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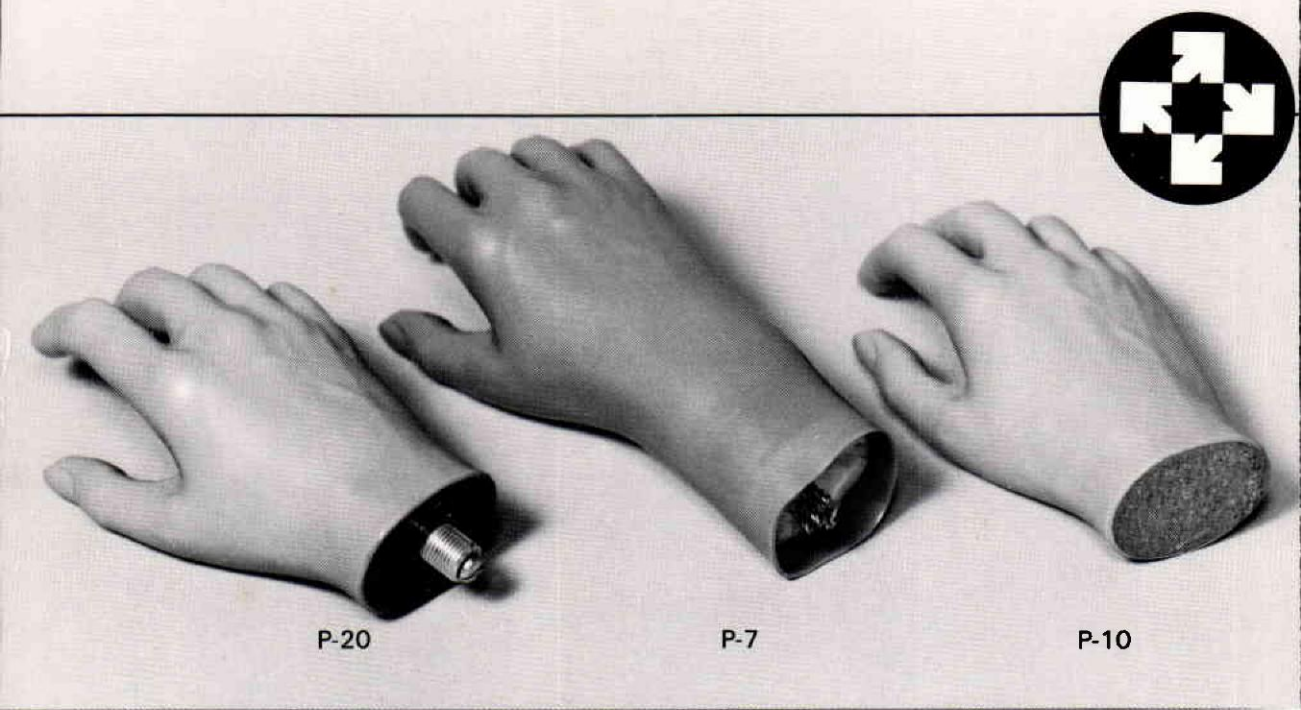
Number 4

Orthotics and Prosthetics

Journal of the American Orthotic and Prosthetic Association



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Orthotics and Prosthetics

Volume 38, Number 4

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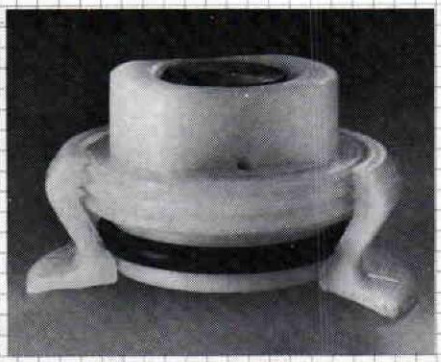

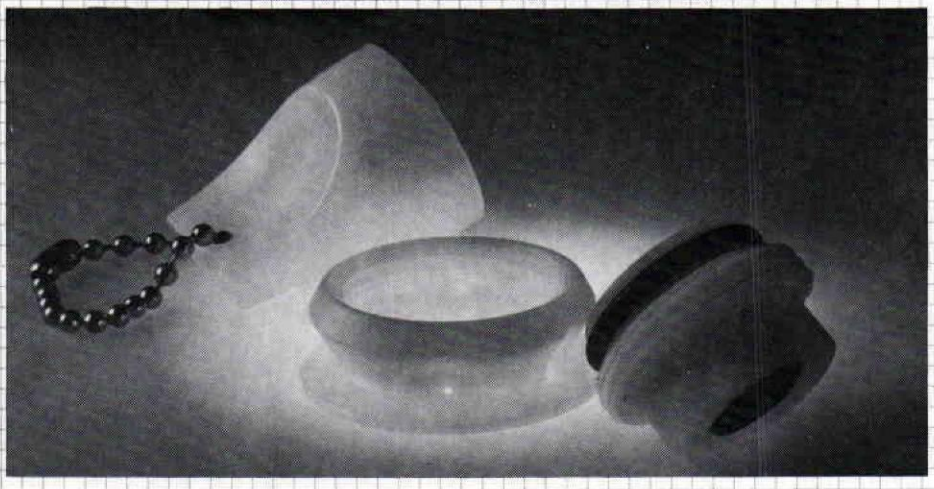

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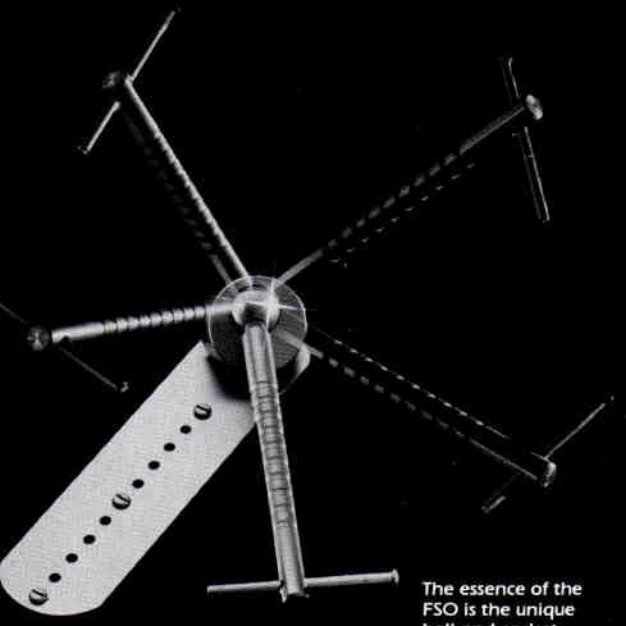

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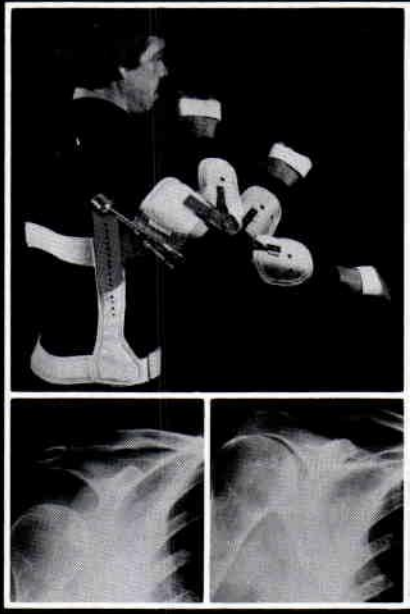

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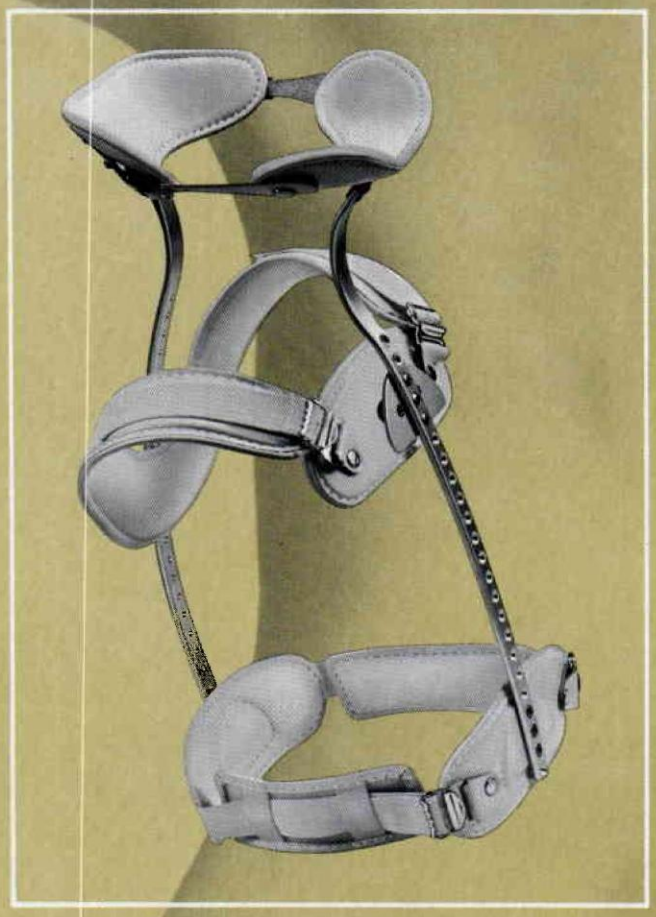

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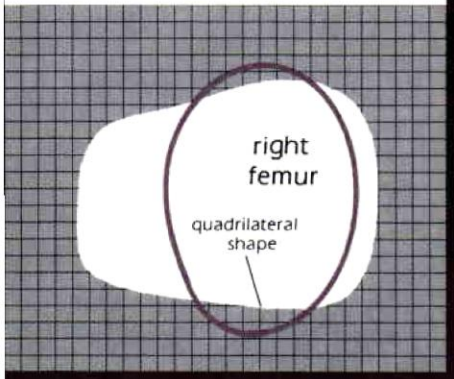

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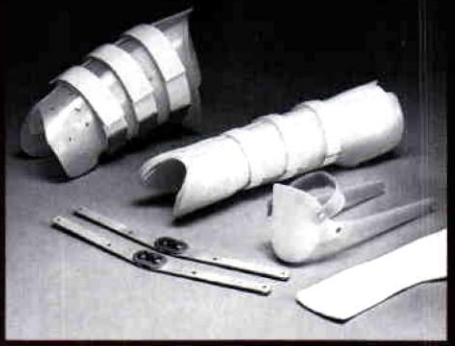

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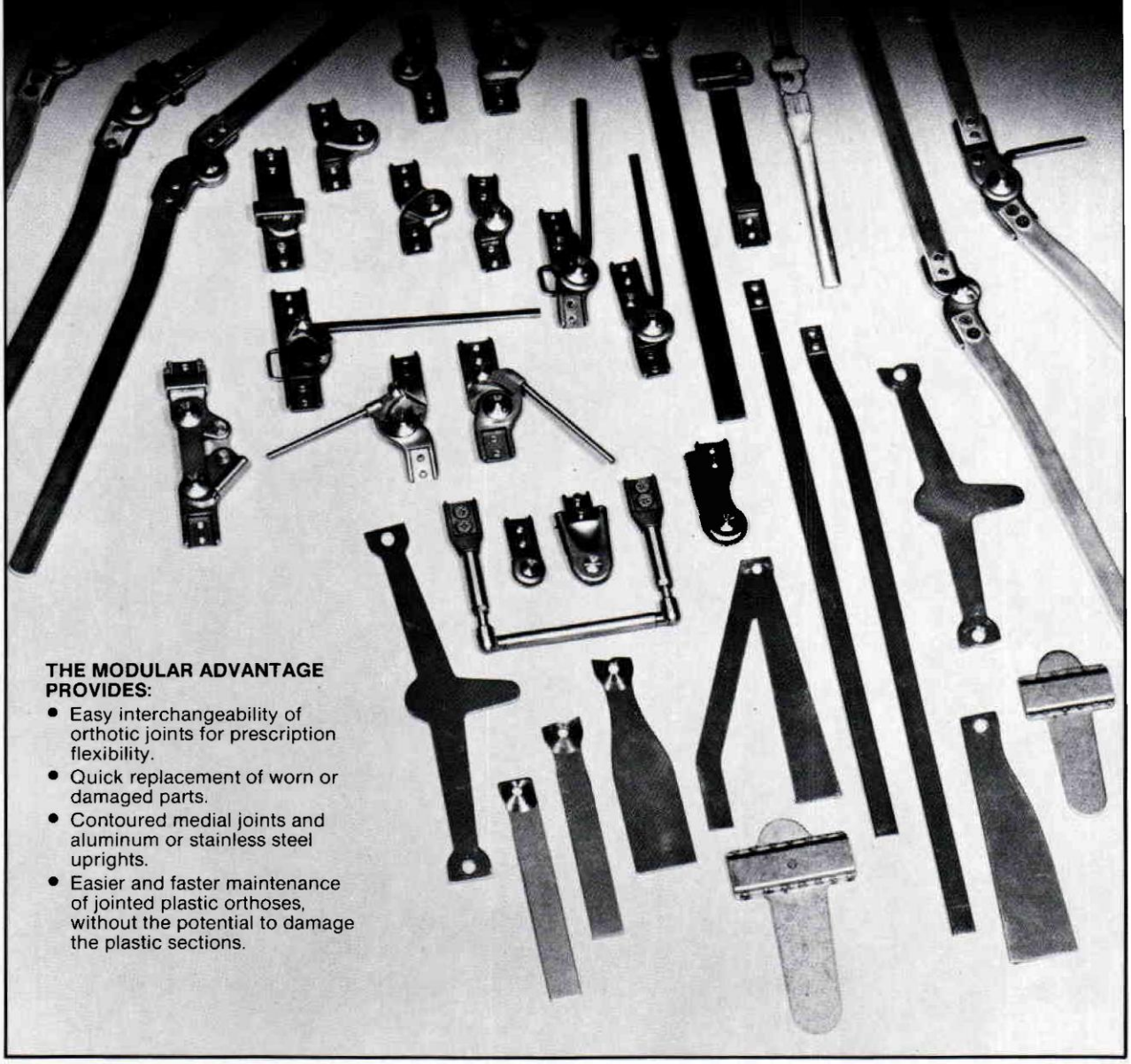

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January 24–29, American Academy of Orthopedic Surgeons Annual Meeting, Las Vegas, Nevada.

January 30–February 3, Academy Annual Meeting and Scientific Seminar, Cathedral Hill Hotel, San Francisco, California. Contact: Academy National Headquarters, 703-836-7118.

February 2, Foot Orthotics and Prosthetics Seminar, 2–5 p.m., Cathedral Hill Hotel, San Francisco, California. Sponsored by the U.S. National Member Society of the International Society for Prosthetics and Orthotics. Contact: Joan Edelstein, Secretary-Treasurer, US-ISPO, 317 East 34th Street, New York, New York 10016, 212-340-6683.

February 16, Midwest Chapter of the Academy Prosthetics Workshop, Northwestern University, Chicago, Illinois.

March 8–9, New England Chapter of the Academy Annual Seminar. Contact: Academy National Headquarters, 703-836-7118.

March 8–10, Third Carl M. Pearson Memorial Symposium, "Frontiers of Rheumatology," sponsored by the Annenberg Center for Health Sciences; UCLA School of Medicine, Division of Rheumatology; and the Southern California Chapter of the Arthritis Foundation. Contact: The Annenberg Center for Health Sciences, Eisenhower Medical Center, 39000 Bob Hope Drive, Rancho Mirage, California 92270; 800-321-3690, in California—800-621-7322.

March 14–22, ABC Practical Examination, Shelby State Community College, Memphis, Tennessee. Contact: ABC National Headquarters, 703-836-7114.

March 22–23, American Academy of Orthotists and Prosthetists Seminar, "Orthotic Management of Spinal Cord Injured Patients," Denver, Colorado.

March 25–29, Boston Scoliosis Brace Course, Boston, Massachusetts. Sponsored by Dept. of Orthopaedic Surgery, Children's Hospital. Contact: Paula Roth, Dept. of Orthopaedic Surgery, Children's Hospital, 300 Longwood Avenue, Boston, Massachusetts 02115; 617-735-6887.

April 11–13, Association of Children's Prosthetic and Orthotic Clinics (ACPOC) Annual Meeting, Tulane Medical Center, New Orleans, Louisiana. Contact: Curtis D. Edholm, M.D., Program Chairman, 235 Wealthy Ave., S.E., Grand Rapids, Michigan 49503.

April 12–13, New York State Chapter of the Academy Seminar, The Hotels at Syracuse Square, Syracuse, New York.

April 18–20, AOPA Region IV Annual Meeting, Wilmington Hilton Hotel, Wilmington, North Carolina.

April 27, Midwest Chapter of the Academy Spring Seminar/Social Event.

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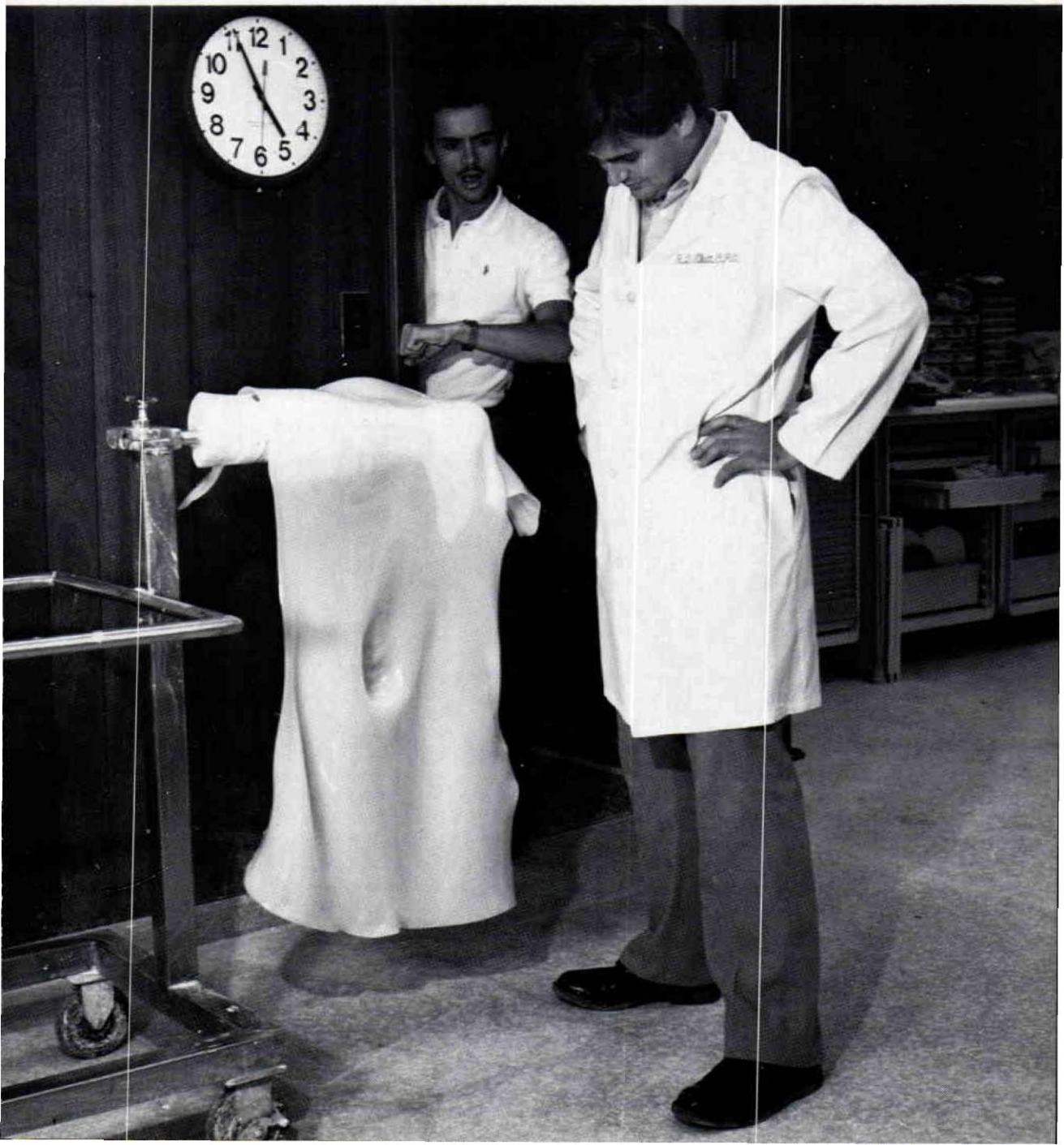

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Orthotics and Prosthetics, Volume 38, No. 4, pgs. 13–23.

The Toledo Tenodesis Prosthesis— A Case History Utilizing a New Concept in Prosthetics for the Partial Hand Amputee

Daniel P. Cole, C.O.
Gerald L. Davis, OTR/L
Janet E. Traunero, OTR/L

Occasionally in orthotics and prosthetics we are faced with a challenging case that falls into the "orphan" category. These cases usually are lacking in the research and development area only because of the infrequency of their occurrence in the field.

One such category that falls short in research and development is the partial hand prosthesis. A prosthetist evaluating a patient who exhibits, for example, a transmetacarpal amputation has only a few avenues available because of the lack of data and material in this area (Figure 1). The current terminal hand devices are intended for use in conjunction with a wrist unit attached to the distal end of the socket that utilizes physiological shoulder excursion as a power source.

When the current prosthetic procedures are applied to the above-mentioned anomaly, certain cosmetic and physiological drawbacks become apparent. One such drawback pertains to the surplus length that is exhibited. The surplus length is due to the lack of room for the wrist unit at the end of the socket that contains the terminal device. The span of the prosthesis compared to the sound extremity produces a disproportioned, elongated appearance. Amputation at the wrist would ameliorate the distorted look, but usually the amputee is recalcitrant to the idea. Physiologically, the surplus length tends to inhibit potential proprioceptive sensations by limiting the operator's ability to accurately perceive environmental placement of the prosthesis. By eliciting proprioceptive sensations, the prosthesis serves as an artificial extension of the operator, a part of the functioning person.

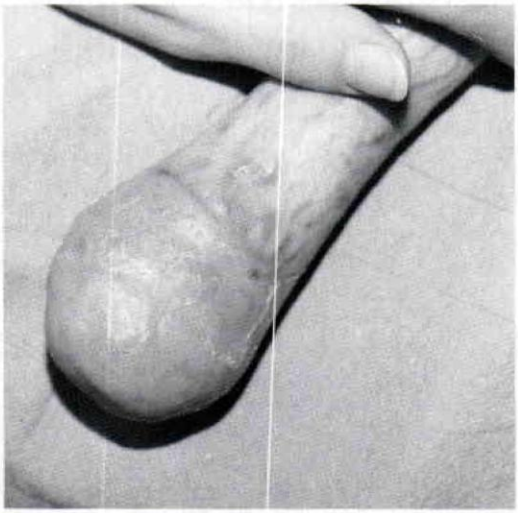


Figure 1. Transmetacarpal amputation, palmar aspect.

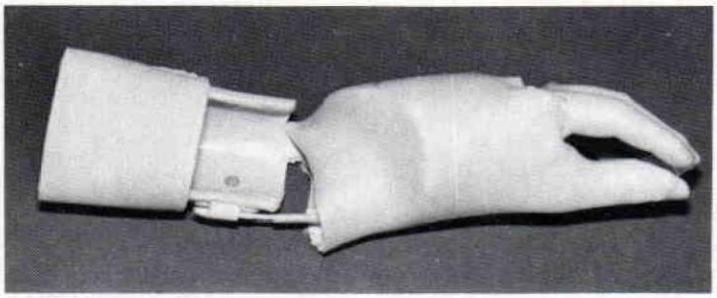


Figure 2. T.T.P. exhibiting wrist extension resulting in passive flexion of the fingers.

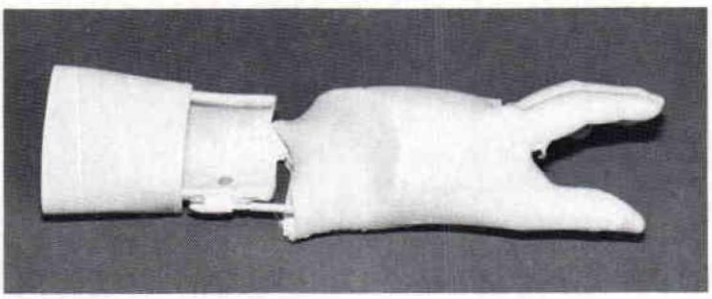


Figure 3. T.T.P. exhibiting wrist flexion resulting in passive extension of the fingers.

