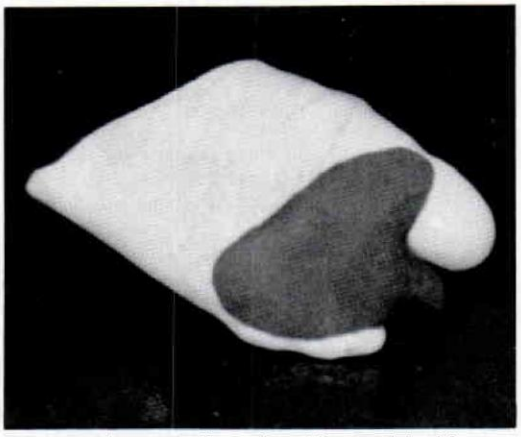

Figure 7. Plantar surface of positive model with completed prosthesis attached.

portion, and filling in the spaces between the other toes, leaving a ridge on the plantar surface to locate and stabilize the prosthesis (Figures 2 and 3). The plaster positive was then dried and coated with a plastic parting lacquer.

A two piece mold was created over the plaster positive model, separating at the peak width around the entire model. Nails inserted in the base of the mold were used to key in the upper and lower portions of the mold when it was poured and for later reassembly (Figures 4 and 5). Enough material was then carved out of the two piece mold sections to restore the toe length, encompass the residual toe, add toenail detail (Figure 6), and provide a plantar surface stabilization wing extending from the peak of the plantar toe pads to a very thin edge following the midline of the metatarsal heads (Figure 7).

A sprue hole was drilled at the distal plantar portion of the prosthetic cavity, and a riser hole was provided at a location away from any area of importance. Dow Corning Elastomer® was poured into the halves of the mold and the plaster positive inserted. The mold was then put together and secured with an elastic wrap.

The mold was set with the sprue hole uppermost to allow any bubbles to work their way out. Extra material was added, as

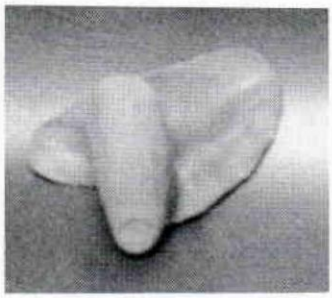

Figure 8. Dorsal view of completed prosthesis.

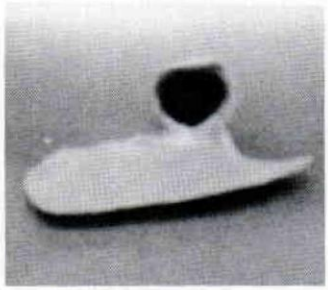

Figure 9. Posterior view of completed prosthesis.

the level reduced in the sprue, until the cavity was completely full. Two prostheses of slightly different colors were made, and the one that best matched the patient's skin tone was provided to the patient (Figures 8 and 9).

AUTHOR

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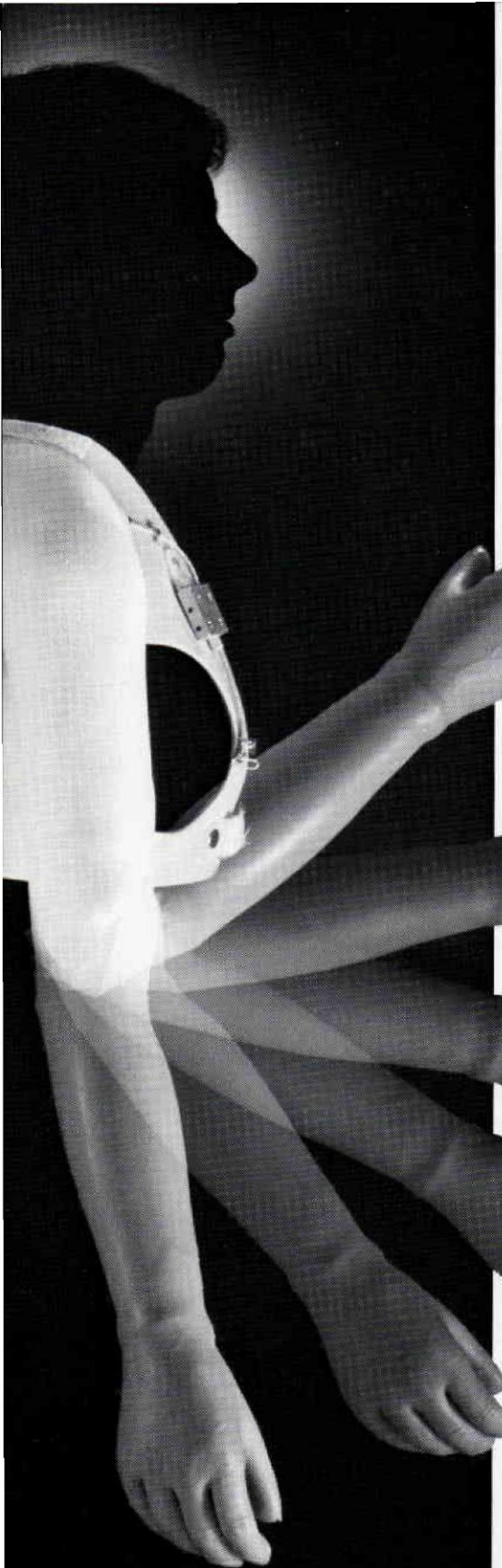