A second drawback to the use of traditional terminal devices on a partial hand is the need to utilize and isolate physiological shoulder movements as a source of power. During the process of conducting this research project, it became apparent that an alternate physiological power source had been overlooked, namely wrist motion.

The concept of utilizing physiological wrist action to power hand devices is not a novel concept. Orthotic devices such as the Engen or RIC tenodesis splints depend entirely on wrist extension to power the devices. Since the partial hand amputee still retains anatomical and physiological characteristics of the wrist, theoretically through the proper design and development of a prosthetic mechanism, physiological wrist generated output forces could be utilized to serve as an alternate power source.

The following article on the Toledo Tenodesis Prosthesis is the result of a recent research and development project conducted by the authors. The purpose for writing this paper is to educate and expand on the methodology techniques used to fabricate this prosthesis, and also to share the gratifying results we obtained.

OBJECTIVES

The objectives of this research project were to design and develop a functional and cosmetic partial hand prosthesis that utilized available sensory and motor capabilities of the transphalangeal/transmetacarpal amputee. The functional prostheses usually prescribed for this level of amputation are geared toward adequate prehension capabilities, but deficient in both aesthetic qualities and the ability to maximize available physiological wrist sensory and motor response. The need for a partial hand prosthesis that displayed function, cosmesis, and utilization of physiological proprioceptive wrist responses motivated this research and development project.

DESCRIPTION

In order to describe the Toledo Tenodesis Prosthesis (TTP) we must first review the term "tenodesis action." Tenodesis action is a method by which prehension of the three forefingers—index, middle, and thumb—is achieved through active wrist extension.

The TTP is designed so that active wrist extension results in passive flexion of the artificial fingers (Figure 2). The index and middle fingers are brought into opposition with the thumb, producing a three jaw chuck prehensive grasp. Once the object has been grasped, release is accomplished simply by flexing the wrist (Figure 3), which results in passive extension of the artificial fingers. These reciprocal actions are accomplished by two articulations, the wrist and metacarpophalangeal joints interconnected by means of a linkage cable. By connecting the wrist and MP's reciprocally, motion occurring at the wrist in the form of flexion or extension is directly proportional to the motion seen at the artificial fingers. This linkage connection also serves as an interface providing the user with valuable pressure-sensory proprioceptive feedback information.

PRESSURE-SENSORY PROPRIOCEPTIVE FEEDBACK

Pressure-sensory proprioceptive feedback pertains to the concept of providing a limb-prosthesis interface through which information regarding applied prehensive pressure to an object by the artificial fingers is transmitted to the physiological power source. It is the author's opinion that the proportionate kinetics the TTP inherits functions as an interface between the prosthesis and residual limb. The direct mechanical linkage between the input (wrist flexion-extension) and the output (finger flexion-extension) provides a significant amount of feedback information directly relating to the applied prehensive pressures on an object. By coupling the residual wrist motion to the prosthetic fingers, the position and movement of the fingers are at all times directly proportional to the position and movement of the wrist. This direct coupling of the physiological wrist joint with the prosthetic finger joint results in the communication of pressure sensory information to the user. The effectiveness of pressure sensory proprioceptive feedback when applied to the TTP is in a large part determined by the ability of the user to assess the information transmitted to the proprioceptors of the wrist.

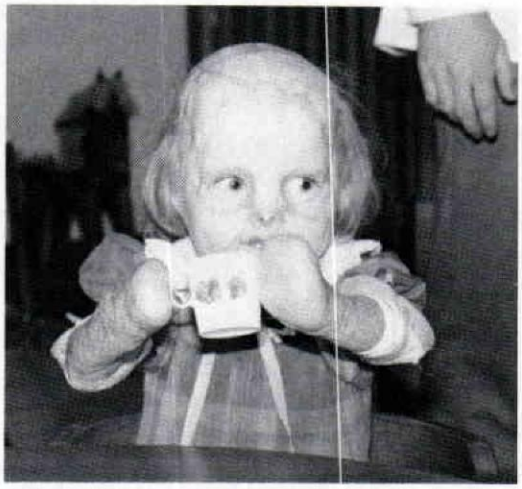


Figure 4. N.W. displaying significant upper extremity limitations.

CASE HISTORY

N.W., a three year-old female, suffered third degree burns over 80 percent of her body as a result of a house fire approximately one year prior to fitting. Injuries from the burns necessitated amputation of all digits bilaterally at the metacarpophalangeal level (Figure 4). Upon initial contact, significant upper extremity limitations were noted in wrist and elbow motions with the following active range of motion:

	left	**right**
elbow flexion	10–15°	0–120°
elbow extension	–10°	normal
forearm supination	0–45°	0–80°
forearm pronation	0–90°	0–90°
wrist flexion	0°	0–25°
wrist extension	0–45°	0–50°
ulnar deviation	0°	0–5°
radial deviation	0–5°	0–5°

Shoulder range of motion was within normal limits bilaterally. Medical history over the past year included multiple skin grafts, and removal of the posterior muscle compartments of both legs and one lower extremity artery—eighteen surgical procedures in all.

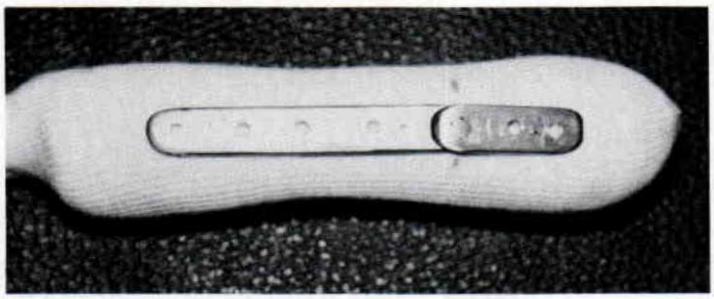


Figure 5. Hinged wrist joint attached to the ulnar aspect of cast prior to lamination of socket-forearm shell.

METHODOLOGY

1) Jointed Socket Design

The design of the TTP begins with the fabrication of a jointed laminated prosthetic socket and forearm shell. The prosthetic socket and forearm shell are connected by a hinged wrist joint that is laminated into the ulnar side (Figure 5). This wrist articulation permits free flexion and extension to occur between the socket and shell. The mechanical wrist joint is aligned anatomically in order to prevent excessive pistoning action. Once the lamination process is complete, the bulbous end of the socket is trimmed to allow ease of donning and doffing of the prosthesis. The trim line of the socket begins just distal to the wrist joint on the ulnar aspect and proceeds in a transverse oblique manner to the apex of the thenar eminence (Figure 6). The extended socket on the ulnar side serves as part of the suspension system that will be discussed later. The forearm shell trim lines extend across the arm for approximately two-thirds the circumference.

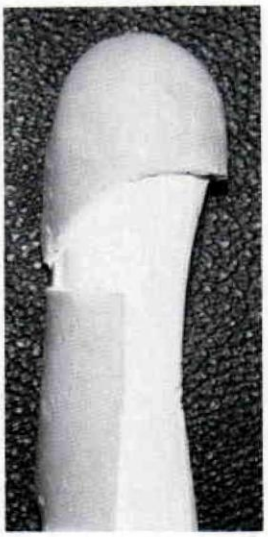


Figure 6. Trim lines of the socket begin distal to the wrist joint and extend in a transverse-oblique manner to the apex of the thenar eminence.

2) Modified Passive Hand/ Finger Module

Fabrication of the finger module first requires obtaining the proper sized passive hand. The passive hand is used to fabricate a rigid facsimile that will later be attached to the prosthetic socket. Before the facsimile is fabricated, the thumb on the passive hand requires an alignment modification to facilitate future opposition. This requires the amputation and reattachment of the thumb to the passive hand.

The thumb is amputated across the thenar eminence continuing to the palmar surface across the third metacarpal (Figure 7). The thumb is reattached with putty, aligning it directly beneath the second and third ray (Figure 8). The modified passive hand is then encased in an algenate mold. The modified passive hand is then extracted and plastic is poured into the mold.

When the plastic is hard, the rigid modified passive hand (Figure 9) is prepared for attachment to the socket. Attachment requires first removing and contouring the excess plastic in the palmar area in order to correctly position the hand on the socket (Figures 10 & 11). The hand unit is then attached with plastic and later sanded smooth (Figure 12).

3) Metacarpal-phalangeal articulation

The fingers are amputated just proximal to the M-P joints (Figures 13 & 14). The future articulation site for the finger module is then contoured to accept the appendages (Figure 15). The excess plastic should be removed down to the end of the socket. The attachment of the finger module to the socket requires drilling a $^{3}/_{16}$ inch hole through the M-P joint of the finger unit in a transverse manner (Figure 16). An equiva-

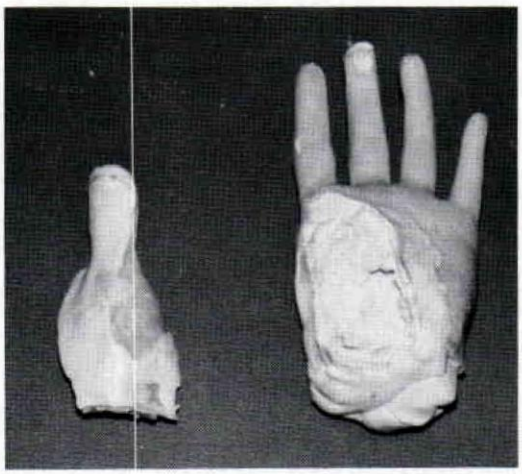


Figure 7. Thumb of the passive hand is amputated to allow for the necessary alignment modifications.

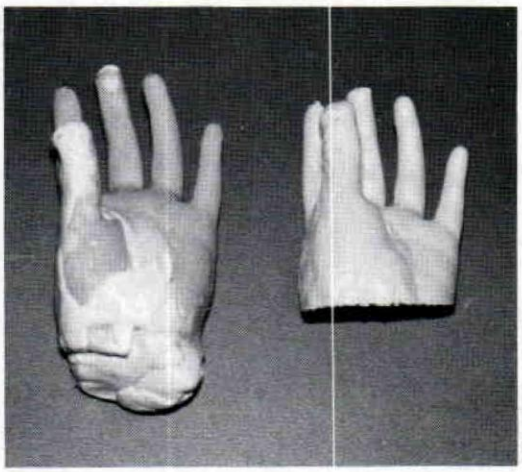


Figure 8. Thumb is reattached with putty and aligned directly beneath the index and middle fingers. Modified passive hand is then cast in an alginate mold required to fabricate the rigid facsimile.

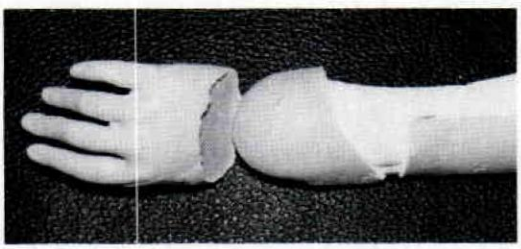


Figure 9. Rigid modified passive hand is prepared for attachment to the socket.

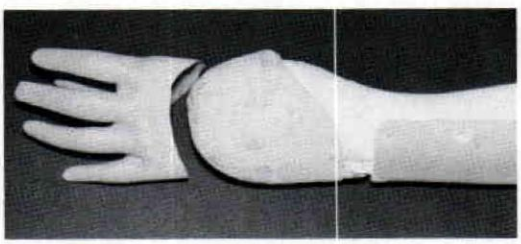


Figure 10.

Figures 10 and 11. Attachment requires first removing and contouring the plastic in the carpal regions.

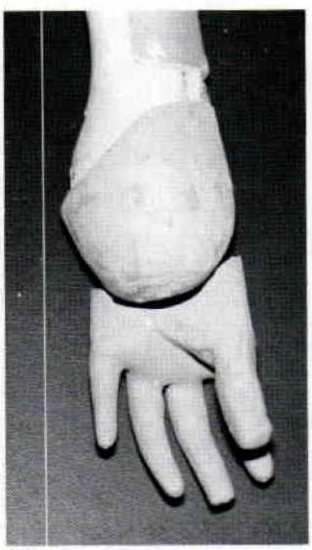


Figure 11.

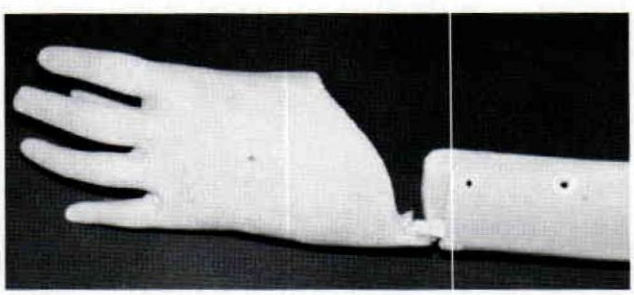
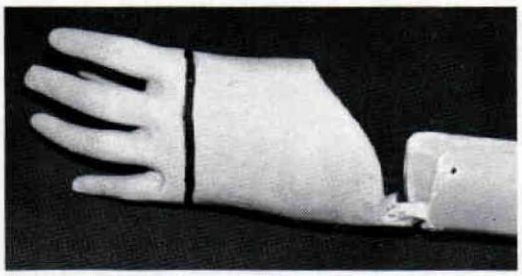
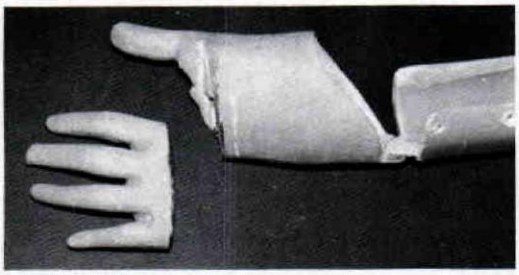


Figure 12. Hand unit is attached with plastic to the socket and sanded smooth.





Figures 13 and 14. A guide line is drawn transversely proximal to the M-P joints. The fingers are then amputated at this site.

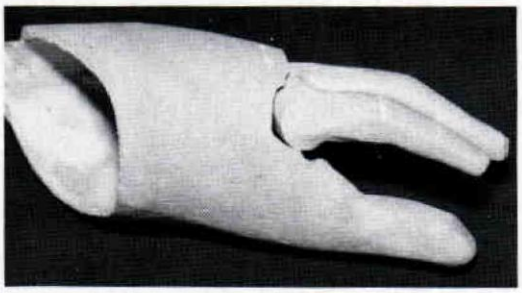


Figure 15. The rough M-P's of the finger unit are rounded smooth. The socket is then ground in a concave manner to accept the finger unit.

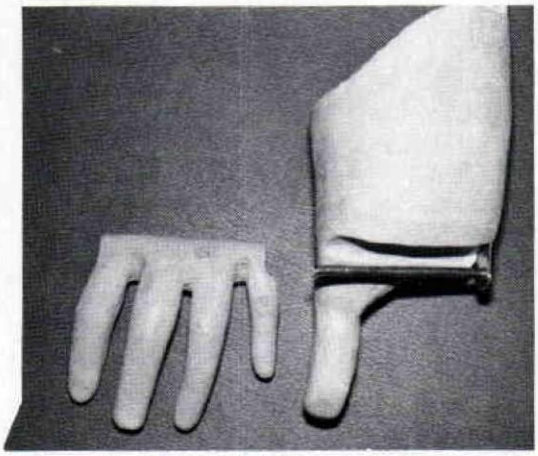


Figure 16. A 3/16 inch hole is drilled transversely through the M-P's of the finger unit to facilitate the drill rod articulation.

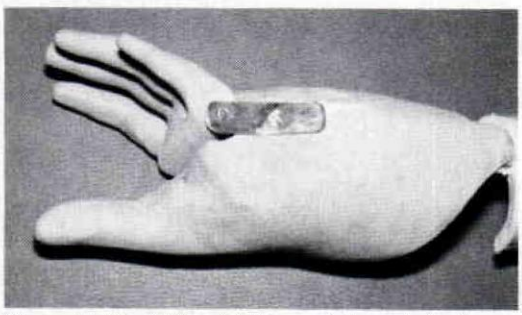


Figure 17. The drill rod is inserted through the finger unit and attached to the prosthetic shell by a stainless steel bracket. This articulation should pivot freely.

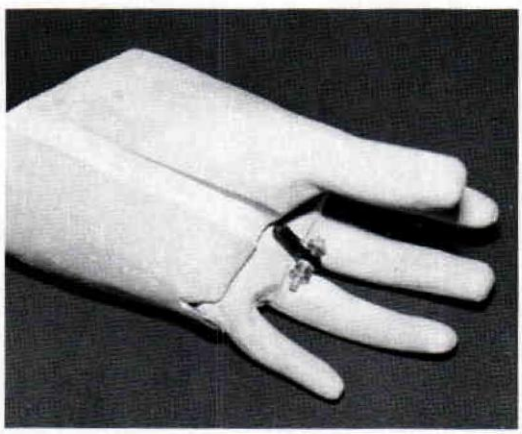


Figure 18. The pivot joint is prepared for attachment to the finger unit.

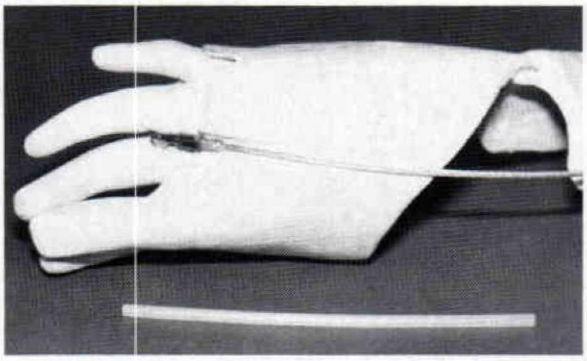


Figure 19. The linkage cable is attached to the pivot joint.

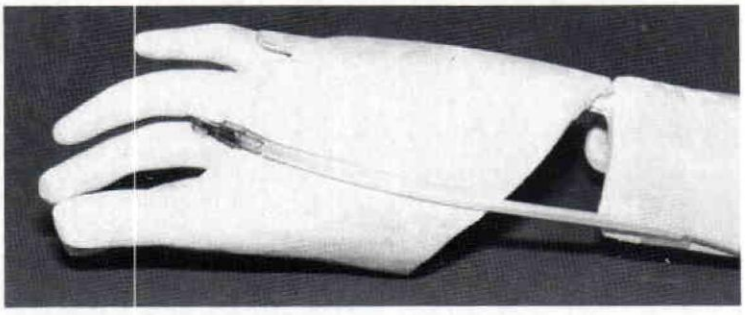


Figure 20. A protective sleeve slides over the linkage cable.

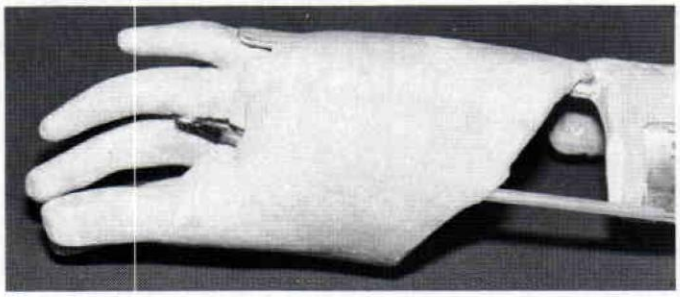


Figure 21. The linkage cable and protective sleeve are laminated into the palmar aspect of the socket.

lent sized drill rod is inserted through the finger unit and attached to the prosthetic shell by means of a stainless steel bracket (Figure 17). The MP articulation should pivot freely on the drill rod.

4) Linkage cable

The distal end of the linkage cable attaches to a pivot joint that is laminated into the finger unit (Figures 18 & 19). The pivot joint attaches at the I-P's of the third and fourth rays. A protective sleeve then encases the cable (Figure 20) and is laminated into the palmar aspect of the socket (Figure 21). The proximal end of the cable is attached to the forearm shell by means of a clamp assembly (Figure 22). The clamp assembly provides the prosthetist with an adjustment for regulating prehension characteristics. Adjusting the length of the cable regulates the prehension characteristics of the fingers and the range of motion at the wrist.

5) Cosmetic glove

The cosmetic glove as designed for a passive hand requires some modifications when applied to the TTP. The intrinsic qualities of the glove are too restrictive to allow freedom of flexion and extension of the fingers at the M-P joint. The remedy for this requires severing the glove transversely at the M-P joints (Figures 23 & 24). Although some of the aesthetics are lost in this procedure, it is necessary to obtain optimal function.

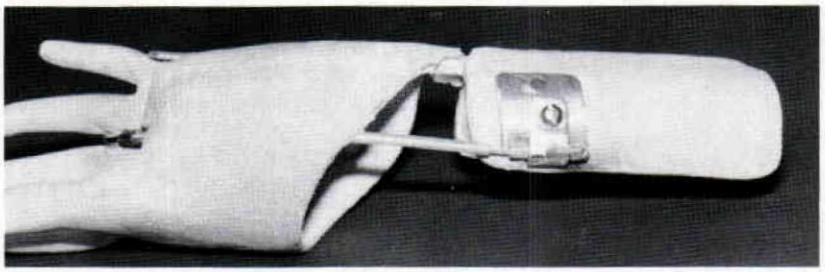


Figure 22. The proximal end of the cable is attached to an adjustable clamp assembly. This permits regulation of the prehensive characteristics by varying the length of cable.

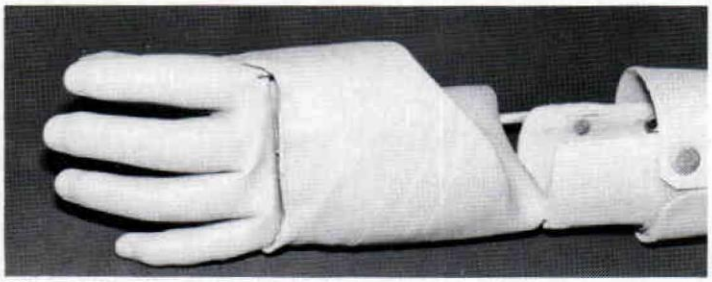


Figure 23.

Figures 23 and 24. The cosmetic glove is severed transversely at the M-P's to allow free flexion and extension at the finger unit.

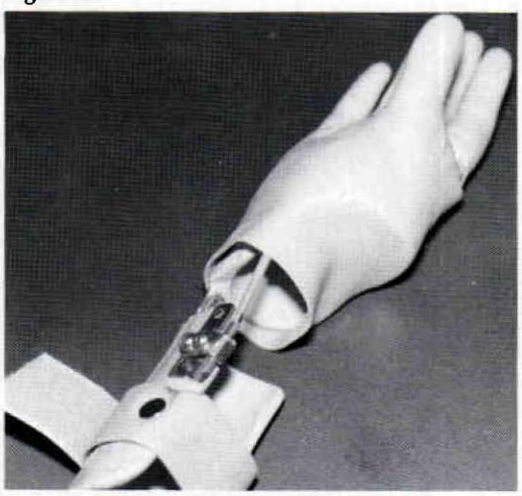


Figure 25. The suspension system is supplied by the expandable, compressive characteristics of the cosmetic glove. The glove is allowed to purchase on the smaller circumference of the thenar eminence due to the trim lines of the socket.

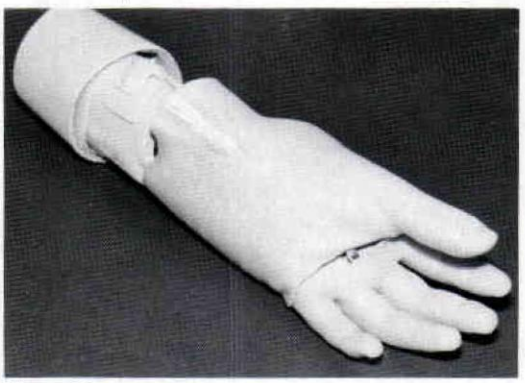


Figure 24.

SUSPENSION SYSTEM

The suspension system of the TTP is supplied by the compressive forces of the cosmetic glove on the thenar eminence (Figure 25). Reviewing the trim lines of the socket, plastic is removed beginning at the wrist joint and proceeding in a transverse oblique manner to the apex of the thenar eminence. This allows the cosmetic glove to purchase on the smaller circumference of the eminence, thus resisting migration of the prosthesis.

TREATMENT

Treatment consisted of nine occupational therapy sessions with the following purposes:

1. prosthetic evaluation
2. initial orientation and training in the use of the TTP
3. incorporation of the TTP into play, self-care, and developmental activities
4. family education

Initial activities were structured to deliver maximum positive reinforcement. Operation of the TTP was learned quickly during the initial session, and treatment proceeded to incorporating use of the TTP into age-appropriate activities. Prehension patterns consisted of three-jaw chuck and cylindrical grasp with which N.W. was able to perform the following types of activities: picking up various objects ranging in size from ¼" to 1½" width (Figure 26), releasing objects into her mouth or containers (Figure 27), stacking ½" and 1" cubes (Figure 28), pouring water from a small pitcher, using a toothbrush, hairbrush, and fork (Figures 29 & 30), scribbling with crayons, holding onto tricycle or rocking horse handles, pulling the ring of a "See 'n' Say," and banging a xylophone with a mallet. Initial focus was unilateral skill building with the less-involved right hand; the left hand served primarily an assistive role in bilateral activities (Figures 31 & 32), and is expected to develop with continued therapy.

The family was instructed in the use and operation of the TTP, care of the device, wearing schedule, appropriate home activities, and the need for continued therapeutic services.

Figure 26. Picking up variously-shaped objects ranging in size from ¼" to 1½" widths.

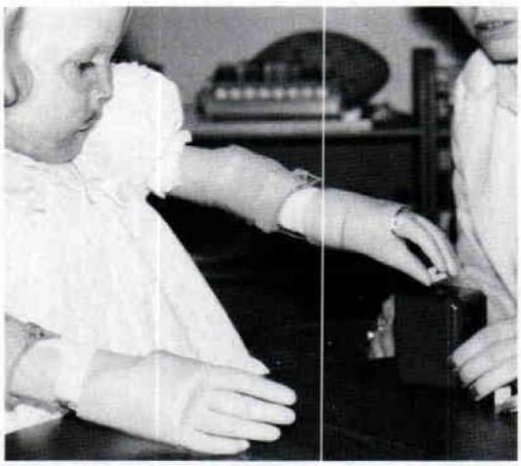


Figure 27. Development of controlled release of objects into containers.

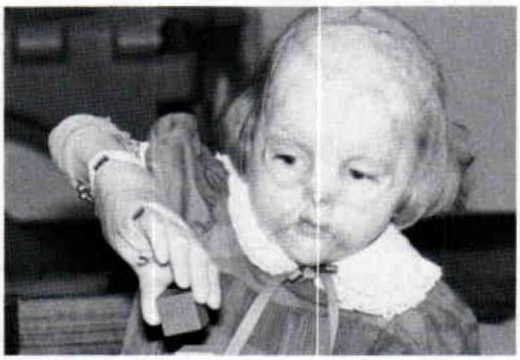


Figure 28. Development of proprioceptive placement of objects.

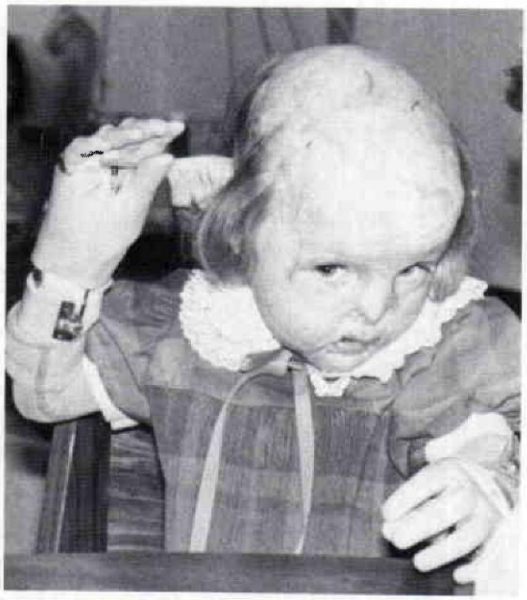
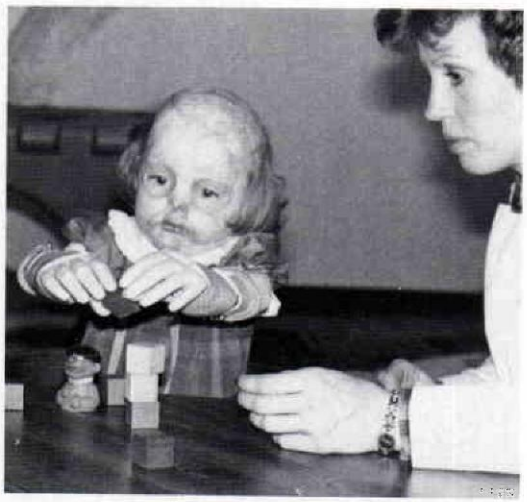
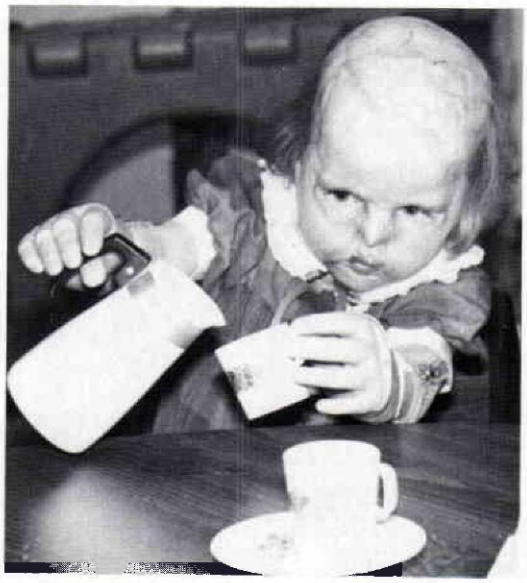


Figure 29. Development of self-care activities with emphasis on maintenance of grasp outside field of vision.

Figure 30. The use of cylindrical grasp on feeding utensils.





Figures 31 and 32. Development of bilateral activities emphasizing proprioceptive placement skills.

DISCUSSION

N.W.'s rapid acceptance of both prostheses does tribute to the cosmesis, ease of function, and the proprioceptive awareness of the devices. Utilization of available muscle power, relying on a natural body motion, is a definitive advantage of this device over other prosthetic systems which necessitate the teaching of a complex set of shoulder girdle maneuvers, for example. The lack of any such harnessing also minimizes certain aspects of fitting/operational difficulties, such as abrasion.

As with any prototype, research continues to be a need if the TTP is to evolve into a cost effective, componentialized, readily available alternative to traditionally promoted solutions, such as hooks and surgical procedures. Further research and development is under way in the following areas:

1. The flexibility of the cosmetic glove, which needs to be improved to allow a more cosmetic appearance (without a "break" at the points of articulation) and unrestricted motion.
2. Adjustments in the selection of hardware and resins, to improve cosmesis and reduce weight.
3. Exploration of alternate suspension systems.
4. Componentialization of parts.*

ACKNOWLEDGMENTS

We would like to express our appreciation to those individuals who contributed to the development of the Toledo Tenodesis Prosthesis, particularly Vern Swanson, C.P. for his assistance in fabricating and fitting procedures, and to N.W.'s family for their patience and trust in this project.

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Additional information regarding the Toledo Tenodesis Prosthesis can be obtained by contacting the authors.

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*Component parts are available in child and adult sizes through U.S. Manufacturing Co., 180 N. Gabriel Blvd., P.O. Box 5030, Pasadena, California 91107-0030.

Orthotics and Prosthetics, Volume 38, No. 4, pgs. 24–33.

LSU Lively Orthosis

Carlton E. Fillauer, C.P.O.
Charles H. Pritham, C.P.O.

In the decades since the end of World War II, medical science has made tremendous advances in its ability to prolong the lives of individuals who formerly would have died of conditions such as spinal cord injury and myelomeningocele. This ability has caused the medical field and society to place new emphasis on helping such individuals achieve the highest level of function possible.

Among these functional goals is independent ambulation. A complicating factor hindering, or even in some instances frustrating, this goal of ambulation has been the formation of soft tissue contractures of the ankle/foot complex and the knee. Before higher levels of function can be achieved, these contractures need to be prevented or corrected. While stretching exercises are undoubtedly efficacious in reducing contractures, the fact remains that they apply forces during a relatively brief period of the patient's total day. The efforts of the best planned surgery may be fruitless if no provision is made post-surgically to combat any deforming forces. The need exists for a device that can exert subliminal dynamic corrective forces over a long period of time, is adjustable, and readily fabricated. The Louisiana State University (LSU) Lively Orthosis is such a device.

The use of the word "lively" to describe an orthosis is undoubtedly unfamiliar to most American orthotists. However, it is common in the British literature and is usually used to characterize active or dynamic hand orthoses. The equivalent American phrase is dynamic flexion (or extension) assist.

In this particular situation, the name LSU Lively Orthosis (Figure 1) describes an AFO (or KAFO) with free motion at the ankle and subtalar joints with elastic straps to dorsiflex (or by modification to plantarflex) the ankle joint and selectively invert or evert the subtalar joint. In the KAFO configuration, there is a rigid portion extend-

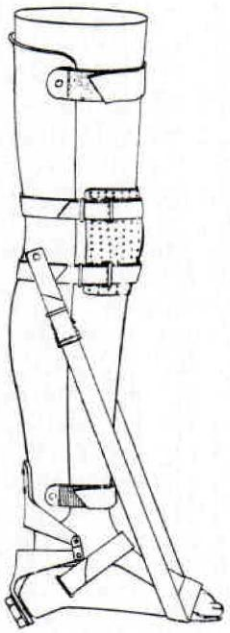


Figure 1. The LSU Lively Orthosis.

ing posteriorly to mid-thigh to block flexion and knee cap with elastic straps to extend the knee. The orthosis is intended to be used in a nonambulatory fashion to correct—and maintain correction of—various soft tissue contractures of the ankle and foot associated with such neuromuscular conditions as spina bifida. This article is written to trace the developmental history, theory, and fabrication techniques involved in its use.

HISTORY AND BACKGROUND

Work on what came to be recognized as the LSU Lively Orthosis began about 1975–76 by Roy Douglas, C.P., now Assistant Professor of Orthopedics, Louisiana State University, New Orleans. At that time, Mr. Douglas was participating in a muscular dystrophy clinic, and was confronted with a number of patients with severe equinovarus deformities. It was desired to reduce these feet to a plantargrade position so that the patients could be fitted with such devices as the LSU Reciprocating Gait Orthosis in an attempt to make them ambulatory. However, surgery for a number of reasons was not feasible. To fill the need, Roy Douglas designed the original Lively Orthosis.

It consisted of a molded plastic AFO with articulations at the ankle to permit plantar/dorsiflexion and inversion/eversion. The objective was for the patients to wear the orthoses full time and to use the elastic straps to exert low grade corrective forces over a protracted period of time to gradually render the feet plantargrade. Despite the relatively crude nature of the articulations, good results were obtained.

In September of 1977, Carlton Fillauer, C.P.O., visited New Orleans as part of a site visit to a number of centers. An exchange of views and a review of recent developments took place, and, as a consequence, a collaborative development effort was initiated. This effort is now bearing fruit, and numbers among its results the LSU Lively Orthosis and the LSU Reciprocating Gait Orthosis.

It was Mr. Fillauer's opinion that the lively Orthosis certainly merited further development, but that a major shortcoming was evident. The articulations consisted of a single pivot joint to permit inversion/eversion and a piano hinge immediately above it to permit plantar/dorsiflexion. Both were mounted on the posterior aspect of the orthosis and were not congruent with the anatomical tibial-talar and subtalar joints. As a consequence, considerable relative motion between the foot and orthosis resulted as correction was achieved. It was felt that the mechanical articulations should be aligned as closely as possible with the anatomical articulations as described by Inman, *et. al.*,[1] to minimize relative motion. It was also agreed that the mechanical components should be prefabricated for the orthotists' convenience. The present day design has evolved from these design criteria.

The mechanical components consist of five different sized assemblies that can be used either for the right or left leg. The free ankle joint proximally is linked to the rest of the assembly by a joint link and rigid pivot point. This rigid pivot point is to be forcibly adjusted as necessary to align the free linkage with the anatomical ankle joint

in the sagittal plane. Portions of the mechanical assembly are recontoured as necessary to improve alignment of both joints.

It is recognized that since the assembly is neuter, true alignment of the mechanical subtalar joint with the anatomical joint is difficult, if not impossible to achieve. In this instance a conscious decision to fabricate the components in a neuter configuration was made to control production and inventory expenses and, ultimately, the selling price. It should be noted, however, that to date no problems as a consequence of this decision have surfaced. Since 1975, over 500 assemblies have been distributed, giving some indication of the number that have been used on patients.

Over the years, the design of the orthosis has evolved. Originally, Mr. Douglas fit some of the orthoses in an AFO configuration, reserving the posterior extension proximal to the knee joint to instances of obvious knee flexion contracture. Today it is recognized as a result of experience gained that all orthoses should be fit high enough to control the knee. This is logical if the bi-articular nature of the gastrocnemious muscle is recognized. If the knee is left uncontrolled and if the posterior structures of the ankle are stretched, then flexion of the knee will ensue. Metal outriggers have been fit to various orthoses when severe deformity precluded developing proper corrective moments about the joints. The epoxy resin used originally to fabricate the subtalar pivot has recently been replaced with methylmethacrylate acrylic resin.[2] Not only is this new material* easier to work with, it is minimally heat sensitive, and thus the possibility of overheating the area about the pivot during fabrication, and thus destroying it, is eliminated.

*Rapidcure, A product of D.F.M.I.

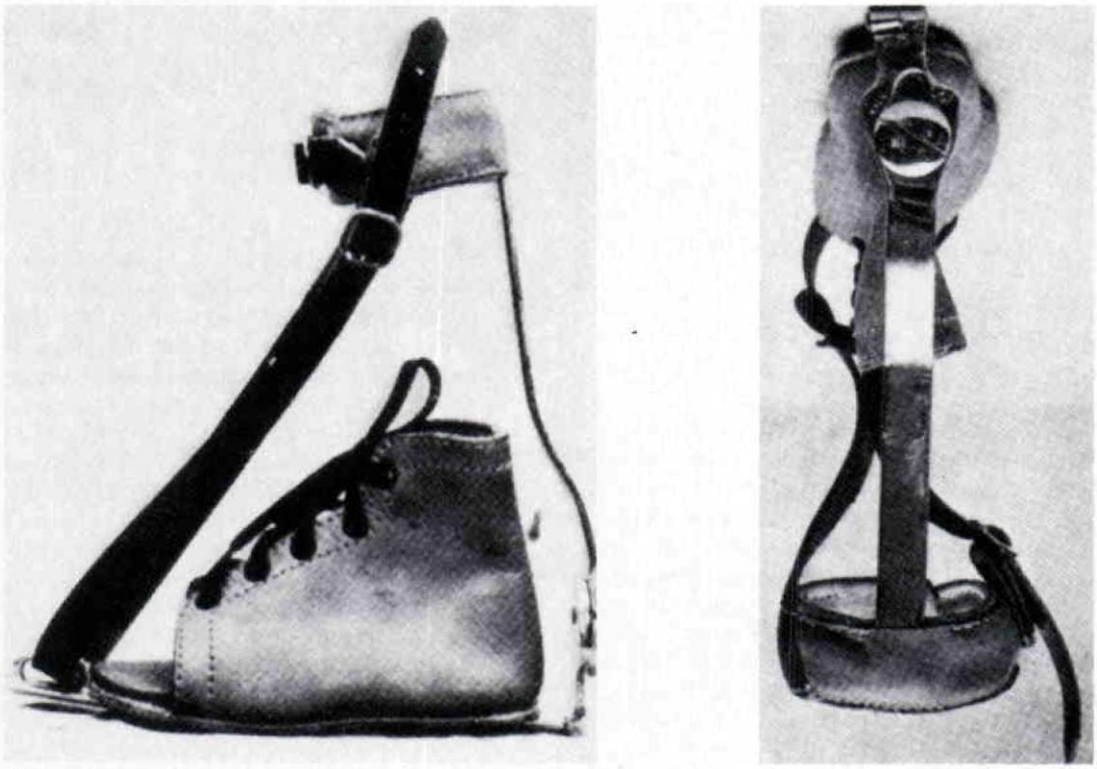


Figure 2. Night Splint described by George A. Pollock for treatment of talipes equinus, or equinovarus deformity in children with cerebral palsy. From *Prosthetics International* Vol. 2, No. 3, 1965, pp. 1273.

The concept of using a low grade corrective force for a protracted period of time is, of course, not new. In his book *Orthopedic Appliances* (1939, reprinted 1963), Dr. Henry H. Jordan[3] credits F. Mommsen with introducing the concept in relation to the Quengel cast in 1922. In his discussion of the Quengel cast (an early example of what has since come to be recognized as fracture bracing, albeit not for fractures) Dr. Jordan states:

> "It was offered as a method of correcting a contracture over a long period of time, using subliminal forces which act uninterruptedly but which are not so pronounced as to cause pain and muscle spasm. The chief obstacle to the correction of contractures consists in reflex spasm to the muscles involved." (Page 21, 2nd Ed.)

In Denmark and other regions of Scandinavia, a device[4] similar in some respects to the LSU Lively Orthosis is used for correction of congenital clubfoot deformity. Designed at the Orthopedic Hospital of Copenhagen, it consists of a series of modular fitting elements that encompass the foot and knee. Adjustable linkages for alignment of the ankle and subtalar axes are provided, as well as rubber straps to exert corrective forces. In addition, the foot component is articulated and fit with an elastic strap for correction of forefoot adduction.

In contrast to the Lively Orthosis, the knee is held at 90° of flexion in the OHC design. In the treatment of an infant with congenital clubfoot and no neuromuscular disease, this is logical and desirable, for it permits a more secure grip of the infant's short chubby leg. In the older person with neuromuscular involvement and the concomitant risk of contracture, it seems much more logical to hold the knee as straight as possible.

In an article published in 1965,[5] George A. Pollock of Edinborough, Scotland, described an AFO for nightwear similar in some respects to the LSU Lively Orthosis. Examination of the photographs (Figure 2) reveals an orthosis of metal with a boot on a sole plate and a single posterior upright. The upright is articulated so as to permit free plantar-flexion/dorsiflexion and adjustment for inversion and eversion. Inelastic leather straps run from the toe of the sole plate to the calf band.

INDICATIONS AND CONTRAINDICATIONS

Objectives:

1. Prophylactically to prevent contractures of the foot and ankle
2. To correct contractures of the foot and ankle
3. Maintenance of correction gained from surgery
4. Secondarily, treatment of knee flexion contractures associated with the above.

Treatment of contractures associated with such neuromuscular conditions as:

1. Spina Bifida
2. Muscular Dystrophy
3. Spinal Cord Injury
4. Multiple Sclerosis
5. Poliomyelitis
6. Cerebral Palsy

Indications:

1. Soft tissue contractures of the foot and ankle (secondary involvement of the knee)
2. Absent or mild spasticity
3. Good prognosis for ambulation
4. Cooperative patient
5. Intelligent cooperation by well motivated family members or nursing staff

Contraindications:

1. Boney involvement
2. Severe spasticity
3. Poor prognosis for ambulation
4. Uncooperative patient
5. Parents or others caring for the patient who seem to be disinterested in his prognosis and unable to cope with his present daily needs.

As should be obvious by now, this orthosis works very gradually, even imperceptibly, over a long period of time. It thus demands frequent, careful, progressive adjustment, and periodic skin care by

whomever is caring for the patient. If such other conditions as severe mental retardation preclude any hope of ambulation or if sufficient commitment to the patient's future cannot be mustered, then the effort of fitting him with the orthoses might as well not be made.

The need for periodic progressive adjustments and hygiene make the need for intelligent, willing cooperation imperative on the parents' or nursing staff's part. Moreover, it should be borne in mind that the orthosis should never exert forces strong enough to cause pain and rejection of the orthosis. The parents, whatever their anxiety or compensation for feelings of guilt, should understand this and be specifically enjoined not to attempt to achieve too much correction too soon. In light of the subliminal forces exerted and even with reasonable care, anesthetic skin should also be considered a contraindication.

FABRICATION**

The patient's leg is cast in the usual fashion with plaster bandage to a point near the perineum and a length of rubber tubing is used along the anterior surface to facilitate removal of the cast. Before wrapping the leg, the leg and foot are examined for malalignment and the amount of correction that can be obtained is noted. The leg and foot are held in as near a normal position as possible until the plaster has hardened. The plaster cast is removed and filled in the usual manner. In addition to the normal relief for boney prominences, a flared edge is built on the posterior, medial, and lateral aspects of the thigh in the general vicinity of the proximal one-third. There should be approximately 1"–1½" clearance between the perineum and the proximal edge of the orthosis.

The positive model (Figure 3) is covered with a layer of A-8 ventilated medium density Pelite, 3mm. thick, that will serve as a liner in the finished orthosis. The Pelite is heated for two to three minutes, molded to the cast and held in place with staples along the anterior centerline of the model. The size of the ankle joint assembly is selected on the basis of the width of the ankle (Figure 4). The minimum clearance over the malleoli with the Pelite liner in place is ⅜" on each side to allow for the thickness of the polyethylene in the finished orthosis and clearance for motion in two planes.

The subtalar joint of the assembly is aligned to coincide as closely as possible with the anatomical subtalar joint axis (Figure 5).

**This portion is derived from *The LSU Reciprocating Gait Orthosis*, a manual published by the Orthopedic Division of Durr-Fillauer Medical, Inc.

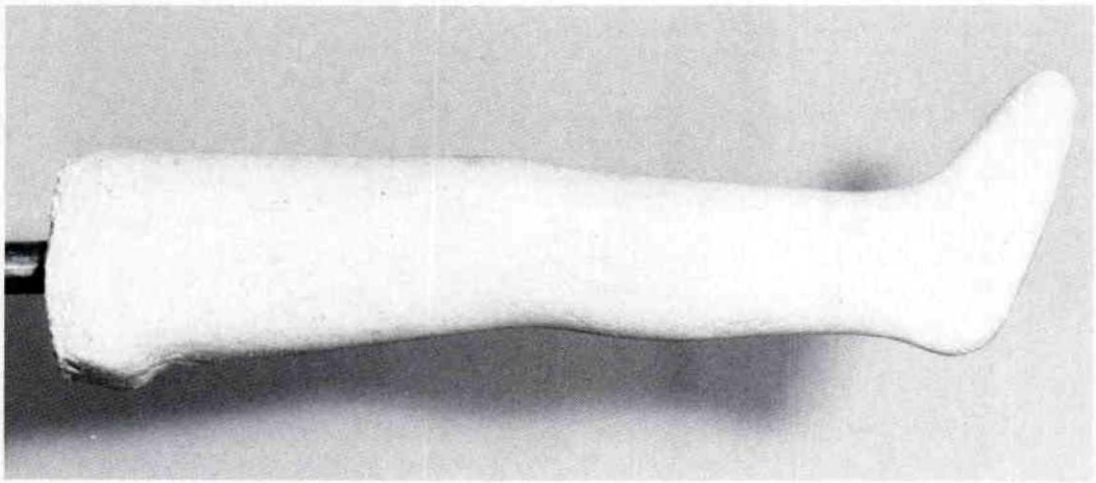
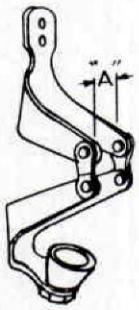


Figure 3. Positive model ready for fabrication of the orthosis.