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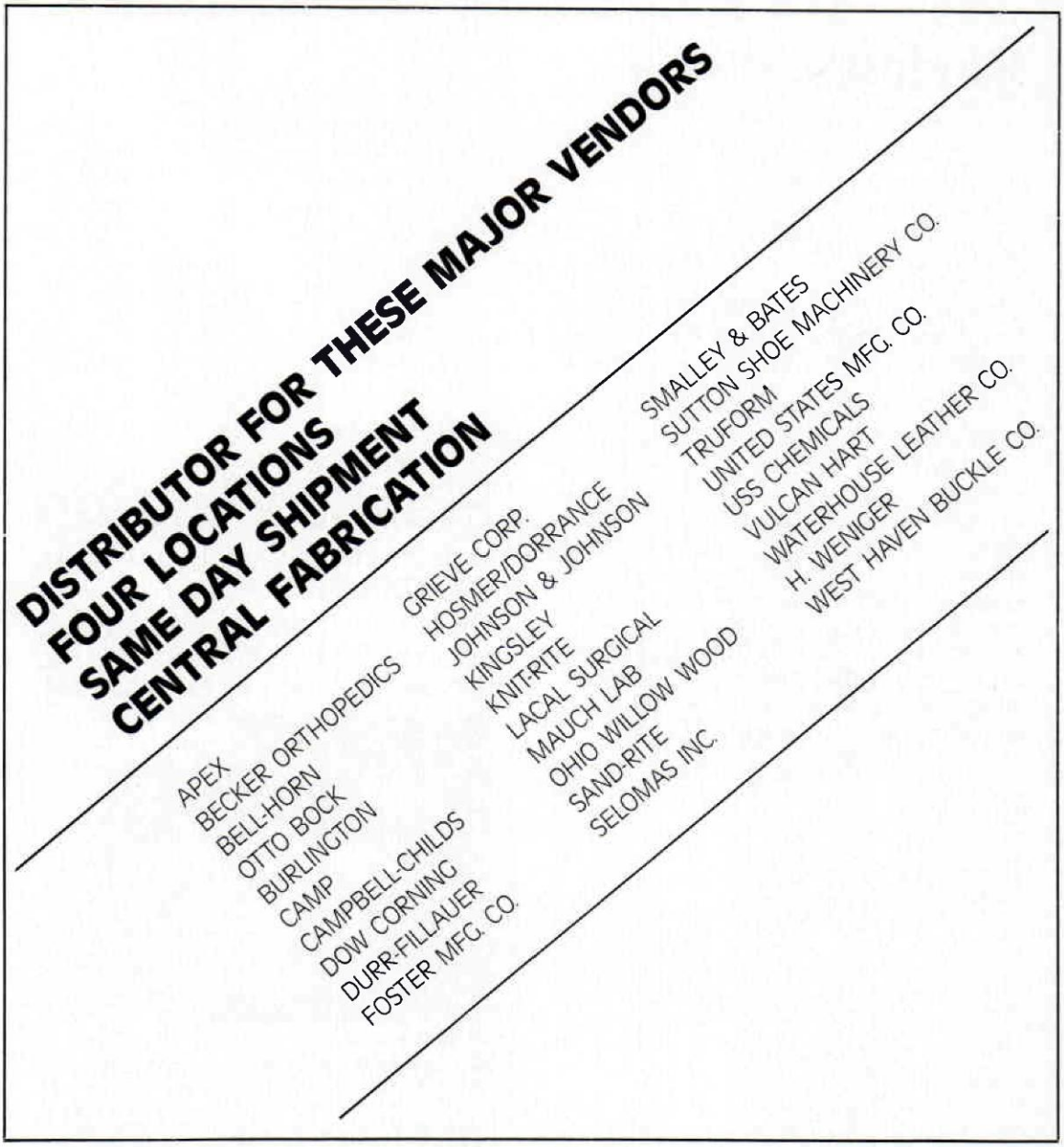