Catalog No.	Size	For Ankle Diameter *	"A"
2340	XSM	Up to 2"	$2\frac{3}{8}$"
2342	SM	$2\frac{1}{16}$" to $2\frac{1}{4}$"	$2\frac{5}{8}$"
2344	MED	$2\frac{5}{16}$" to $2\frac{1}{2}$"	$2\frac{7}{8}$"
2346	LGE	$2\frac{9}{16}$" to $2\frac{3}{4}$"	$3\frac{1}{8}$"
2348	XLGE	$2\frac{13}{16}$" to $3\frac{1}{4}$"	$3\frac{5}{8}$"



* Minimum Clearance at Malleoli — $\frac{3}{8}$"

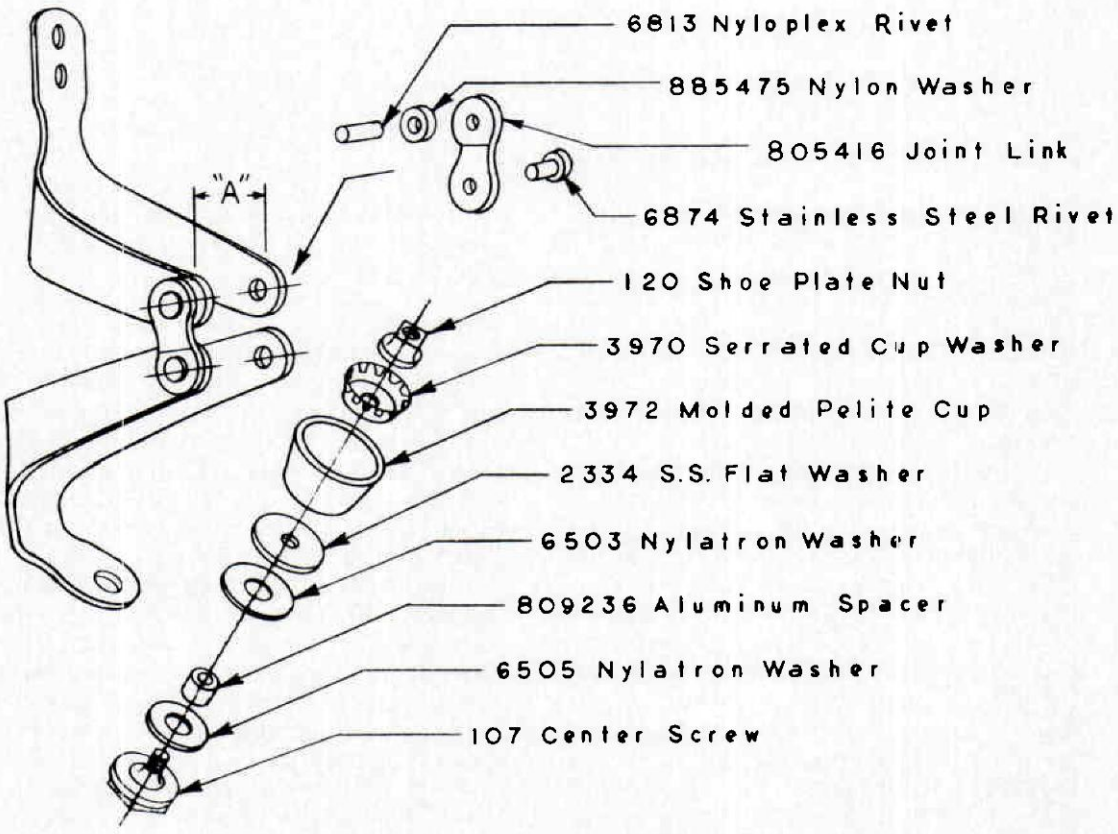


Figure 4. Selection of the Ankle Joint Assembly.

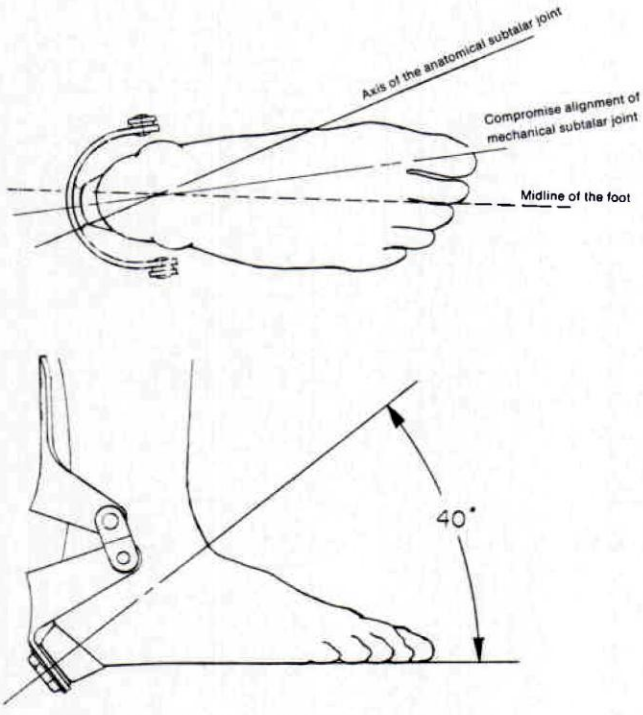


Figure 5. Alignment of the subtalar axis.

Sagittal: approximately 40" elevation from posterior to anterior relative to horizontal.

Transverse: approximately 25° internally rotated relative to the longitudinal axis of the foot (for reasons of economy and practicality, the ankle joint assembly is neuter. This means that alignment will undoubtedly prove to be a compromise).

As necessary, portions of the structure are contoured to achieve proper alignment. In aligning the ankle joint, the rigid linkage is forcibly adjusted, if needed, so that the loose linkage is aligned with the anatomical ankle axis (Figure 6).

Acrylic compound or epoxy is used to fill and anchor the molded Pelite cup that serves as a pivot point for control of the subtalar point. The matrix is mixed and poured into the Pelite cupe (Figure 7) with the pivot assembly intact; the cup is held in place on the heel with tape (Figure 8) until the resin hardens. The edges of the Pelite cup are then faired into the surrounding Pelite surfaces (Figure 9). If acrylic resin is used, this can be accomplished most efficiently by using a finger dipped in the catalyst to smooth the edges out before it sets completely.

Polyethylene, 3/16" thick, is heated to 375–400°F., and vacuum-formed over the model by the hand drape method. The area over the pivot point hole in the Pelite cup is heated and cut away (Figure 10) to provide access to the nut for the center screw. The area is then reheated (Figure 11) and the subtalar joint is assembled and tightened so that a seat is formed for the stainless steel flat washer (part #2334).

Caution should be taken not to overheat the area, which may cause softening of the matrix and inadvertent loosening of the shoe plate nut (part #120). This caution is not necessary if acrylic resin is used, as heat does not degrade it in the same fashion as it does epoxy.

While the assembly is in place, the proximal attachment holes are drilled (Figure 12). Trimlines are then established. A gap of ¾" between the foot and leg sections is necessary so as to permit free motion without pinching the patient. The plantar

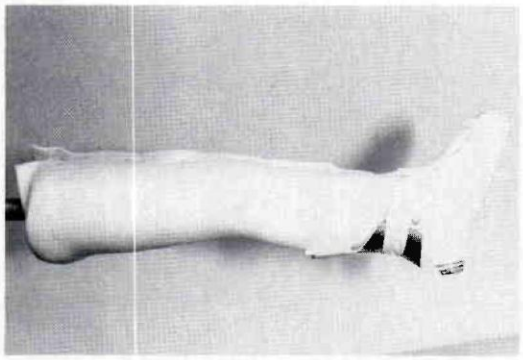


Figure 6. Metal assembly in place ready for filling the Pelite cup with matrix. Note presence of Pelite pad beneath proximal portion of the assembly to serve as a spacer to allow for the thickness of the polyethylene.

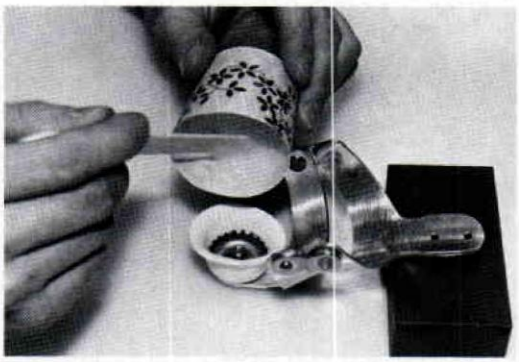


Figure 7. Filling the Pelite cup with matrix.

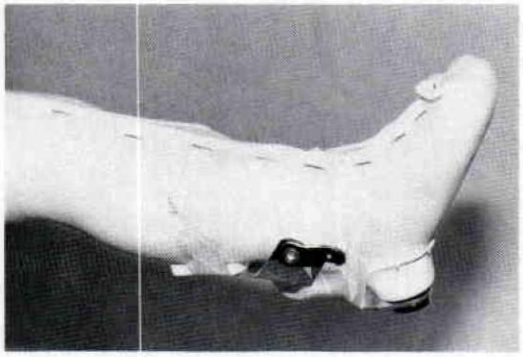


Figure 8. Assembly held in place with tape.

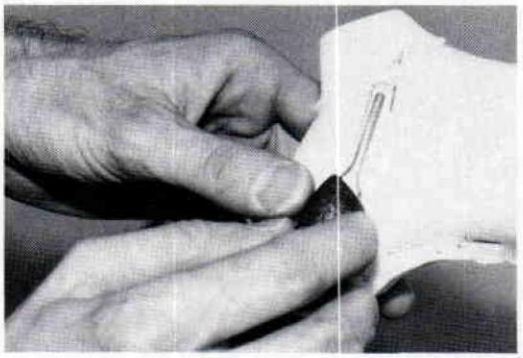


Figure 9. Fairing the edges of the cup into the overall contours of the model.

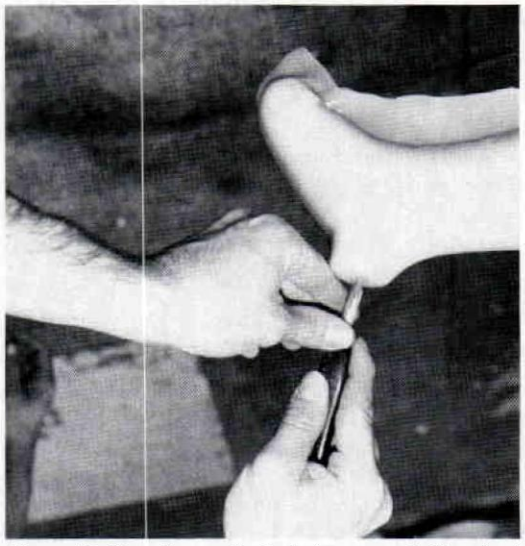


Figure 10. Opening up the hole for access to the pivot point of the subtalar axis.

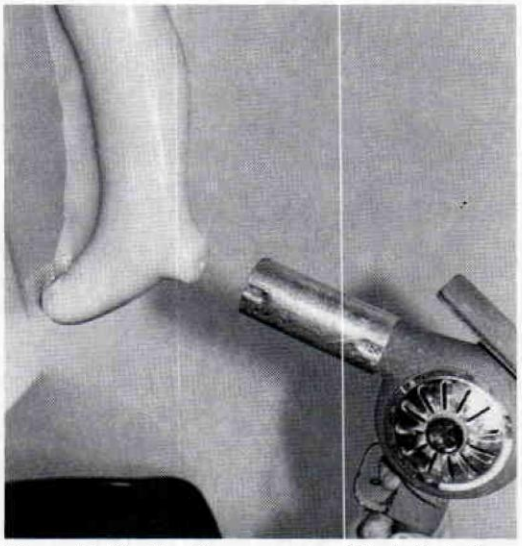


Figure 11. Heating the area around the hole to form the flat seat.

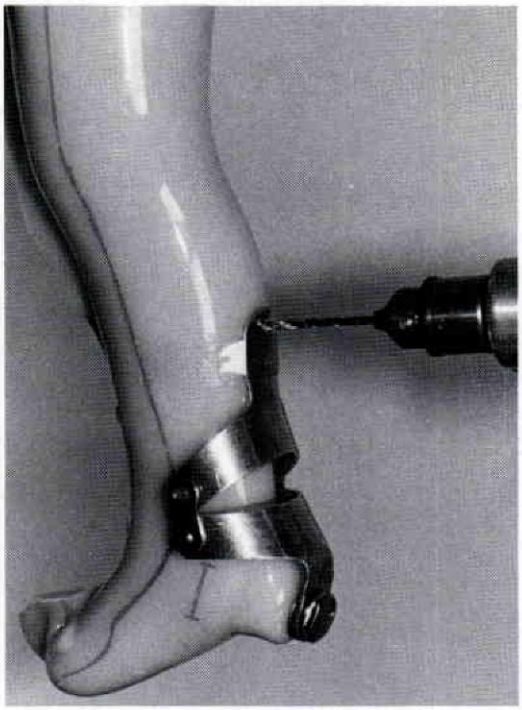


Figure 12. Assembly in place and holes for proximal attachment being drilled.

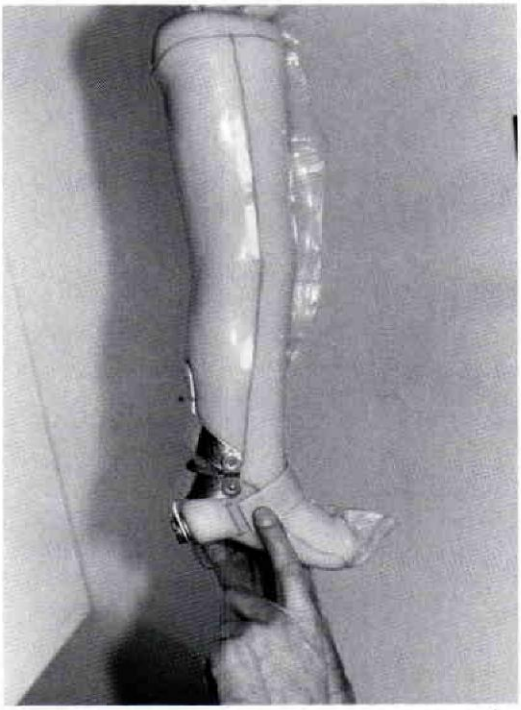


Figure 13. Trim lines drawn on model. Use of a one inch strap facilitates proper orientation of slots cut in the footplate.

surface of the footplate should extend beyond the toes for comfort and to prevent impingement of the edge. One inch long slots (Figure 13) are cut in the foot section for the Velcro® strap that pulls the foot and leg posteriorly into the orthosis. The strap should be located in the smallest part of the instep and the slots should be perpendicular with the strap. Location of the strap and orientation of the slots is best established with the aid of a strap or piece of tape. The orthosis is then cut out along the established trimlines and the edges are smoothed and finished. The ankle joint assembly is then riveted to the leg shell.

A piece of extra-firm A-30 perforated Pelite is molded over the patellar area of the positive model to provide a knee extension pad (Figure 14) for distributing the pressure over the knee when the orthosis is in place. Two 1" wide elastic straps are installed horizontally on the knee pad to apply an extension force. Velcro® straps, 1" wide, are used at the ankle and proximal thigh areas to hold the orthosis in place.

The medial and lateral 1" wide elastic straps that control the foot and ankle are installed (Figure 15). If necessary, an outrigger or outriggers can be used to establish a proper line of pull and torque in severely plantarflexed limbs. Two-pronged buckles are used to secure the elastic straps.These buckles are mounted on 1" wide dacron straps with loops in the straps for the distal strap of the knee-cap. This is to maintain the knee-cap in its proper location. The 1" dacron straps are riveted to the posterior shell so as to insure proper alignment of the knee-cap.

FITTING

The orthosis is applied, checked for excess pressure, and modified appropriately. The elastic corrective straps should be adjusted to exert light-to-moderate pressure. The parents should be cautioned to always have the patient wear a stocking inside the orthosis and not to attempt to gain too much correction at once. Wearing tolerance

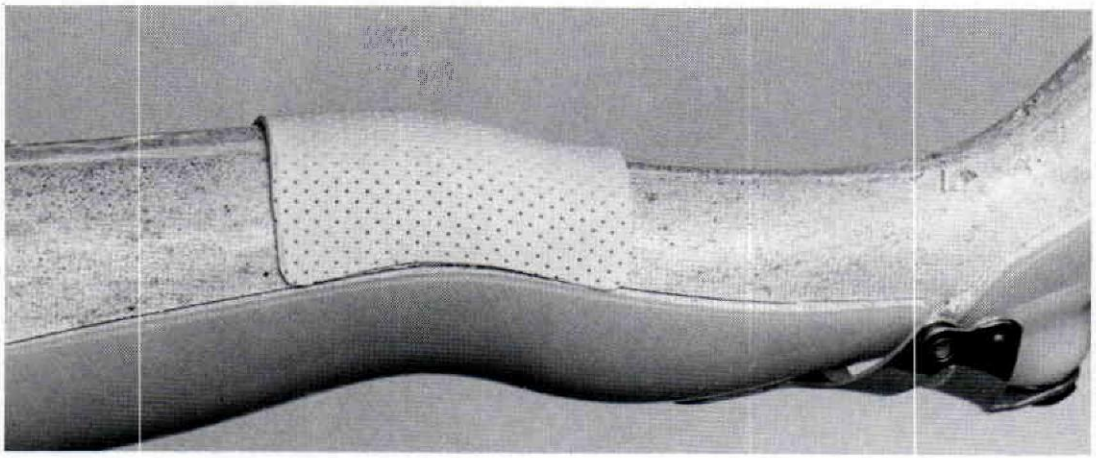


Figure 14. Molded Knee-cap of extra-firm A-30 Pelite.

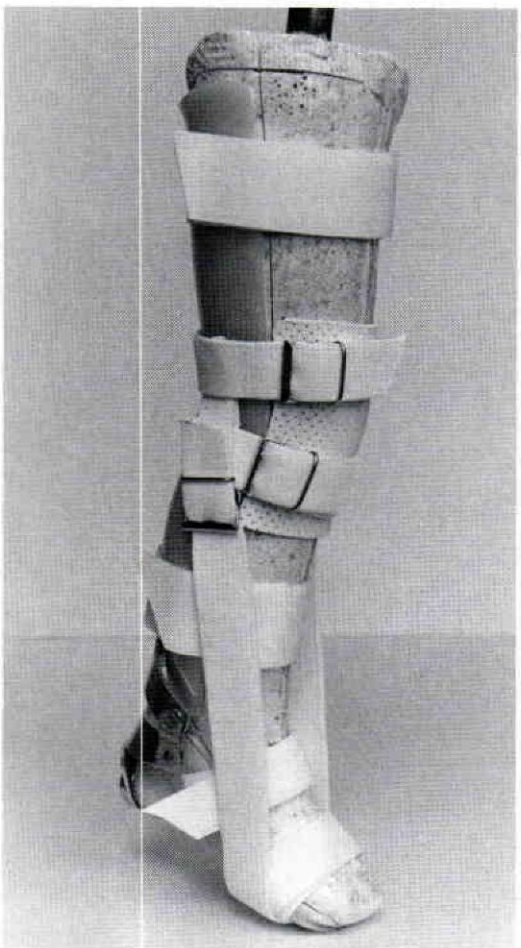


Figure 15. Finished orthosis with elastic and Velcro® straps in place.

should be built up slowly, starting initially with a period of an hour or so and culminating several weeks later with all night wear. The elastic straps should be tightened gradually.

CONCLUSION

Today more than ever, the advances in medicine prolong the life expectancy of severely involved patients. Society expects, and ethics demand that, whenever possible, these individuals be afforded a lifestyle with maximum dignity and independence. The prevention and correction of contractures play a definite role in the achievement of these goals. The LSU Lively Orthosis is one device to aid the medical team in meeting this goal.

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TRIO

Karl D. Fillauer, C.P.O.

INTRODUCTION

Sports medicine physicians have been concerned over the need for adequate knee protection both for post surgical and non-surgical patients. New surgical techniques being performed, and new instabilities being described, have created the need for new orthotic designs. These designs, while developed from conventional orthotic principles, have been modified for sports activity.

Conventional orthoses, such as the Knee-Ankle-Foot Orthosis, certainly provide adequate knee stability both in the M-L and A-P plane. The problem is that we not only wish to stabilize the knee, but also provide the patient with the ability to actively participate in sports.

The Knee-Ankle-Foot Orthosis which is attached to the shoe, or even an insert type stirrup, does not allow the patient adequate mobility for most athletic endeavors.

GOALS

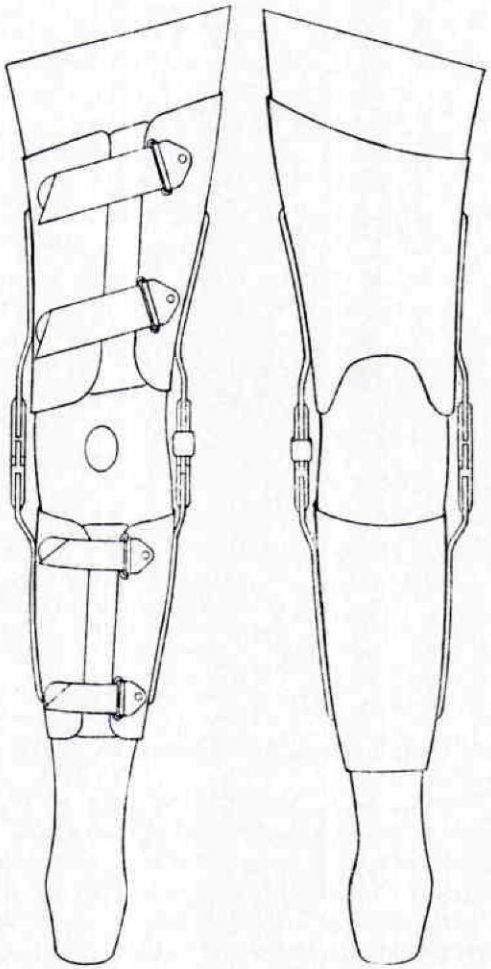
Goals in treating sports related knee injuries are different than other categories of knee instabilities. The main goal is to return the patient to sports activities without the injury resulting in permanent damage or disability.

It is important to commence rehabilitation of the patient as soon as possible after knee injury. Many physicians are sending their patients to sports medicine therapists for total rehabilitation programs five to six weeks after surgery. In order for them to safely give these patients adequate exercises, it is necessary to have some type of orthosis that will not only provide a controlled range of motion, but will also prevent abnormal motion or recurrence of the injury during the physical therapy program.

In formulating our goals for this orthosis, it was considered desirable to have it readily adaptable from a state of controlled motion to one of free motion or limited motion, so that it could be used in sports activities. When work began on the TRIO, most designs did not have the latitude to allow this conversion. The designs we had used prior to the TRIO were either for post-operative or sports activity, not both.

In the post-operative patient, maximum control and support are needed. The trimlines in the knee area are kept as close to the popliteal fossa as consistent with knee flexion. The patient's activity on the affected extremity is at a minimum until adequate strength and stability in the knee returns (see Figure 1, post-op version). When the patient is able to return to sports activity, the trimlines are modified to allow more freedom of motion. This is accomplished by creating openings in the posterior calf and thigh sections to allow for active muscle volume changes. The length is also shortened to eight inches. These modifications allow the patient with the potential of recurrent knee instability to return to his/her sports activities (see Figure 2, athletic version).

Another goal was to be able to modify the basic design of the orthosis so as to be able to address the specific needs of the



Anterior view—both models.

Posterior view—Post-Op model (strap system not shown).

Figure 1. Two views of TRIO.

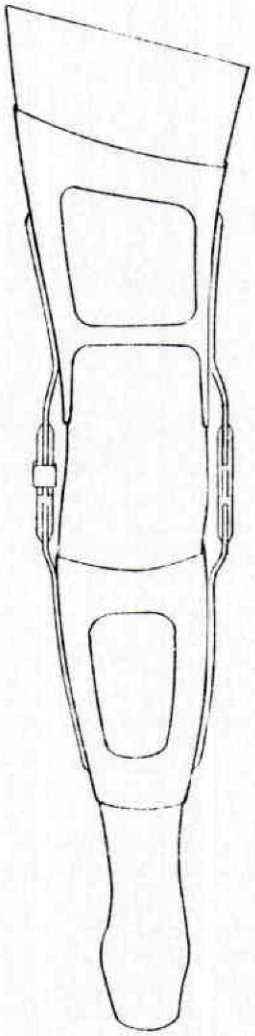


Figure 2. Posterior view of athletic model showing windows cut in cuffs to permit flexion. Strap system not shown.

most common types of knee instabilities. Designs seen to date do not vary as to the type of knee injury.

The most common knee instabilities are: antero-medial rotary, antero-lateral rotary, posterior cruciate rotary, and posterior-lateral rotary. In this categorization system[1], the instability is classified according to which side (medial or lateral) of the tibia moves relative to the femur and in which direction (anterior, posterior) it rotates. The tibia is assumed to be rotating around the intact elements of the sound side of the knee and not around the axis running down the center of the leg. Therefore, an antero-medial rotary instability means that the medial tibial condyle rotates anterior relative to the femur. All these instabilities have a linear, subluxing component, and in the posterior-cruciate rotary instability, this is the major element. Laxity of the posterior-cruciate ligament

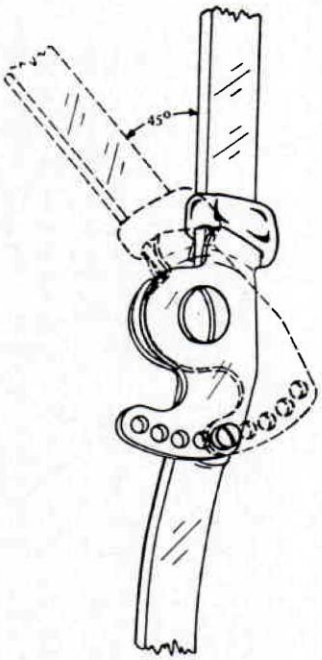


Figure 3. Knee joint with extension strap and drop lock. Maximum extension position can be varied from 0°-45°.