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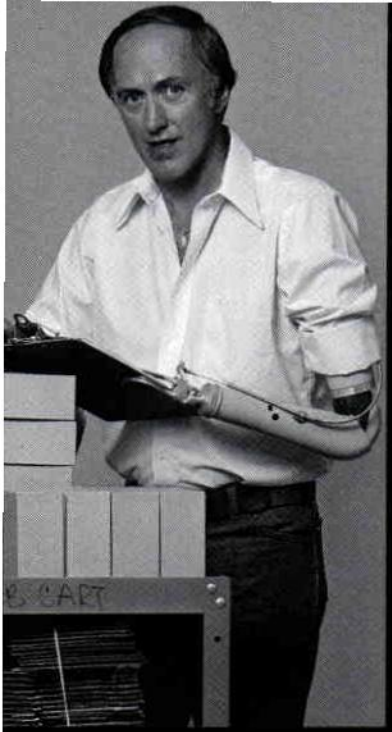
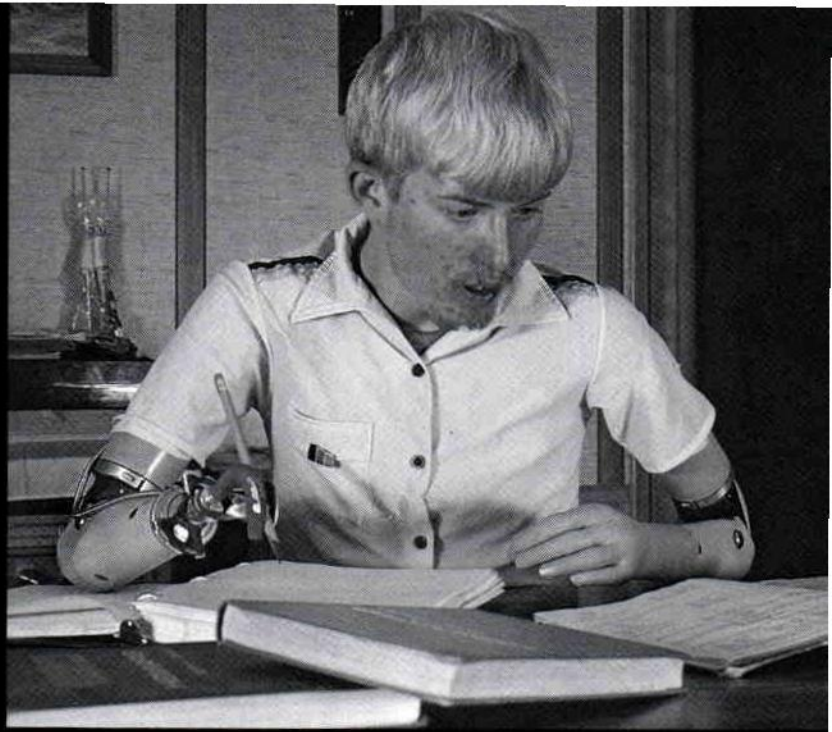
Reviews

Yearbook of Orthopedics, 1984, Ed. by Mark B. Coventry, Yearbook Medical Publishers, 35 East Wacker Drive, Chicago, Illinois 60601.

This book is a compilation of abstracts published in a multitude of orthopedic journals from around the world. For someone who wishes to keep abreast of the literature in the field, it undoubtedly is of considerable interest. The abstracts are grouped under a variety of general headings. None of them specifically deal with orthotics or prosthetics. The reader should bear in mind that the results are totally dependent on the discretion of the editors and personnel writing the abstracts.

Charles H. Pritham, C.P.O.