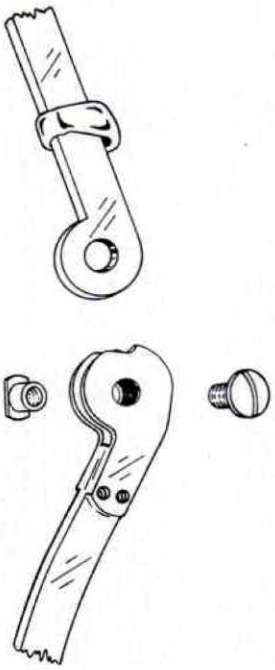


Figure 4. Free motion knee joint obtained by removing extension lock plate.

permits posterior subluxation of the tibia and some concomitant rotational instability.

A fifth goal was to devise a rotational control system that was more effective than the few designs on the market. It is felt that those orthoses with rotational straps offer little or no benefit. The need for internal or external rotation is paramount and depends upon the knee instability diagnosed.

The last goal was to have the orthosis self-suspending, since eliminating the use of Ace bandages or waist belts with a knee orthosis increases patient acceptance.

NEW DESIGN

With the goals set forth, various fabrication techniques were tried. All designs have the basic three point pressure system, but this design features total contact tibial and thigh components. The total contact concept was felt to be preferable, as the more area in contact, the less force per unit area.

Considerable thought was given to the types of thermoplastic materials available. Each was evaluated as to what it offered in strength, durability, and moldability. Today, with the many plastics available, it is important to choose the right material for an orthotic design. The material chosen is 3 mm. Subortholen and 3 mm. PE-LITE.® Subortholen offers the rigidity of polypropylene and the flexibility of polyethylene. Also, it has a unique characteristic known as cold flow. This allows for changing its shape without having to heat the material; a good quality to have as long as substantial force is required. If a low force could change its shape, the material would not provide adequate strength.

The joints used are a clevis type, manufactured by Durr-Fillauer Medical, Inc. This particular joint enables the user to add attachments to the joint head so as to control motion as desired. This feature is needed to protect some surgical repairs in the post-operative rehabilitation period as prescribed by the physician.

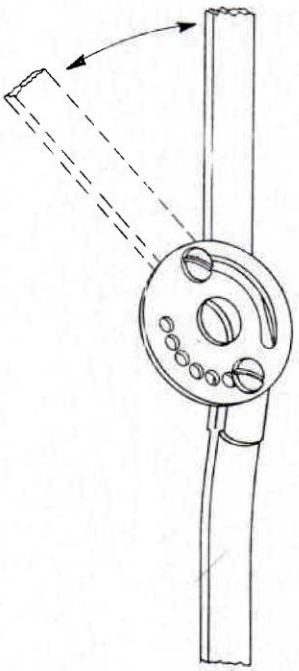


Figure 5. Knee joint which allows limited range of motion. Angles of maximum flexion and extension varied by the holes in the distal segment of the plate.

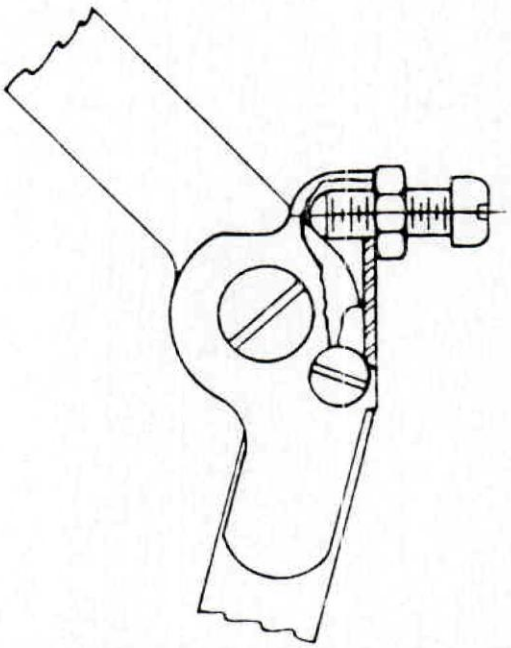


Figure 6. Knee joint with adjustable extension stop and screw in the distal portion of the joint to limit flexion.

The attachments or modifications to the joint are as follows:

1. A 0° to 45° adjustable extension stop or drop lock between 0° to 45° (Figure 3).
2. Free motion, converted from joint #1 above by removing the extension lockplate (Figure 4).
3. An extension flexion dial, which allows motion in a limited range (Figure 5).
4. Placement of two screws in the joint head, one in the anterior lower section for extension control, and a second screw in the posterior lower section which restricts flexion (Figure 6).

No specific explanation can be made as to when to use each design joint, as surgeons differ greatly as to what they wish to accomplish with knee orthoses. The surgeon should be queried to determine what range of motion he wishes to permit, and joint selection made accordingly. The most common instability seen in our office has been antero-medial rotary instability associated with anterior cruciate injuries, and the most common joint design used has been the second one listed above.

The rotation control system used consists of one or two rubber straps 3" wide. These straps are placed so as to provide a moment or torque at the knee that will create internal rotation if the patient has antero- or postero-medial instability and external rotation for antero- or postero-lateral instability. This moment, or torque, is produced by the combination of skin traction and the spiraling of the strap up the limb (see Figure 7). During swing phase, this moment positions the patient's leg so that at heel contact, the knee will be in proper alignment; the resistance of the elastic straps to abnormal rotation during weight bearing prevents any feeling of instability or "giving away." In addition, the straps are placed so that they will also provide either an anterior or posterior directed force on the tibia or femur to resist subluxation, depending on the type of instability.

In addition to the rotational straps, a 1" elastic pre-tibial strap producing a posteriorly directed force is used to retard anterior subluxation of the tibia in cases involving anterior cruciate tears.

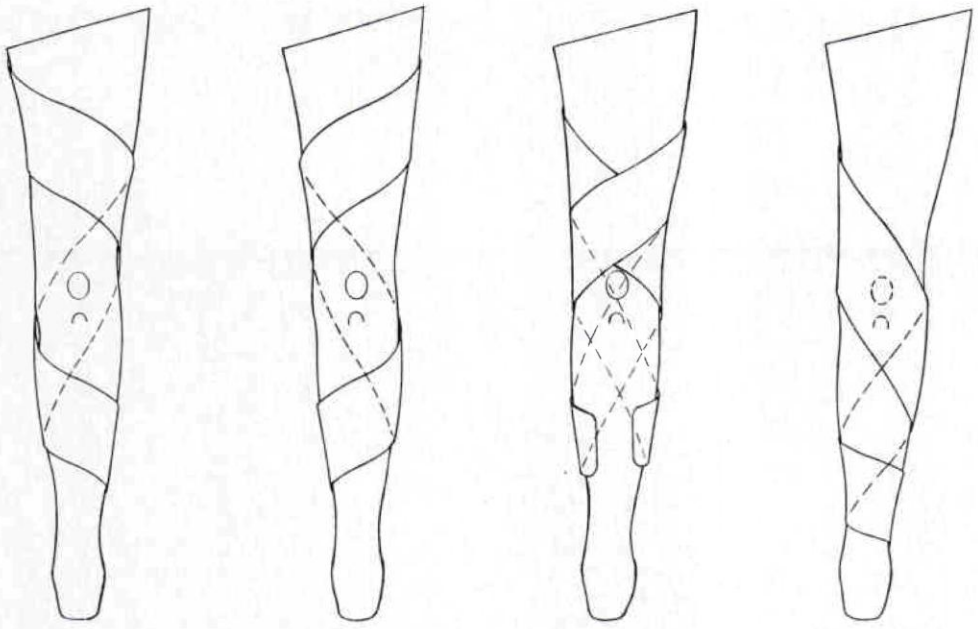


Figure 7. Rotary strap arrangement used with different types of instabilities.

Suspension is accomplished by bilateral supracondylar wedges that lock the orthosis in position (see Figure 8). The medial wedge is located just proximal to the adductor tubercle. After the patient has been wearing the orthosis for eight to ten days, additional padding material to tighten the fit may be needed due to subcutaneous atrophy in this area.

FABRICATING TECHNIQUES

The procedure for fabricating this orthosis is no more difficult than with other designs. A measurement from knee center to perineum is taken. The length of both thigh and calf sections of the post-op model will be equal to two-thirds of this distance. The thigh and calf sections of the athletic model are equal to one-half of this measurement, but no less than eight inches. A plaster wrap of the leg is required. The wrap must extend from the groin to ankle. Prior to casting, the knee center is marked with an indelible pencil and during cast-

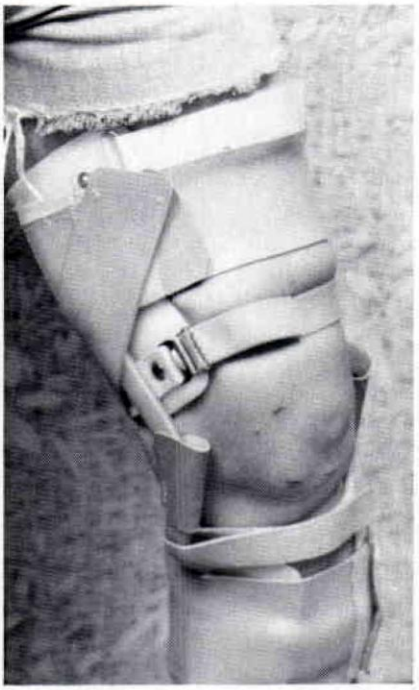


Figure 8. Medial view of completed orthosis showing supracondylar suspension and rotary system.

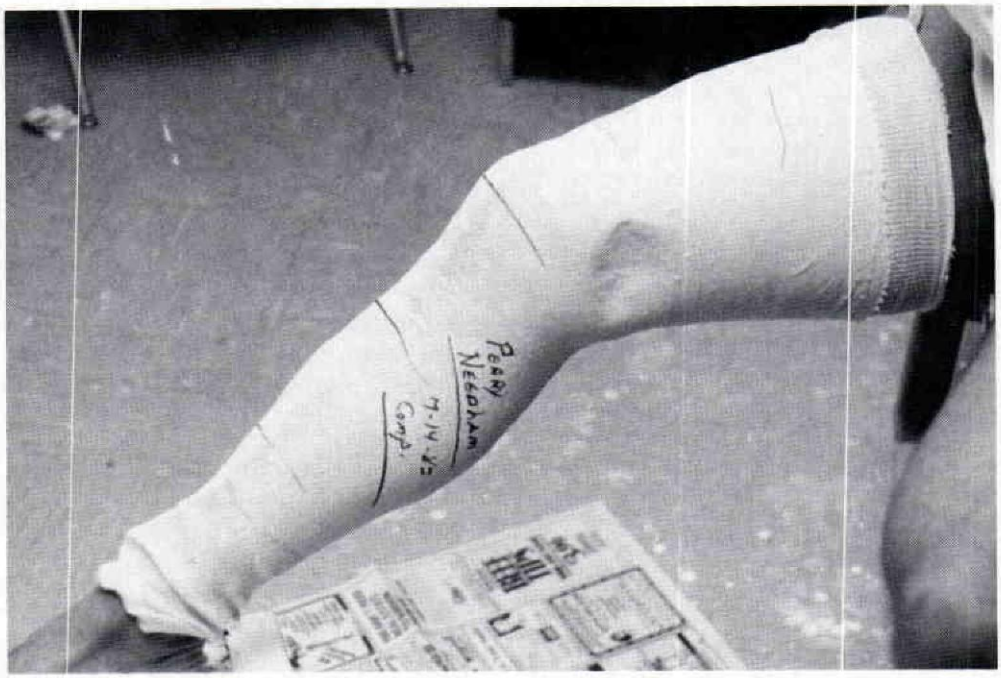


Figure 9. Cast of the patient's leg showing indentation proximal of the adducter tubercle.

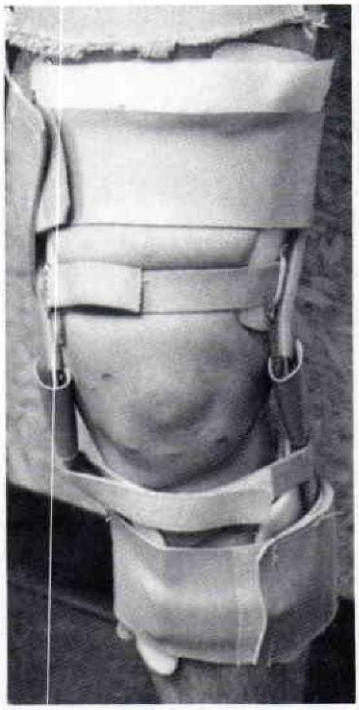


Figure 10. Anterior view of completed orthosis. Same patient as Figure 8.

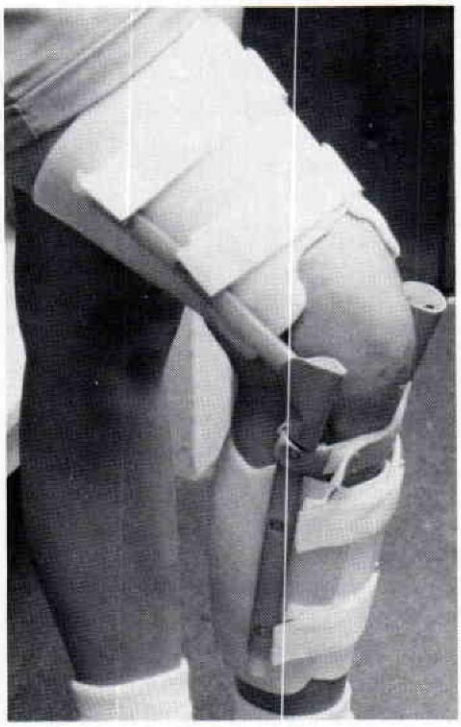


Figure 11. Lateral view of orthosis.

ing, while the plaster is setting, the medial supracondylar area is palpated and indented (see Figure 9).

The knee joint alignment is identified, a joint spacer is positioned, and the wrap is poured. After stripping the cast, the usual cast modifications are performed, with the exception of the medial supracondylar area. In this area, plaster removal is important, in order to obtain adequate pressure to suspend the orthosis. Good judgment and experience will aid in determining how much plaster is to be removed.

A PE-LITE liner is first molded on the cast. Best results have been achieved with 3 mm. A-20 firm density. Once this is completed, 3 mm. Subortholen is formed in two sections without vacuum. The leg and thigh sections are initially trimmed 3" proximal and distal to knee center. The desired knee joints are then formed to the model, tongues of extra firm A-30 PE-LITE are molded, and the proper straps added. Figure 7 shows the various methods of placing the straps.

A slot (or slots) is cut as far distally in either the posterior-medial or posterior-lateral corner (or both if two straps are used) depending on which derotation strap is used. The distal end of the derotation strap exits through this slot and is secured to the outside of the Subortholen cuff with Velcro.® Before the uprights of the joints are riveted to the Subortholen cuffs they are covered with rubber surgical tubing for padding during athletic competition. Leather is used to cover the joint heads.

SUMMARY

As of late 1983, we had fit more than 100 TRIO Orthoses (Figures 10 & 11). Knee instabilities have been varying and for the most part, we have been able to control and prevent recurrent injury. Patient acceptance has been very good. However, the rotational strap may cause irritation initially and patients may complain of heat and pulling of the skin during wear. Irritation and pinching in the popliteal fossa are easily eliminated with an elastic knee support. The device is waterproof and therefore is readily cleaned with water. Being waterproof, there is no contraindication to snow or water skiing.

This new combination of material, joint system, and straps has aided us in the management of knee injury patients. We feel this orthotic device has provided better stability for athletes with knee instabilities when compared to other available knee orthoses today, as well as allowing early rehabilitation by protecting post-operative knees.

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AUTHOR

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Sheet Plastics and Their Applications in Orthotics and Prosthetics

David C. Showers, B.S., C.P.O.
Martha L. Strunck, B.S., C.P.

INTRODUCTION

Around 1970, a flexible plastic shell type orthosis was introduced to provide dorsiflexion assist during the swing phase of gait. Since then, polypropylene has become the most widely used and accepted material for this application.

However, many other types of sheet plastics are being used by orthotists and prosthetists today. Some plastics have more applications than others, but many types of plastics seem to have a particular characteristic which lends itself well to certain disabilities or even to certain body segments.

The decision to use one type of plastic over another, or to use plastic at all, is being determined more frequently by the orthotist and prosthetist. This decision has been placed in the hands of these practitioners by physicians and other health professionals, because it is felt that this could best be decided by the practitioners who work most closely with these materials.

It is important to remember that in many situations, when treating a disability orthotically, any one of several different types of plastic may be utilized. The particular plastic chosen may be a subjective decision based on prior experiences. However, in any event, the responsibility of this decision is one that most orthotists and prosthetists have willingly accepted.

In order to communicate some basic knowledge of sheet plastic technology to orthotists, prosthetists, physicians, therapists, and other professionals, this article is presented as a guide to the variety of sheet plastics now available. This list may serve as an accurate reference for those sheet plastics most widely used in orthotics and prosthetics.

TERMINOLOGY

At the Physical Medicine and Rehabilitation Department at the Hospital of the University of Pennsylvania, orthotics has advanced to incorporate the vast utilization of thermo-plastics. The techniques applied to fabricate an orthosis require that a negative impression of the body segment be taken. After specific laboratory assembly procedures, a custom molded orthotic device is created for the patient's disability. The terminology used to refer to these orthotic devices includes:

- FO—Foot Orthosis
- AFO—Ankle Foot Orthosis

- KAFO—Knee Ankle Foot Orthosis
- HKAFO—Hip Knee Ankle Foot Orthosis
- KO—Knee Orthosis
- HO—Hip Orthosis
- WHO—Wrist Hand Orthosis
- EWHO—Elbow Wrist Hand Orthosis
- SEWHO—Shoulder Elbow Wrist Hand Orthosis
- SO—Sacral Orthosis
- LSO—Lumbar Sacral Orthosis
- TLSO—Thoraco Lumbar Sacral Orthosis
- CTLSO—Cervical Thoraco Lumbar Sacral Orthosis

Prosthetics differs in the terminology used, but the techniques performed in developing a functional prosthesis are similar to those as practiced in orthotics.

A negative impression is taken of the residual limb and, from that mold, a socket is fabricated to fit the residual limb intimately. The goals achieved by a proper socket fit are maximum function and comfort for the amputee.

The type of prosthesis is referred to as either an endoskeletal or an exoskeletal. The terminology commonly used today includes:

- TM—Transmetatarsal amputation
- AD—Ankle Disarticulation
- BK—Below Knee
- AK—Above Knee
- HD—Hip Disarticulation
- HP—Hemipelvectomy
- WD—Wrist Disarticulation
- BE—Below Elbow
- ED—Elbow Disarticulation
- AE—Above Elbow
- SD—Shoulder Disarticulation
- IT—Interscapulo Thoracic

A GUIDE TO ORTHOTIC AND PROSTHETIC USES OF SHEET PLASTICS

Low Temperature Plastics:

Orthoplast

Orthoplast is possibly used in orthotics more frequently than any other sheet plastic. Occupational therapists, orthopedic technicians, and physicians like this material because it can be applied directly to the patient, thereby making a negative impression on the patient unnecessary. Orthotists will use this material often when asked to fabricate orthoses used in the treatment of fractures.

Orthoplast may also be incorporated in a device which may need to be flexible and custom molded over two positive models for an improved fit. However, it is usually not the preferred material because of its shorter life expectancy when compared to the other, more durable flexible sheet plastics. Even so, many orthotists will choose to use orthoplast in the orthotic treatment of scoliosis with a Milwaukee style orthosis

Low Temperature Plastic	Most common applications	Properties	Forming temperature	Time Required to Heat	Forming Process	Available thickness, density, color
Orthoplast	Splint designs, Milwaukee pelvic girdles, fx. orthoses, T.L.S.O.'s	Thermoplastic, low heat forming, durable, cohesive, comfortable, self-adhering, can be riveted, strapped, bonded or hinged, one year life expectancy	160°–170°F	Dry heat or hot water until flexible	Applied over positive cast or over protective sleeve on limb	1/8" Plain or perforated White

Figure 1.

or a T.L.S.O. "body jacket" because the material can be easily adjusted with a heat gun even after the finished orthosis has been worn by the patient.

High Temperature Plastics:

Kydex

A rigid plastic, Kydex is an excellent reinforcing material over soft plastic foam. It is also used as the supporting material in Philadelphia collars. Some orthotists prefer its use in upper extremity applications such as the wrist-hand-orthosis with or without articulation at the wrist. In many locales, it is popular for use in spinal orthotic prescriptions. Kydex can be reheated and changed repeatedly over its long life.

Nyloplex

Nyloplex is routinely used in upper extremity orthoses. Its use, however, often depends on the practitioner's past training. For example, Nyloplex is popular with practitioners graduated from New York University, while those trained at Rancho Los Amigos might prefer aluminum, which is most frequently used there. Nyloplex is cosmetic and can be reheated repeatedly like Kydex. It is also transparent and durable. Moreover, it has been used for spiral and hemispiral AFO's, but durability is still a problem in these applications.

Polypropylene-Standard Grade

Standard Grade Polypropylene is the most widely used sheet plastic in orthotics and prosthetics. In most cases, the nonarticulated AFO is fabricated from polypropylene and is referred to locally in Philadelphia as a "MAFO" (molded AFO). It must be remembered, however, that not all MAFO's are solid ankle designs, nor are all nonarticulated MAFO's flexible at the ankle trim. Since metal joints are frequently used when treating certain disabilities, I would emphasize that the metal hinge be attached to the more rigid polypropylene sections as opposed to, for example, the flexible polyethylene anterior shell.

Polypropylene is the strongest sheet plastic available which can be formed over a positive model. Common orthotic uses include upper extremity devices designed for long term use, MAFO's, KAFO's, CTLSO's, TLSO's, pelvic bands and joints, pelvic girdles, and other innovative devices where rigidity and durability are essential.

Co-Polymer

Co-polymer is more rigid after the forming process than orthopedic grade polypropylene, but is slightly more flexible than standard grade polypropylene. Many practitioners appreciate the choice between the slightly different characteristics of these three materials, while others will routinely choose only one type.

Co-polymer would be the plastic of choice when custom molded orthoses are prescribed for permanent orthosis wearers such as post-poliomyelitis patients. In this situation, co-polymer meets the critical needs of durability, cosmesis, light weight design, and intimate fit. I emphasize that the decision to use co-polymer or to use polypropylene may not always be an obvious one for the orthotist formulating the orthotic design.

Polypropylene-Orthopedic Grade

Orthopedic grade polypropylene is standard grade polypropylene with an additive which makes it more flexible and, therefore, more durable under stress. However, this additional flexibility can be undesirable when maximum rigidity is required. A careful evaluation at the initiation of orthotic treatment is essential to determine the most appropriate material and design. When a custom molded fracture orthosis is prescribed for an active patient, orthopedic grade polypropylene is an excellent choice, which will diminish the incidence of rupture in high stress areas. If desired, a soft foam plastic interface may be positioned on the positive model, and the hot polypropylene will adhere to it during the vacuum forming process.

High Temperature Plastic	Most common applications	Properties	Forming temperature	Time Required to Heat	Forming Process	Available thickness, density, color
Kydex	Reinforcing material on Philadelphia collars, Milwaukee girdles, TLSO, orthospinal orthoses & upper extremity orthoses	Acrylic-polyvinyl chloride, chemically resistant, very rigid, resistant to tearing, finishes nicely	350°–400°F	moldable within seconds	Drape mold over positive cast (can not be vacuum formed)	1/8" Beige, white
Nyloplex	Upper extremity orthoses, spiral & hemispiral AFO's	Clear acrylic bonded with nylon, may be sanded or buffed, subject to rupture under repeated stress	285"–300°F temp for 2 hours at 90°C)	moldable within minutes	drape mold over positive cast can not be vacuum formed)	2mm–4mm transparent
Ortholen	AFO with flexible trimline, W.H.O.	thermosetting, self lubricating, tough, and corrosion resistant. Does not become brittle or absorb perspiration, can be sterilized	356°F	3-5 minutes	Drape and wrap (can not be vacuum formed)	1 mm–6mm
Vitrathene	TLSO, Milwaukee pelvic girdles, upper extremity fracture orthoses	odorless, non-toxic, compression molded polyethylene resistant to alkalines, dimensionally stable, non allergenic	350°–375°F	10-15 minutes	drape molding with or without vacuum over positive cast	1/8"–1/4" Flesh tone
Polyethylene	TLSO, Milwaukee pelvic girdles, custom-molded lower limb orthoses, fracture	tough, waxy, flexible, odorless, tasteless, well tolerated by skin tissue	350°F	7-15 minuites	vacuum formed over positive	1/8"–1/4" low density flesh or natural

Poly-propylene (standard grade)	AFO, KO, KAFO, HKAFO, TLSO, LSO, HO, WHO, EWHO, SEWHO	cosmetic orthoses tacky when heated, rigidity with increased thickness, gets brittle, discolors with age.	400"–425°F	8-10 minutes	drape vacuum form over positive cast	1/8", 1/4", 3/8" stress relieved or non stress relieved natural or flesh
CoPolymer	Lower limb orthoses	for permanent orthosis wearer, very durable & rigid enough	400°–425°F	8-10 minutes	drape vacuum form over positive cast	1/8, 1/16", 1/4" natural natural
Poly-propylene (orthopedic grade)	AFO, KO, KAFO, TLSO, LSO, HO, WHO, EWHO, SWEHO	an additive (Butyrate) to standard grade polypropylene gives added flexibility & durability	400"–425°F	8-10 minutes	drape vacuum form over positive cast	1/8", 5/32",3/32", 1/4" Natural Natural

Figure 2.

Ortholen

The most frequent use for ortholen is in the posterior leaf spring type AFO, which is usually used when weak dorsiflexors coexist with active plantarflexors. Durability at the posterior section of the orthosis is questioned by some practitioners who, therefore, prefer not to use this plastic. *Subortholen* is a new material, which is reported to be more durable than ortholen.

Vitrathene

Vitrathene is a pink colored form of polyethylene used by some orthotic practitioners, who feel that this plastic is more durable than the low density polyethylene. The most frequent use of this material is in the custom molded low profile T.L.S.O. "body jacket," as it is commonly called, used in the treatment of idiopathic scoliosis or for stabilization of the spine following surgical treatment, such as Harrington rod placement. In addition, Vitrathene could be used for any upper or lower limb orthoses where flexibility is desired, but caution should be taken when considering this material where high stress conditions may be expected or where rigidity is essential.

Polyethylene

Similar in characteristics to Vitrathene, polyethylene is next to polypropylene in popularity with orthotists and prosthetists. One of the reasons the Prosthetic and Orthotic lab of the Hospital of the University of Pennsylvania prefers polyethylene to vitrathene is the color matching which is possible when combining both polyethylene and natural polypropylene in an orthosis.

Other important reasons for its popularity are cost effectiveness, variety of different thicknesses, flexibility, and availability through most local plastic manufacturers. It is also relatively easy to work with during fabrication, provides a pleasant appearance, and is easier to smooth the edges on than with many other sheet plastics.

The most frequent uses for polyethylene are the anterior forms on custom molded AFO's and KAFO's, TLSO's, and upper extremity orthoses where joints are seldom used, such as in passive types of HO's, WHO's, and EWHO's. Polyethylene is an

excellent choice when immobilization of a joint is required for a patient who needs a durable, flexible, and removable device. An additional advantage is that when vacuum forming over soft plastic foam, the polyethylene will adhere securely to the soft interface, providing improved comfort for the patient.

TRANSPARENT HIGH TEMPERATURE PLASTICS

*Thermo-vac (Surlyn)®**

The most recent addition to the list of sheet plastics used in orthotics and prosthetics is thermo-vac® which has the unique characteristics of flexibility and transparency. It is commonly used as a check socket for trial fittings on difficult cases. It may also be used in the finished orthosis or become a part of the definitive prosthesis.

Thermo-vac can be vacuum formed with a frame, drape vacuum formed, or drape molded without vacuum. Extreme care must be taken when working with this material when it is hot because it will readily adhere to the skin, causing a burn. This caution also applies to sanding and finishing of the material, which will quickly raise an area of the thermo-vac to the melting point.

Orthotists frequently use this material for nonambulatory MAFO's, custom molded knee orthoses without hinges, upper limb fracture orthoses, T.L.S.O.'s, and custom molded cervical orthoses. Prosthetic applications include check sockets for BK, AK, and upper limb amputees, and it may also be used in the socket of an intermediate or definitive prosthesis when an optimum fit has been achieved in the check socket.

*A product of DuPont

Transparent High Temperature Plastic	Most common applications	Properties	Forming temperature	Time Required to Heat	Forming Process	Available thickness, density, color
Thermo-vac	TLSO, fx. orthoses, W.H.O., A.F.O., clear check sockets	Clear optics, high tensile strength, thermoplastic polymer, difficult to finish, not recom- use in areas of high stress	250°–300°F	5 minutes mended for	drape or vacuum form	1/8", 3/16", 1/4", 3/8"
Lexan	clear check socketsmust be	Hydrophilic, Heat to pre-dried, odorless, high tensile strength and impact strength, clear polycarbonate, rigid, may be sanded and buffed	Dry: 275"F minimum form 400°–450°F	Dry 48 hours frame form 10 to 30 minutes	vacuum form with holding	1/2" transparent

Figure 3.

Patient acceptance of this material has been favorable compared to other sheet plastics due to the cosmesis of a clear device. However, it will rupture in high stress areas sooner than the other plastics, making it unacceptable for many applications. Moreover, it is much more expensive than the available alternatives.

Lexan

Lexan is a very rigid, high impact strength, transparent sheet plastic which has been found to be a good material for prosthetic check sockets. Its clarity is superior to that of thermo-vac, and its rigidity more closely simulates that of the laminated plastic socket it preceeds. Lexan may be bonded to an extension block and attached to an alignment fixture, and safely used for dynamic fit and alignment trials. The major disadvantage is that, being hydrophilic, this material must be predried for two to six days, requiring a separate drying oven. Moreover, it must be vacuum formed using a holding frame and platen, and, therefore, is not readily accepted by many practitioners who do not already have this equipment. A Lexan check socket may be relieved by grinding, but not by spot heating as may thermo-vac. The Lexan check socket also cannot be used as a part of a definitive prosthesis.

SOFT FOAM INTERFACE PLASTICS

Pelite

Pelite is a light weight, moisture proof, sponge foam polypropylene with excellent

Soft Foam Interface Plastic	Most common applications	Properties	Forming temperature	Time Required to Heat	Forming Process	Available thickness, density, color
Pelite	lining material for orthotic and prosthetic applications, molded tongue flaps	light-weight foam foam polyethylene, non-allergenic, soft, washable, thermoplastic, shock absorbant	300°–400°	less than one minute	drape & wrap (thermo bonds to polyethylene & polypropylene)	variety of thicknesses Perforated and non-perforated Firm, medium, or soft white and flesh
Plastozote	interface for orthotic and prosthetic applications	closed cell polyethylene, auto adhesive in dry heat, non-toxic, low flamability, easily cut & sanded, shock absorbing	285°–300°F	less than one minute	drape molding (may be reinforced with vitrathene & clear polyethylene)	perforated, 1/16"–1" white flesh non perforated: 1/16"–1/2" white flesh (other colors, thicknesses, and densities available)
Aliplast	general padding and lining material for orthotic & prosthetic applications	light-weight foam, easily cleaned, exceptional padding, anti-shear, self-adhesive is available	300–350°F	one minute	drape form or vacuum form	1/8"–1/2" white

Figure 4.

shock absorption characteristics. It is available with invisible ventilation holes, or with visible perforations. It also comes in a wide variety of thicknesses, densities and colors. Pelite is most frequently used as a BK liner material, but is also used in pads or complete liners in pelvic girdles, AFO's, and other orthoses.

Fabrication is relatively simple, requiring only a heat gun (or oven) and an elastic bandage to hold the material in place over the positive model until it cools. Because of its ease of fabrication, durability, and washability, it has largely replaced the Kemblo and leather BK liners in most areas.

Plastizote

A commonly used soft foam, plastizote is used as a liner material in both orthoses and prostheses. It may be used in insoles, pads in MAFO's, KAFO's, and in spinal orthoses. It may also be used in upper extremity orthoses for arthritic patients. As a BK prosthesis liner material, it should be used only for inactive patients, as plastizote will compress under weight bearing whether in a prosthesis or orthosis. On the other hand, it is very popular in the medical field because it is relatively easy to work with and may be vacuum formed or drape molded.

Aliplast

Aliplast is a lining material that is smoother in appearance than plastizote. It is popular with orthotists because of its softness as an interface, and for its ability to adhere to polypropylene, polyethylene, and thermo-vac during their vacuum forming. Prosthetists have found Aliplast to be of use as a BK liner material for patients who have very sensitive residual limbs or where skin breakdown seems probable. This liner material is not as durable as others and should only be used where these special problems exist.

At the laboratory of the Hospital of the University of Pennsylvania, we use an Aliplast liner for a temporary prosthesis and for patients who have difficulty wearing a hard socket. Whenever it becomes practical, we will use Pelite as the liner for its longer life and superior performance under active wear. The Aliplast liner for prosthetic or orthotic use is fabricated using a drape molding technique, with or without vacuum.

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The Development of a Molded Pelvic Girdle and the Pelvic Casting Fixture

Carlton E. Fillauer, C.P.O.
Charles H. Pritham, C.P.O.

INTRODUCTION

The idea of a reciprocating gait orthosis originated at Ontario Crippled Children's Center as part of a total system directed towards meeting the needs of children with Spina Bifida and other spinal lesions. Since its original inception in Canada, work on the concepts involved has continued elsewhere.

A Swedish firm manufactures the components necessary for reciprocating hip joints, and such developments as the Shrewsbury "Clicker" (fundamentally a standing frame mounted on a swivel walker base) in England are outgrowths of the work in Toronto. Of crucial importance to its continued development and implementation in the United States have been the efforts of Roy Douglas, C.P., of Louisiana State University, and his interaction with personnel of Durr-Fillauer Medical's Orthopedic Division.

Mr. Douglas has, as a consequence of his great personal enthusiasm and energy, been responsible for not only establishing a successful program at L.S.U., but also for interesting countless others in pursuing the challenge. Durr-Fillauer became involved with the reciprocating gait orthosis in 1977, almost by accident, but since then, the interaction of the staffs of the Orthopedic Division and of L.S.U.'s Department of Orthotics and Prosthetics has been most productive.

Durr-Fillauer, with the resources of a large specialized manufacturing facility, and as a result of the objectivity that comes with geographical separation as well as indirect clinical involvement (as opposed to direct involvement), has been able to refine original concepts and procedures as well as pursue new developments and make them available to others. The results of this research and development effort have been continuously fed back to clinicians such as Roy Douglas for comment and continued improvement. Nonetheless, the reciprocating gait orthosis, no matter how important it is to the people who benefit from its use, remains a highly specialized device for a small segment of the total prosthetic/orthotic population. Far more important are the "spin offs" it has helped produce.

The L.S.U. Lively Orthosis was originally developed as an adjunct to the use of the reciprocating gait orthosis. Today it has been employed in meeting the needs of people who would by no stretch of the imagination be considered candidates for the reciprocating gait orthosis.

Carbon Fiber Composite sheeting with acrylic matrix was originally developed for use as inserts[1] for reinforcing or rigidifying the ankle sections of AFO's and KAFO's as used in the reciprocating gait orthosis. Since then it has been used as a reinforcing agent in a wide variety of prostheses and orthoses. Karl Bremer, C.O. has even been led to use it as a substitute for aluminum bands in conventional double upright AFO's and KAFO's.[2]

Lessons learned in the design of hip joints for the Reciprocating Gait Orthosis

are currently being applied to the design of a new hip joint for the Scottish Rite Orthosis.

The late William Svetz, C.P.O. as a consequence of experience with the Reciprocating Gait Orthosis, was led to utilize the same principles and pelvic joint assemblies to fill the prosthetic prescription aimed towards meeting the needs of a bilateral above knee amputee.[3]

In a more general sense, the Reciprocating Gait Orthosis program has been instrumental in reiterating and reemphasizing many of the lessons and experiences gained in the 60's and 70's as a result of the application of bio-engineering principles and sheet thermoplastic technology to the design and prescription of orthoses.[4] The present day design of the Reciprocating Gait Orthosis is, of course, a result of this process. Yet for some it is their first introduction to it. Lessons gained in the fabrication and fitting of Reciprocating Gait Orthoses are applied to a much larger patient population with less critical demands.

The topic of this paper, Molded Plastic Pelvic Girdle with Hip Joints, must be viewed in this context. It is, by an evolutionary process, the product of experience with one device and the precursor of new devices or applications.

ROLE OF THE PELVIC BAND

At its simplest, the pelvic band is merely a structural element tying together bilateral KAFO's. With reciprocating hip joints, such a structural element is necessary for the proper coordination of movement between the two distal sections. Far more critical, however, is its role as a fitting element or reaction point for the control of motion about a joint or joints.

An individual so involved as to need a reciprocating gait orthosis is going to need control of lumbar lordosis and hip flexion. In this instance, the pelvic band should fit as low distally across the sacrum and buttocks as is compatible with sitting comfort. So located, the band is properly located to work at best advantage as a component of a three point pressure system (or systems) in coordination with other reaction points both proximal and distal.

For a pelvic band used in conjunction with hip joints to achieve proper results, the following criteria must be met:

1. Broad surface area pressure distribution,
2. Accurate contouring for proper pressure relief and pressure application,
3. Accurate alignment of the hip joints for maximum congruence of anatomical and mechanical axes during flexion so as to provide sitting comfort (no inadvertent increase in pressure) and maximum cosmesis (no gapping).

While it is, of course, possible to achieve these criteria using conventional methods and materials, considerable time and effort is necessary to do so. In the past, little incentive existed to spend the effort necessary to insure proper results. The advent of the reciprocating gait orthosis made it, to our minds, imperative.

The crucial element is criterion number three. It must be conceded that individuals needing bilateral KAFO's with hip joints and a pelvic band will spend the majority of their time sitting, no matter how sophisticated the orthosis is. If sitting comfort is compromised, then the orthosis will be removed and once removed, little incentive exists to reapply it. The orthosis, therefore, is relegated to the role of exercise equipment, and is not integrated into the patient's total lifestyle. In recognition of this fact, and in an attempt to fulfill the three criteria set forth, we developed the molded plastic pelvic girdle and the fabrication technique involved.

THE MOLDED PLASTIC PELVIC GIRDLE

Obviously, we feel the molded plastic girdle (Figure 1) meets the criteria. A plaster of Paris positive model is obtained by which proper trimlines, surface contours, and hip joint alignment can be established. Hip joints suitably modified for strength

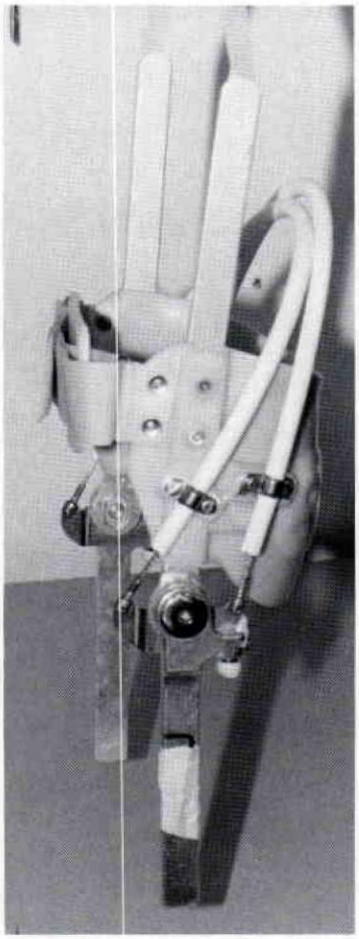

Figure 1. Molded plastic pelvic girdle.

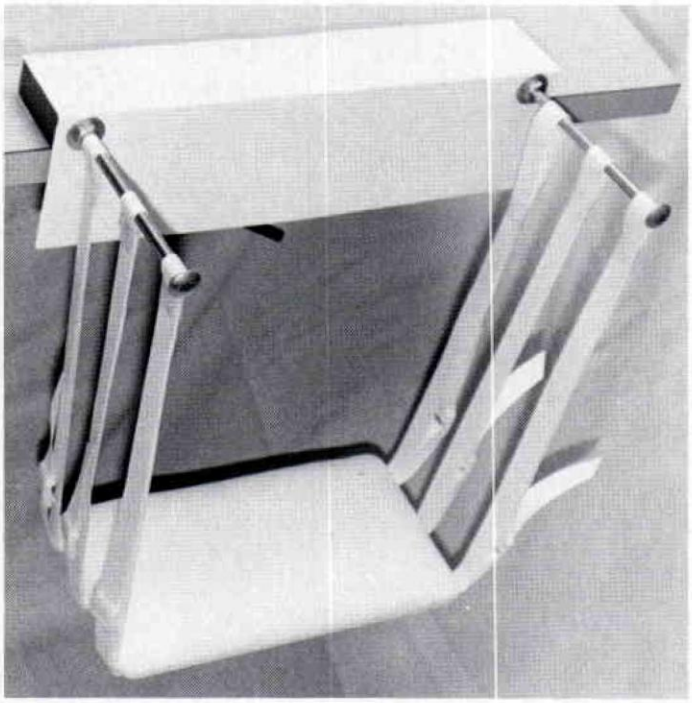

Figure 2. Casting fixture in place.

and stability are laminated inside two layers of co-polymer polypropylene, along with a third narrow strip of co-polymer. This strip of co-polymer ties the posterior outriggers of the two hip joints together and creates a corrugation.

The result is a pelvic girdle that is rigid enough for its intended purpose, yet has a measure of give, or flexibility, to it. This give or flexibilty seems to increase the comfort level of the orthosis and serves to protect the mechanical hip joints, as do the plastic thigh and shin sections of a polypropylene KAFO.

Vertical channels are formed on each side of the pelvic section for inclusion of thoracic extensions. These metal thoracic extensions provide for the incorporation of Velcro® straps or even, if necessary, of a molded plastic thoracic band for control of spinal curvature (In the presence of a preexisting CTLSO or TLSO, we have in the past recommended use of a metal pelvic band on top of the existing orthosis).

We have been quite pleased with the results achieved with these molded plastic girdles. Experience, however, soon showed the need for specialized casting techniques and equipment to achieve satisfactory results.

THE CASTING FIXTURE

A special casting fixture has been designed, which clamps to the end of most casting tables (Figure 2). An integral part of the fixture is a platform, adjustable in height, which supports the patient's knees. The top surface of the casting fixture stands above the surface of the table and supports the patient's pelvis. By this

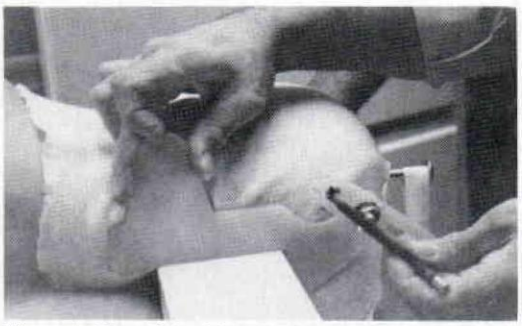

Figure 3. Use of the hip joint gauge.

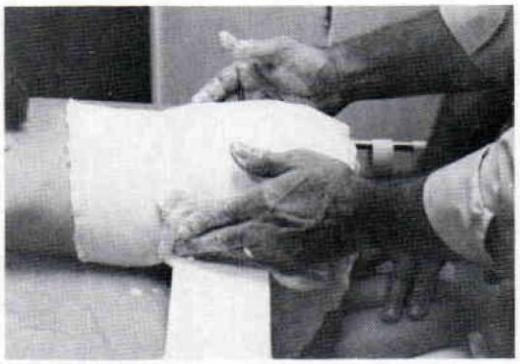

Figure 4. Molding the splint to the patient.

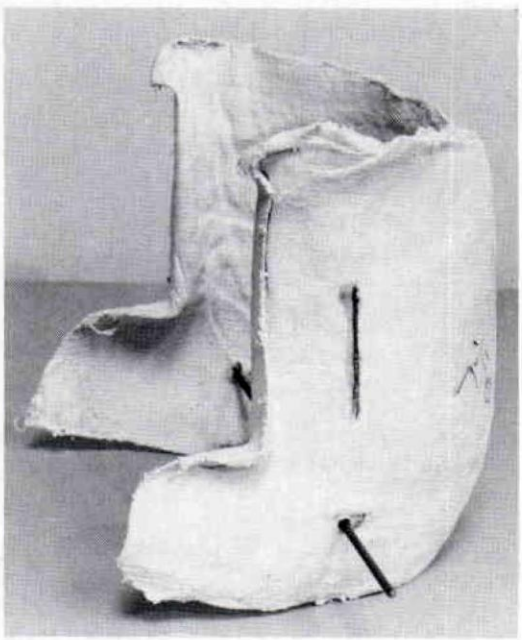

Figure 5. Finished cast.

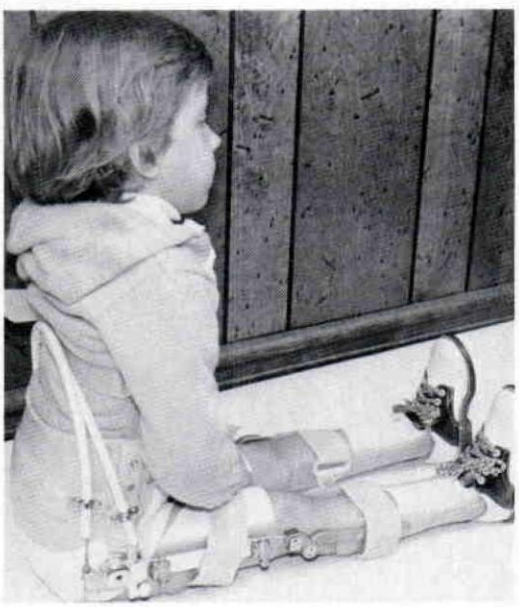

Figure 6. Completed molded pelvic girdle on the patient, showing the close fit during sitting.

means, and by adjusting the support afforded by the knee platform, the desired degree of lordosis is achieved.

The vertical and horizontal surfaces of the pelvic support provide reference planes for an adjustable hip joint gauge which rests on the two surfaces. This hip joint gauge is set for proper location of the hip joint axis by comparing it to first one hip joint and then to the other, and is used to mark the location of the axis on the outside of the cast (Figure 3). In use, one splint of nine layers of eight-inch wide plaster of Paris bandage is used, simplifying the process (Figures 4 & 5).

Use of this special casting fixture, the gauge, and the technique involved has eliminated our earlier problems, when instructions are followed carefully (Figure 6). This is quite gratifying in and of itself, but what is truly interesting are the implications for further use.

FUTURE IMPLICATIONS

While we have not had experience with all of the following suggestions, we consider them quite feasible and commend your attention to them. We, of course, realize that other uses exist and invite your suggestions:

1. Use of molded plastic girdles with bilateral HKAFO's without reciprocating gait.
2. Use of molded plastic girdles with bilateral above knee prostheses with or without reciprocating gait.
3. Use of a molded pelvic girdle, thigh cuff, and hip joint especially modified to prevent unwanted motions in cases of recurrent dislocation of total hip joints.[5, 6]
4. Use of the casting fixture to cast for the posterior section of a two stage cast for a TLSO orthosis.[7]
5. Use of the casting fixture to cast for a "sitting orthosis" either with splints or with a vacuum dilatency casting bag.[8]

CONCLUSIONS

Few techniques or devices can be called revolutionary. Rather, they are the result of an evolutionary process through which experience refines existing approaches and suggests new ones for the same problem or similar ones. It is through this process that the field progresses and it is one that all prosthetists/orthotists participate in. In this article, some suggestion of the process in general is given, and specifically the evolution of the molded plastic girdle and other "spin offs" of the reciprocating gait orthosis program are traced, and possible future developments of the molded plastic girdle are suggested.

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Orthotics and Prosthetics, Volume 38, No. 4, pgs. 54–57.

Role of Cephalo Cervico Thoracic Dynamic Splint in Management of Congenital Torticollis

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Lt. Col. H.S. Oberoi

INTRODUCTION

Congenital torticollis, an entity which, though perhaps occurs due to birth injury, manifests itself at five to six years of age. In a large number of cases, it is missed at birth, and is recognized only when deformity has set in.

The recognition of the condition at an early stage—before gross facial and neck deformities have set in—and its adequate treatment, are therefore of paramount importance.

Immobilization of the head and neck in a corrected or overcorrected position is a must during post-operative management of torticollis patients. This has been achieved by using a bulky and uncomfortable orthosis currently in use. However, these devices are static and therefore maintain the position of head and neck at the same place during the entire period of immobilization, unless the entire orthosis is changed again at great inconvenience and cost to the patient.