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All listings are considered editorial material, and are published at the discretion of AOPA and the Managing Editor of *Orthotics and Prosthetics*. All submissions become the property of AOPA.

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   B. AOPA members
   C. Firms which advertise in AOPA publications
   D. All others
2. Firms will be able to have only one (1) listing published in the new products section during a single *Orthotics and Prosthetics* volume year.
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*patent applied for

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Bruce McClellan, CPO
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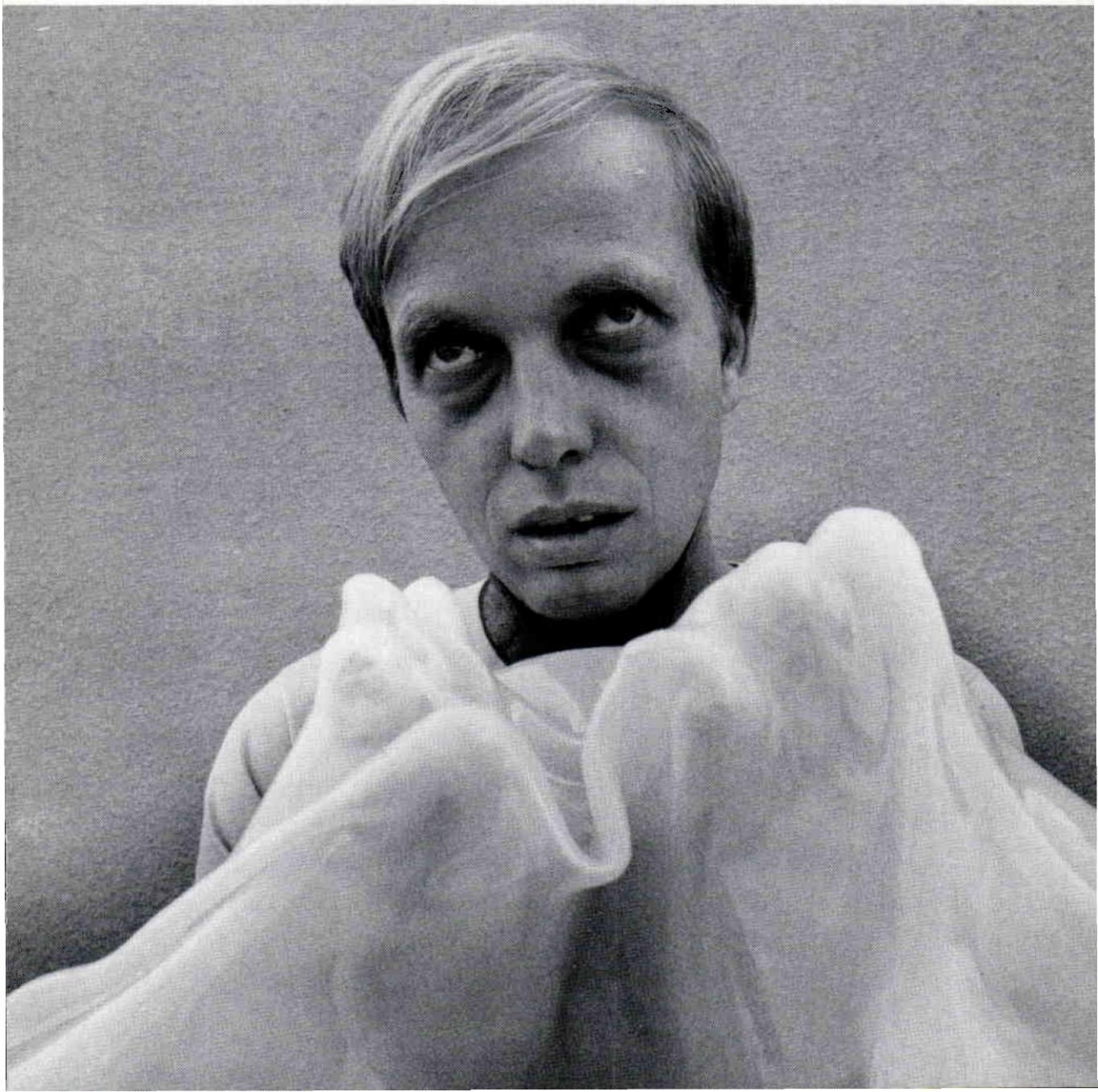

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