It was therefore decided to make an orthosis that would be light, hygienic, less cumbersome to wear, and dynamic in nature, so that it not only maintained the head and neck in its corrected position, but also helps in exerting corrective forces to achieve further correction/overcorrection.

MATERIAL AND METHOD

Seventeen cases of congenital torticollis were treated at the Armed Forces Medical College, Artificial Limb Centre Pune, and a large base hospital, between 1970 and 1980.

History of involvement of other members of the family and congenital bias were investigated. Details were taken of the history of pregnancy. Problems arising in the labor, such as forceps delivery and prolonged or difficult labor, were also noted.

All cases were thoroughly investigated and, where necessary, x-rays of cervical spine and thoracic outlet were taken to exclude any abnormalities in this region. Every case above three years of age was referred to an opthamologist to exclude any primary or secondary occular problems in these cases.

We felt that to get the best results, motivation and close co-operation of the patients in the post-operative period were very essential. Thus, all patients and their parents were fully apprised of the importance of the post-operative regimen.

TORTICOLLIS SPLINT

The Torticollis corrective orthosis designed by us consists of cephalic and

shoulder girdle bands, a harness, and straps for providing dynamic corrective forces (Figures 1, 2, & 3).

Cephalic and shoulder bands are made of polyethylene. These bands are made by accurately forming them over the positive molds obtained from the negative molds of the regions. This provides an intimate fit of these bands around the head and over the opposite shoulder.

The cephalic band is circular in shape and open anteriorly. It is fastened to the head with a Velcro® strap anteriorly.

The shoulder band is horse-shoe shaped and also conforms to the contours and depression over its upper, anterior, and posterior aspect. It is fastened into place by a Velcro® strap under the axilla.

In order to prevent the displacement of cephalic and shoulder polyethylene bands from their original position when the corrective forces are in operation, a harness system is essential. The shoulder band is retained in its place by a figure eight harness mechanism, whereas the cephalic band is retained in its place by chin and overhead straps.

Figure 1. Lateral view of the orthosis.

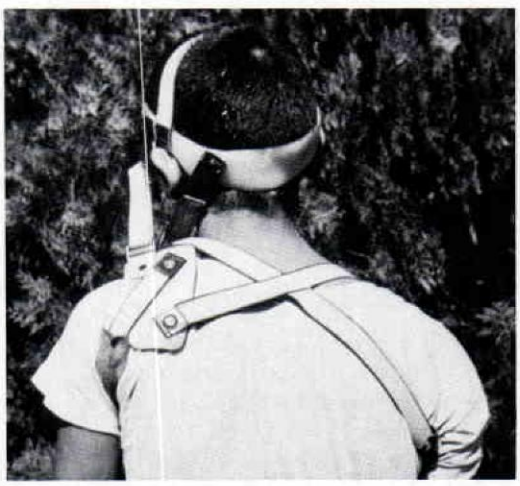

Figure 2. Posterior view.

Figure 3. Anterior view.

The dynamic force-exerting bands are attached to the shoulder band and the cephalic band in a criss-cross fashion. The upper fixed attachment points of these straps are located anteriorly and posteriorly to the sagittal plane. The lower free ends of these straps are attached to the buckles fixed over the anterior and posterior aspect of the shoulder band.

These straps are made of a tough elastic material and by exerting appropriate pull on them, the head, neck, and chin can be maintained in a corrected position postoperatively. By increasing tension in the

bands gradually, mild deformities can be corrected without any operation, and undercorrected deformities can be fully corrected in due course.

OBSERVATIONS

In this series we had three females and fourteen males. Except in two cases, we did not find any unusual problems associated with the pregnancy or delivery. Four cases reported to us within one year, and an equal number were seen within the first five years. We had six cases between five and ten years of age, and three cases beyond ten years of age.

We found pain and tenderness only in the sternomastoid in three cases. There was induration and localized swelling in the sternomastoid in six cases, and a short and tense sternomastoid without any swelling in the other eight cases.

We divided these cases according to the severity of deformity:

- *Stage I*—Minimal tilting of the head with or without tenderness of muscle.
- *Stage II*—Moderate tilting of the head.
- *Stage III*—Severe tilting of the head with secondary changes in face and skull.

We had six cases with Stage I, eight cases with Stage II, and three cases with Stage III torticollis in this series.

TREATMENT

We received four infants in the first few months after birth. All of them had marked tenderness in the lower part of the sternomastoid. All these cases were treated conservatively by manipulation. The correct method of manipulation was taught to the parents and they were advised to carry out the procedure at their home. They were reviewed at monthly intervals. Parents of three other cases, two of Stage I and one of Stage II, refused operation and were thus treated by conservative treatment and splints.

An operation was done in ten cases. Simple division of the sternomastoid at its lower end was done in six cases. More extensive excision of the lower part of the sternomastoid and division of the fascia and strap muscle and the other tissues holding correction was done in four cases. Postoperative healing was uneventful in all cases.

POSTOPERATIVE MANAGEMENT

Every attempt was made to keep the corrected position of head and neck by cast immobilization or by dynamic orthosis. Our first four cases were treated with casts, but later we treated all our postoperative cases with the dynamic orthosis.

RESULTS

Seven patients were treated by manipulation and dynamic orthoses. Four patients with Stage I deformity had good results. In two patients with Stage II deformity and one with Stage I deformity, results were not satisfactory. Ten patients were treated by operation and maintenance of post-operative corrective position by cast or orthosis. Out of six cases of Stage II deformity, the results were good in four cases, satisfactory in one, and poor in one. There were three cases of Stage III deformity, out of which results were satisfactory in one case and poor in the remainder.

DISCUSSION

Many factors have been blamed for the causation of congenital torticollis. This series is too small to throw any further light on this subject.

The results of treatment of these cases depend not only on the surgical correction, but also on the time when the treatment is started (Coventry, 1959).[4] If the treatment is started in infancy, many of these could be controlled by manipulation and later by giving them dynamic orthoses. We achieved good results in such cases by this procedure in 62 percent of the cases. But the biggest problem we find here is that a considerable percentage of cases are lost in follow-up, and we do not know actually

what the final results are when the children reach seven or eight years of age.

The operative procedure for correction of torticollis is simple, but may need extensive division of fascia and contracted muscles or any tissue which prevents the correction. This has to be reviewed meticulously at the time of operation, as was suggested by Brown (1950).[2]

We agree with Armstrong (1965)[1] that of equal importance is the maintenance of corrected position in the postoperative period. We maintained the corrected position for a prolonged period of four to six months. Initially we maintained this position by case immobilization, but this is cumbersome, heavy, and becomes intolerable in summer. Two of our patients removed it by themselves and reported with recurrence of deformity.

After many experimentations and considerable efforts, we have tried to find an ideal orthosis for this condition. The Buckminster-Brown type of orthosis used in the past was bulky and difficult to fit. Even the orthosis by Lango (1977)[5] is static.

We have now devised a cephalo cervico thoracic dynamic orthosis to be given to these patients in their postoperative phase and in early Stage I cases and all those who refused operation. It is light and comfortable. It is readjusted from time to time and can be used for as long as required. It is opened two or three times a day to give physiotherapy and manipulation.

We used this orthosis in ten cases. Six were given this orthosis after operation and four were given to those who were early Stage I or who had refused operation. The results after its use were consistently good. The further management of cases in their post-operative period became comfortable for the patients and easy for the treating surgeon. The orthosis, described here, is mechanically sound and contains dynamic corrective forces ingrained in it. It has been very well accepted by all of our patients.

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The P.A.D.*—A New Alignment Device for Prosthetic Systems (The Case of an A.K. Endoskeletal Prosthesis**)

Gilbert Pierron
Michel Palfray
Marcel Berthet

INTRODUCTION

The alignment of an above knee prosthesis can be defined as the position and angulation of the foot, knee joint, and socket relative to each other. These are essential characteristics of prostheses. Every change you make when moving one component affects many important characteristics of the amputee, including:

- comfort
- stability and safety
- energy consumption
- cosmesis of gait.

Alignment also modifies the level of tensile and shear forces on components, thereby affecting reliability.

REVIEW OF THE FIELD

In the past, highly competent craftsmen worked to achieve good visual alignment, never being sure when the best possible configuration was established. Over the past 30 years, a vast range of alignment systems have been designed.

The principal systems can be grouped in three categories:

1) *A.K. adjustable legs*

One of the first designs was made at the University of California at Berkeley. It is a good system; however, its disadvantages include:

- its availability with only a single axis knee mechanism
- increased weight during training
- extra work and tooling for duplication.

2) *Alignment couplings*

The Staros Gardner unit is well-known, but it requires extra work and tooling for duplication.

3) *Incorporated alignment systems*

The Blatchford and Otto Bock systems are very popular. However, some disadvantages need to be considered:

- an increase of weight
- often, a decrease in reliability
- use is limited to a medium or a short residual limb (if you want to adjust the socket position with respect to knee-joint)

Moreover, it is our experience that all alignment devices on the market have one major deficiency: adjustment of the socket angulation affects the socket position with respect to foot and knee-joint.

In Figure 1, you can see that hip flexion draws back the socket. An A.P. shift is absolutely necessary to correct the socket po-

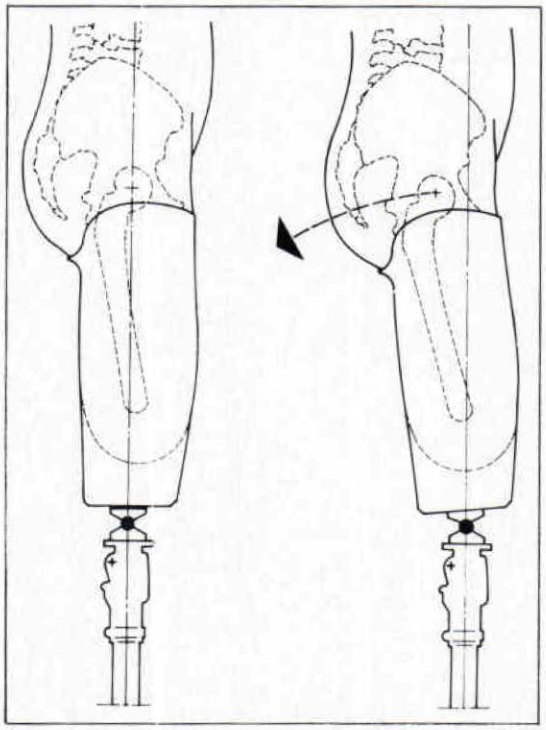

Figure 1. A flexion draws back the socket.

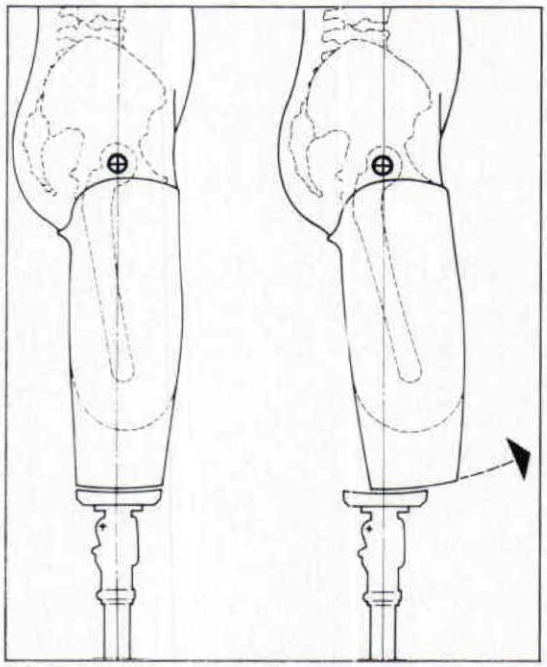

Figure 2. P.A.D. is designed according to physiology: its center of tilt matches the hip-joint of a "universal patient."

sition. But that is not always possible with devices on the market. In some cases, the range of adjustment is limited.

DESIGN AND FEATURES

To satisfy requirements of the amputee and the prosthetist, we have designed the P.A.D. to incorporate many advantages over other alignment devices. As you know, the above knee residual limb moves with respect to the hip-joint. The P.A.D. is designed according to human physiology. Its center of tilt matches the hip-joint of the "universal patient" (Figure 2). Flexion, extension, abduction, and adduction adjustments do not affect the socket position with respect to the hip joint. Tilting and shifting adjustments are independent.

Each adjustment is independent of the others. Figures for all adjustments are as follows:

- anteroposterior tilt: 10° flexion–10° extension (Figure 3).
- anteroposterior shift: 50mm. anterior–50mm. posterior (Figure 4).
- mediolateral tilt: 10° adduction–10° abduction (Figure 5).
- mediolateral shift: 50mm. medial–50mm. lateral (Figure 6).
- internal/external rotation is derived from the knee mechanism.

The P.A.D. is thin. It does not require any more room than would a socket attachment block (approximately 37mm). It adds no extra weight to the prosthesis. It replaces a socket attachment block without any increase of weight after trimming (160 g. after trimming in a standard shape). The P.A.D. is also adaptable on a vast range of knee mechanisms.

The unit does not require any extra work for duplication. When the best possible configuration for your patient is obtained, you drive a screw through the P.A.D., where marked, to secure the final position (Figure 7). You then trim and sand off any excess material (Figure 8), and laminate in the whole system along with the socket (Figure 9).

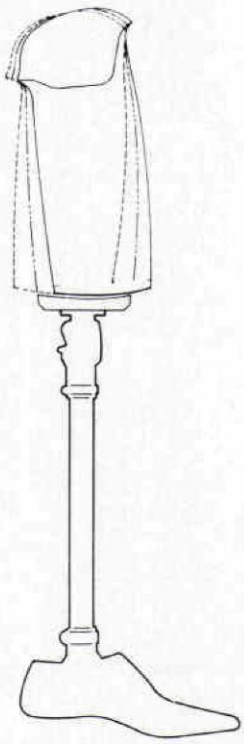

Figure 3. Anteroposterior tilt.

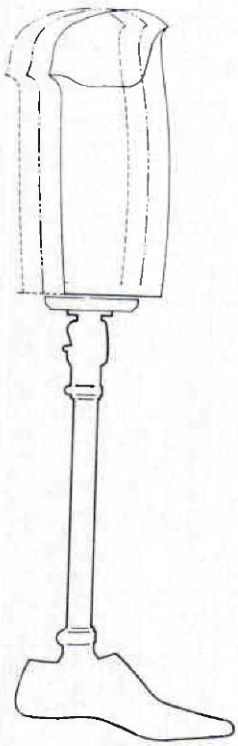

Figure 4. Anteroposterior shift.

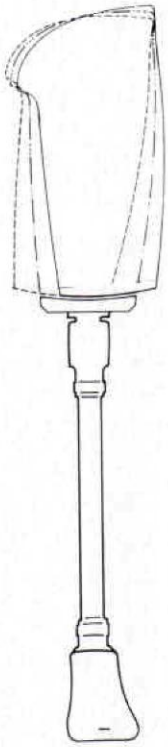

Figure 5. Mediolateral tilt.

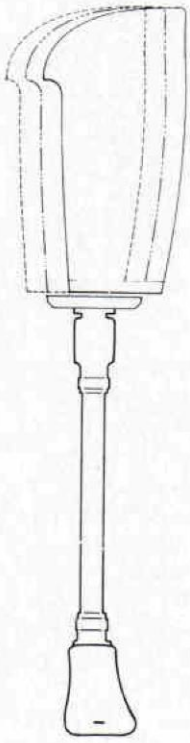

Figure 6. Mediolateral shift.

Figure 7. AN A.K. socket dynamically aligned with P.A.D.

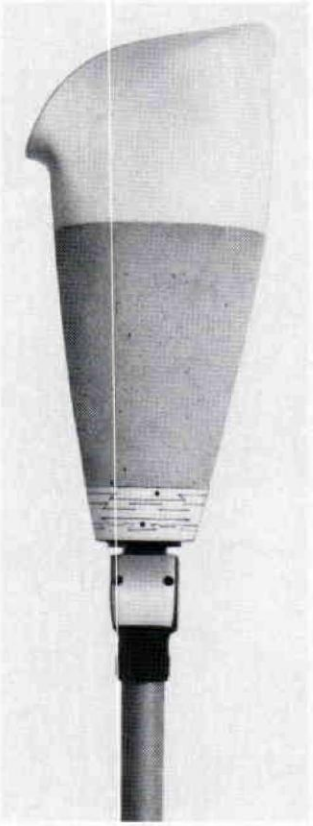

Figure 8. An A.K. socket after trimming and sanding off excess material.

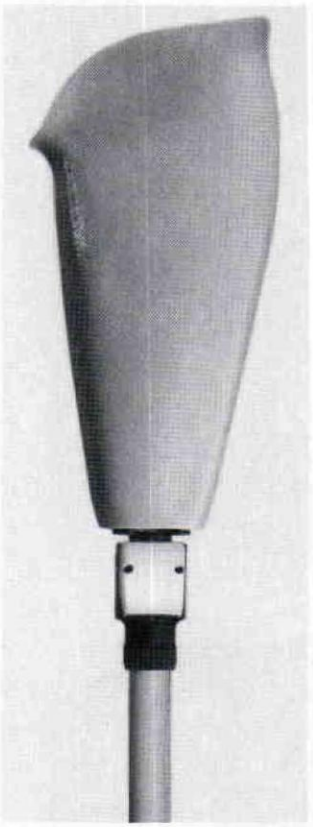

Figure 9. An A.K. socket laminated with P.A.D.

DISCUSSION

In a finished definitive, above knee endoskeletal prosthesis aligned with the P.A.D., only adjustability of internal and, external rotation of foot, socket, and height remain. One question to answer is whether or not it is necessary and desirable to have full capability for alignment adjustability present in a definitive prosthesis.

Only a very few times, from experience, has this capability been necessary. This occurs if the temporary prosthetic alignment time is too short, or if the alignment procedures are not strictly critiqued. But, in most cases, with incorporated alignment systems on the market, is it possible to really readjust the socket position and angulation?

Permanent adjustability may not always be desirable if we want to meet the needs of the majority of amputees. Most of our patients are sixty years old or over, with vascular diseases and several involvements. They need a light weight prosthesis, which would not be available with the standard permanent alignment couplings. The majority of the other amputees have fewer troubles with the alignment of their prostheses.

Moreover, it is our experience that, with the P.A.D., the alignment procedure is easier, and the prosthetist can quickly obtain the best possible alignment for his patient. In Figures 10 and 11 you can see a patient during the trials for fitting and adjustment.

CONCLUSION

According to our experience, the P.A.D. offers the most advantages of all alignment devices:

- tilting does not affect socket position,
- all adjustments are independent of each other,

Figure 10. A patient during trials for fitting and adjustment.

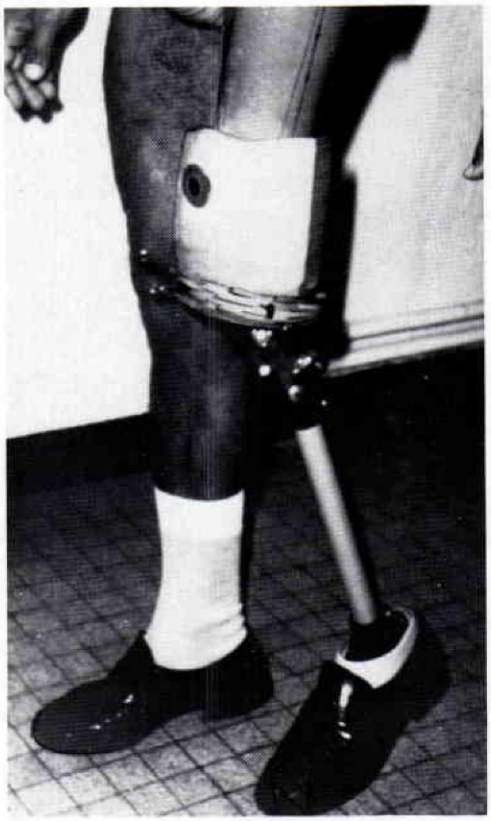

Figure 11. The same patient; he has a medium length residual limb but a very short femur.

- no transfer and increase of weight or length is required,
- no duplication procedures are necessary.

The P.A.D. provides for an easy, short, and accurate alignment procedure for the prosthetist and a light-weight prosthesis for the patient.

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*patent pending

**Other designs of A.K. and B.K., both endoskeletal and exoskeletal are available.

Orthotics and Prosthetics, Volume 38, No. 4, pgs. 63–68.

Multiple Durometer Socket Liners for P.T.B. Prostheses

Timothy B. Staats, M.A., C.P.

INTRODUCTION

Patella tendon bearing socket liners have traditionally been fabricated using leather and Kemblo rubber.[1] In recent years, a variety of new materials have been successful in replacing the original technique. Liners composed of Pelite, Plastazote, silicone gel, etc., each provide slightly different characteristics as related to durometer and wear resistance. Certain qualities of each material are desirable in various applications and have been incorporated in inserts to solve residual limb problems.

This paper will examine the experimental and clinical applications of P.T.B. socket liners fabricated using an integration of materials with different durometers blended into the liners. The desirable durometer characteristic of a specific material may be strategically located within the interface of the liner. The primary use of multiple durometer liners may be seen with the problem experienced by below knee amputees with very boney, badly scarred or intermittently painful areas on the residual limb. In addition, the very active P.T.B. wearer, requiring added protective padding about the residual limb surface, will derive benefits from the below described techniques.

Nitschke[2] reported in 1972 the use of a copolymer liquid called "Cordo" that could be used as a liner material when impregnated in gauze. Plastizote was placed over the boney prominences, in particular, the anterior distal end of the tibia. Cordo is not widely used primarily because of a lengthy fabrication process.

In 1980, Graves developed a selectively placed silicone gel liner system for the P.T.B. prosthesis.[3] In that report it was stated that for ambulation and most routine activities, a P.T.B. prosthesis with either a hard socket or conventional liner is adequate. However, for more demanding activities, more protection is needed. The Graves system is a Pelite and leather liner with silicone gel applied over the anterolateral surface and crest of the tibia. Figure 1 shows Graves testing the selectively placed silicone liner on a specially designed ski leg, which incorporates a Lenox Hill brace over a below-knee prosthesis.

During the period from 1974 to 1980 at the University of California at Los Angeles Prosthetics-Orthotics Laboratory, a search for materials to replace silicone gel as a liner material inadvertently led to the development and clinical application of two hybrid P.T.B. liners known as multiple durometer liners.

Figure 1. Below knee ski leg with "selectively placed gel liner and Lenox Hill Brace to assist in stability and suspension."

Figure 2. Raw Haflex 1962.

THE HOT MELT LINER

The inherent problems of fabrication and longevity of silicone gel socket liners led to the first alternative material, called a "Hot Melt Copolymer Gel." In its raw state, hot melt gel or Haflex 1962[4] appears worm-like, and is used in the manufacturing of fishing lures and squishy toys (Figure 2). The hot melt liners are fabricated by melting raw Haflex 1962 in an oven at 400° Fahrenheit until the gel is molten. A leather liner applied in the standard manner over a plaster positive model is immersed into the molten material, developing a build-up of about ¼" thickness (Figure 3). The cast is carefully rotated until the hot material has cooled. Attempts to lay up a nylon mesh or stocking over the external surface of the molten material have proven to be difficult. While the technique described is crude, and equipment rudimentary, the resulting liner looks and feels promising.

Proper handling of the hot melt gel involves heating the material in a double boiler with a lid. The double boiler should have a bath of castor oil or a high flashpoint petroleum oil, such as golden Shell No. 40. It should withstand temperatures to 400° Fahrenheit.

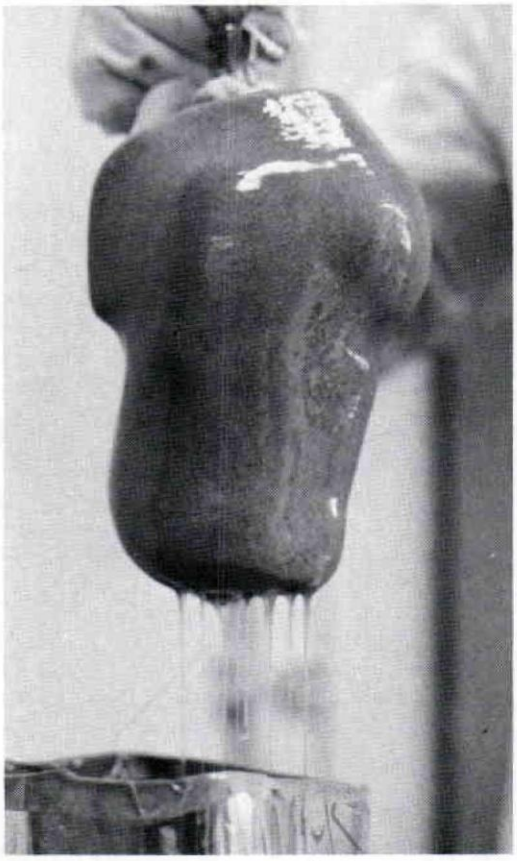

Figure 3. Hot-melt gel liner in dipping process.

A large electric roaster has been used for this purpose and will hold up to 30 pounds of the hot melt. The hot melt is completely reclaimable, although scraps should be cut for ease in melting. Overheating or prolonged heating will weaken the hot melt material. Detailed manufacturers instructions are available and should be consulted.[4] Open heating in an oven is slow and produces smoke, and is, therefore, not recommended.

Three problem below-knee amputees consented to try the new hot melt liners. Figure 4 shows one typically difficult below-knee residual limb with painful boney areas and a deep scar over the medial tibial flare. The scar had a slightly draining sinus that was irritated by every attempt at fitting and ambulation despite a variety of sockets and liners, that included a silicone gel liner. The other two patients fitted with hot melt gel liners had residual limbs with different yet classical fitting problems.

In Figure 5 the hot melt liner is shown donned with a patient wearing a three-ply residual limb sock. No reports of skin irritation or allergic reactions have been encountered. The prostheses were fabricated and aligned in the standard manner. In Figure 6, a P.T.B.-S.C.-S.P. or P.T.S. with Fillauer removable medial wall proved excellent, functionally and cosmetically. The patients who have been fitted with hot melt liners were remarkably comfortable.

Within a period of three months, the hot melt liners developed cracks at the patellar notch area (Figure 7). Reinforcement of the hot melt liner in this area is necessary for better wear. The hot melt liner was repaired by locally heating the liner with a heat gun to reconstitute the gel (Figure 8). Months later, additional repairs involved sewing in place Kemblo patches over the patellar notch area. This multiple durometer approach stabilized the AP dimension of the socket and prevented further tearing.

The hot melt multiple durometer liner provides the same mechanism of comfort as the silicone gel liner. The gel-like consistency of the liner reduces shear forces on the residual limb by absorbing shock and rotation. Due to lack of facilities and time for research, the hot melt insert was dis-

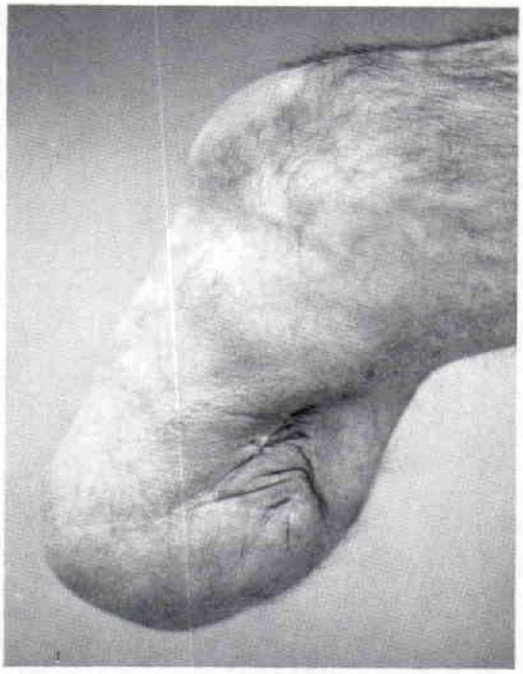

Figure 4. Badly scarred below knee residual limb, a typical candidate for the multiple durometer liner.

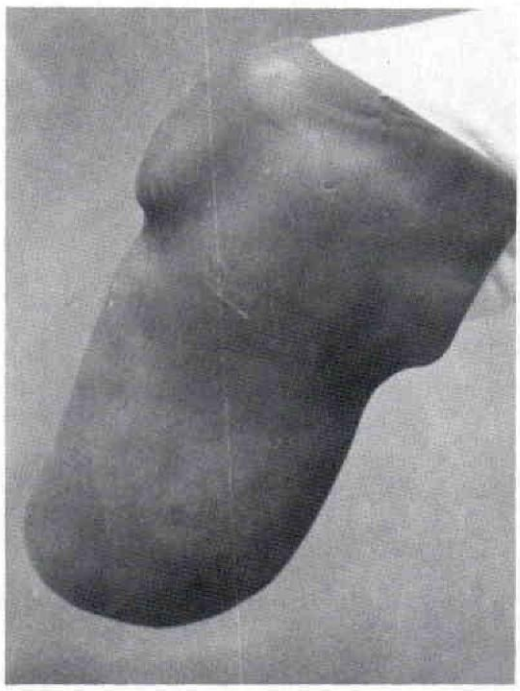

Figure 5. The hot-melt gel liner.

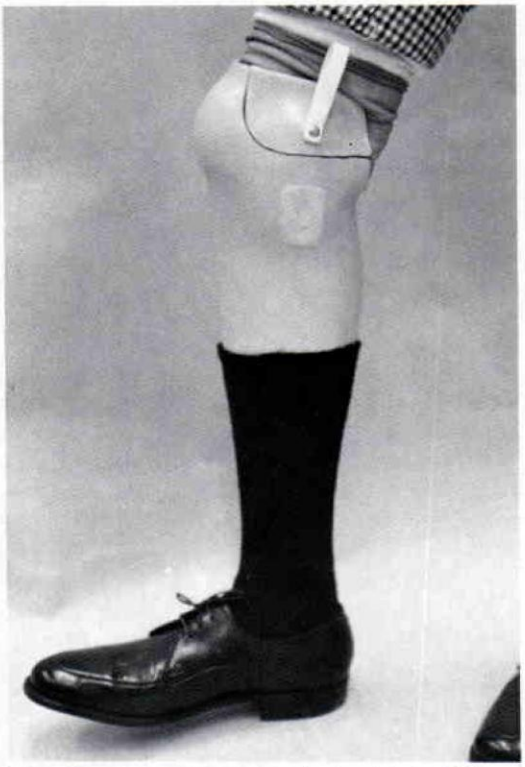

Figure 6. A P.T.B.-SC-SP prosthesis with the Fillauer removable brim and hot-melt gel liner.

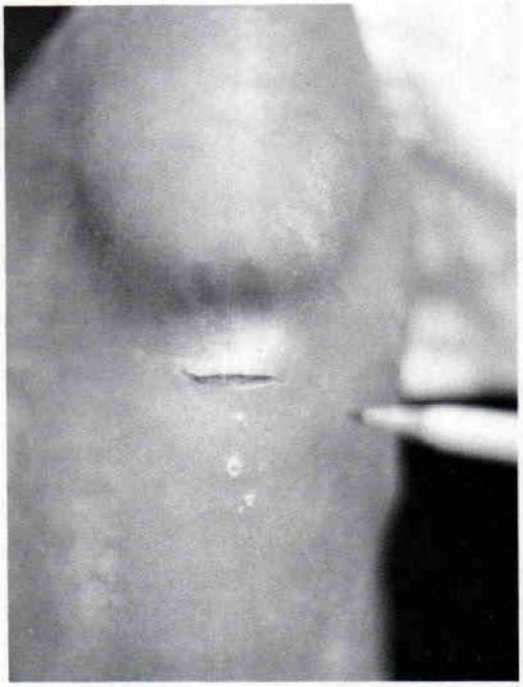

Figure 7. Common area of deterioration in hot-melt liners.

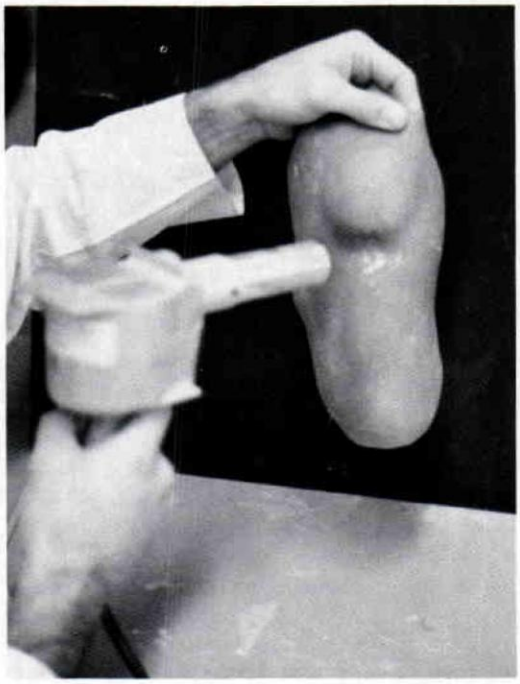

Figure 8. Repair of the hot-melt liner is accomplished by reheating the deteriorated area with a heat gun.

continued, and more traditional materials and methods were again used on a regular basis.

After three years, the hot melt liner patients returned to the U.C.L.A. lab. It was at this point that the durability of the hot melt liner was fully recognized. After long term wear, the hot melt liners were intact, although somewhat compacted and worn. The compression of the hot melt gel appeared uniform and without the migration that is common in silicone gel liners. No further research is planned or anticipated on hot melt liners. However, information and technical experience is available on this material for anyone wishing to pursue its applications.

THE ALIPLAST-KEMBLO LINER

By 1979 a variation of Kemblo-leather P.T.B. liner was fabricated as a replacement

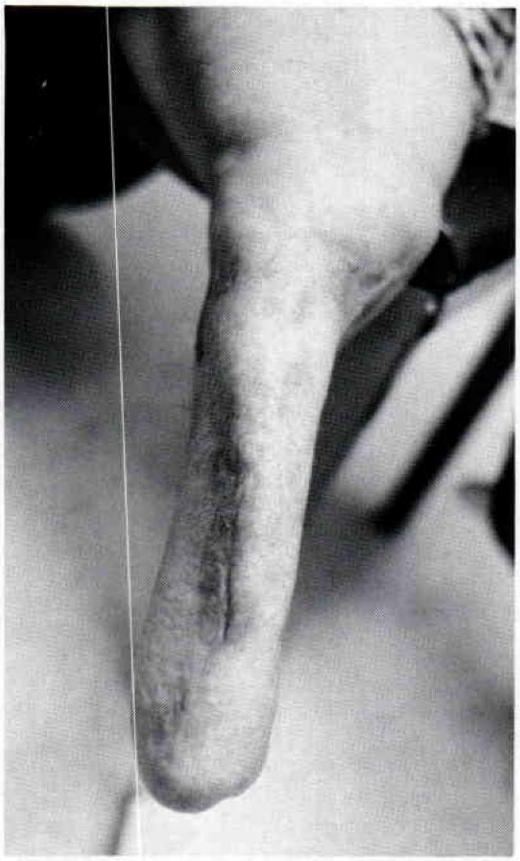

Figure 9. A below-knee amputee who is a candidate for the Kemblo Aliplast multidurometer liner.

for hot-melt liner wearers. An Aliplast-Kemblo multiple durometer liner was designed for the problem below-knee amputee shown in Figure 9. The oddly shaped residual limb was extremely boney in areas where normally there is more padding. Furthermore, a rather fragile scarred area over the anterior tibia made a hard socket or conventional liners extremely difficult, if not impossible, to fit.

The Aliplast-Kemblo liner is fabricated by first constructing a leather insert in the standard manner. Very soft Aliplast patches are glued to the insert and carefully beveled to blend imperceptibly into the leather (Figure 10). The positioning of the patches relates directly to the locations in the liner where extra softness is desired. Normally the patches are placed over the crest of the tibia, beginning approximately

Figure 10. Appearance of liner with Aliplast patches in position.

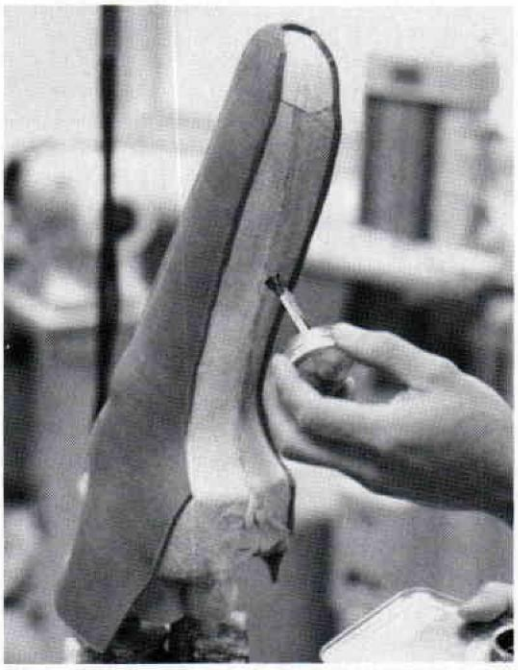

Figure 11. The Kemblo backing is applied in the standard manner over the Aliplast patches.

½" distal to the patellar tendon, and covering the entire anterior and distal area of the tibia and over any boney areas around the knee. Additional Aliplast patches are applied over the head of the fibula (Note: The positive model has been modified in the standard manner and standard plaster of Paris buildups have been applied). The multiple durometer liner is completed by adding a layer of Kemblo in the conventional manner (Figure 11). Pelite or Spenco could also be used in this final fabrication step.

Clinically, the results with the multiple durometer liner (Aliplast-Kemblo) have been excellent. The first six below-knee patients selected for liners were either previous silicone gel, hot melt gel insert wearers, or classified as difficult to fit patients. An additional type of residual limb was found to benefit from the multiple durometer technique. In cases where the cut tibia is not carefully beveled, and skin covering is drawn tautly over the cut edges of the bone, an intermittently painful residual limb often results. Multiple durometer liners can also be used when this type of problem is anticipated.

When worn for the first time, the multiple durometer liner feels somewhat tight yet comparable to other liners. Patients have consistently reported that, within one week, the liner adjusts to the residual limb by partially packing out the Aliplast material. Initially it was thought that the Aliplast would continue to pack out completely, thereby ruining the fit of the liner. However, this speculation proved unfounded as the liners seemed to pack only to the degree required for relief of the boney prominences. The added support of the Kemblo not only maintains the fit, but enhances the wear resistance of the liner.

At least six multiple durometer liners have been worn for over one year with no problems other than those normally associated with maintaining the A-P fit in a Kemblo-leather liner. The Aliplast buildups still continue to provide cushioning. It has been speculated that with careful casting and bone identification, buildups on the positive model of the residual limb may not be as necessary when the properly fabricated multiple durometer liner is used. The above technique is now used frequently, and multiple durometer liners can be included routinely in prostheses by asymptomatic amputees.

CONCLUSION

In conclusion, the clinical success of the multiple durometer liner does not signal any major philosophical shift in the fitting of P.T.B. prostheses. This simple variation has proven to be exceptionally beneficial and functional in a wide variety of below-knee amputees using liners in their prostheses. The method of fabrication makes it easy to adapt to techniques already in common practice.

The hot melt get liner with a Kemblo A-P insert has worthwhile aspects that warrant further research. The hot melt liner is less difficult to fabricate than is the silicone gel liner, and it appears to be stronger and less prone to cold flow or migration, which is common in silicone gel liners. When the technical development of the hot melt gel liner is continued, it could lead to a good alternative to the silicone gel liner.

In high activity sports prostheses, multiple durometer liners are indicated. The support and suspension of the Lenox Hill brace may also be considered as a viable addition to the multiple durometer liners for high activity P.T.B. prosthesis wearing patients, where high stress forces are placed on the patient and the prosthesis.

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Professionalism: A Review of Its Impact on the Health Services

Robert L. Rhodes, B.A., C.O.

INTRODUCTION

In Ancient Egypt the rules were simple. Occupational position was hereditary: if you were born into a "professional" household, you were a professional (Titler, n.d.). Even six hundred years ago, although a different rule applied, the rule was still simple. If you spoke Latin in your work, you were a professional (Joe, 1981). Thus, the three traditionally learned professions, law, clergy, and medicine have a common linguistic base. Such was the status of professions until the rise of the universities in the later middle ages. There was no social trauma in accepting the university professor—he was probably a cleric, at least he was schooled in Latin (Cogan, 1953).

The present state of the professions arose as a result of the Industrial Revolution. In 1833 Samuel Taylor Colderidge wrote, "Every true science bears necessarily within itself the germ of a cognate profession, and the more you can elevate trades into professions the better." As technology has brought increased specialization, the individuals within those specialties, fragmented from the traditional professions, have aspired to be recognized as being of professional status. This "professionalization" has been most noted in the helping professions, particularly in medicine. Martin (1934) described the difficulties of professionalizing surgery, and Reiser (1983) noted 152 allied health specialties constituting one-third of the medical work force.[1]

This paper will review the literature of professionalism, comment on professionalism as it relates to the health services professions, present a model of reaction to professionalization, and draw conclusions about the results of this trend.

REVIEW OF THE LITERATURE

Flexner (1915, p. 576) was the first to attempt to delineate the basic characteristics unique to a profession. They are as follows:

> ". . . professional activity was basically intellectual, carrying with it great personal responsibility; it was learned, being based on great knowledge and not merely routine; it was practical, rather than academic or theoretic; its technique could be taught, this being the basis of professional education; it was strongly organized internally; and it was motivated by altruism, the professionals viewing themselves as working for some aspect of the good of society."

Carr-Saunders and Wilson (1933) agreed basically with Flexner and predicted a gradual extension of professionalism into all occupational fields (Bennett and Hokenstad, 1973, p. 24). Attempts to "nail down" a definition have been as complex as Wilensky's (1964) and Hall's (1968), both of whom listed ten characteristics, or as simple as Hughes (1958), who said that a profession has a lay clientele. Significant attempts have been those by Coogan (1953),

Goode (1957, 1960), Greenwood (1962), Volmer and Mills (1966) and Moore (1970).

Finally, in 1973, Morrow reviewed nine of the major definitions of "profession." Characteristics were divided into "Attitudinal Qualities" and "Structural Qualities." Included were 11 characteristics (Figure 1).

Most proved to be in agreement in structural characteristics, but attitudinal characteristics were emphasized less by Foote (1953) and gradually again approached Carr-Sanders' 1928 original by 1968 (Hall).

Attitudinal Qualities

- Colleagues are major reference group
- Public service value
- Self regulating
- Sense of calling
- Autonomy
- Rewards justification

Structural Qualities

- Full time occupation with specialized knowledge
- Own training schools
- Professional association
- Licensing/certification, community recognition
- Code of ethics

Figure 1

Volmer (1966, p. vii) in his monumental work *Professionalism,* attempted to put the matter in its proper perspective:

> ". . . we avoid the use of the term 'profession,' except as an 'ideal type' of occupational organization which does not exist in reality, but which provides the model of the form of occupational organization that would result if any professional group became completely professionalized. . . . We suggest, therefore, that the concept of 'profession' be applied only to an abstract model of occupational organization, and that the concept of 'professionalization' be used to refer to the dynamic process whereby many occupations can be observed to change certain crucial characteristics in the direction of a 'profession,' even though some of these may not move very far in this direction . . ."

Flexner had undoubtedly anticipated the problems of specific definition, for he qualified his analysis:

> "What matters most is professional spirit. All activities may be prosecuted in the genuine professional spirit . . . The unselfish devotion to those who have chosen to give themselves to making the world a fitter place to live in can fill social work with the professional spirit and thus to some extent lift it above all the distinction which I have been at such pains to make."

Professionalism has all in all been seen as something good (Durkheim, 1957).[2] Both internal and external forces work on the segments (Strauss, 1975, p. 21) within an occupation and generate the dynamics that move towards professionalization (Gustafson, 1982, p. 508). In the health care area this has been brought about by an increasing de-professionalization (Haug, 1973, p. 197) of the physician and an increasing specialization of function that causes the physician to rely more and more on auxiliary personnel (Barish, 1975, p. 974). The public has certain expectations of ability in health care workers (Battle, 1981), (Barringer, 1983), identifying quality health care with innovation. There is a positive correlation between change, innovation, and professionalism (Palumbo, and Styskal, 1974). From within the developing profession, roles (Gingras, 1984) and abilities (Schoenwald, Scott, and Lance, 1984) are identified. As previously noted, the process is deemed "good" and even Marxist scholarship (Larson, 1979, p. 613) attributes this quality:

> "Professionalism also contains potentially emancipatory elements: the most significant are, in my view, the claim of work autonomy and self control, together with the aspiration to 'serve' human needs and to produce worthy, high quality objects or services."

We have established that "professionalism" is an ongoing societal process

affecting the health professions: it is needed, desired, and beneficial. Let us now comment on health services specifically in terms of professionalism. Precedence for and evaluation of a health service was set by Tworek (1981) in his study of the physician's assistant. Tworek attributes ten characteristics of "professionalism" to Schein (1972), and it is by this standard of ten that I will proceed.

1. **A Full Time Occupation.** Health service professionals are, except in very few instances, employed in their profession as their full time livelihood.

2. **A Strong Motivation or Calling for the Career.** While many health service professionals find themselves in a profession by placement or birth, many find "a dignity to one's work that can be affirmed . . . [and] a sense of fulfillment and meaning that can come from being of service to others and to the common good" (Gustafson, 1982, p. 584).

3. **A Specialized Body of Knowledge and Skills Acquired During a Prolonged Period of Education and Training.** Health service professionals require a minimum of two years college-level training. Most require a minimum of four years, though it may be combined didactic and clinical learning. In many specializations claiming to be professional, the educational requirements are sadly lacking. This is surprising as, "The most common criterion describing professions . . . is their emphasis on education" (Nyre and Reilly, 1979, p. 10).

4. **Decision Making on Behalf of the Client in Terms of Principles, Theories or Propositions.** "To be a professional person is to learn to think . . . and to exercise practical reason in making judgements. . . . Exercising discretion, making judgements and moving from the established and familiar to what is different in particular features distinguishes professions from most other occupations" (Gustafson, 1982, p. 506).

5. **Service Orientation.** "All true professions deal with humans in special existential states of vulnerability in which there is some wounding of the very humanity of the person in need. . . . The tradesman's promise to help is made as a means to make a profit, not primarily for the good of the customer" (Pellegrino, 1983, pp. 172, 174).

6. **Service Based on the Objective Needs of the Client and Mutual Trust.** "The action taken and advice given must be not only technically correct but 'good'; that is, it must be congruent with the best interests of the person in need" (Pellegrino, p. 173). Trust in the professional to act in this way and in maintenance of confidence and the withholding of judgment (Tworek, p. 112) is implicit in any health care professional patient relationship.

7. **Autonomy of Judgment for Performance.** Health service professions are at varying levels of autonomy. Most, even if doing repetitive tasks, must possess a high level of skill and judgment to be able to carry out that function. The question of autonomy is often raised and hotly debated. Wilensky (1964, p. 156) stated, "It seems clear that ancillary medical occupations will arrive at an autonomy befitting professional status only at the expense of the control now in the hands of physicians and board members who will not readily yield." The end result is that "Physicians are likely to be very poorly informed about any institutional and occupational resources that lie outside their own jurisdiction . . ." !(Freidson, 1970, p. 150). In this contest, the health service professional is truly caught in the middle. Skills and services are needed by the patient, but a health service professional's employment may be jeopardized if discretion is not exercised (Barker, 1979). Nickel (1983, p. 14), on the other hand, relates that "My method is to emphasize the skills of each professional required for a competent rehabilitation service and note the improvement in patient care that will result when all members are permitted to work to their full potential."

8. **Formation of Professional Associations and Other Professional Credentials.** ". . . this is accompanied by a campaign to separate the competent from the incompetent. This involves further definition of essential professional tasks, the development of internal conflict among practitioners of varying background, and some competi-

tion with outsiders who do similar work" (Wilensky, 1964, p. 144).

9. **Specific Set of Knowledge.** In the health professions, each has a function in which, while the knowledge application and its results are not necessarily unique, the skills of application and the yielding of results are unique.

10. **Professionals are Not Allowed to Seek Out Clients.** Most professional codes of ethics forbid or at least regulate these practices. Health professionals are all in a state of "professionalization." None have yet achieved an equal standing with the established professions. The achievement of professional status has been accomplished by surgery, dentistry, and veterinary medicine. I would propose a model by which professionalism occurs in the health service professions (Figure 2).

The occupation tends to stay as it is by force of social inertia. Traditions of place externally and traditions of skill internally tend to maintain the status quo. Conflict then comes to a head (Wilensky, p. 144) with the recognition of the ecological niche that needs to be filled and with the fledgling professional's realization that he or she may be the one to do so. Thus, aspiration changes self image.

Power is not absolute, but is often viewed as if it is. Power gained is thought to be gotten from someone. Physicians are not eager to give up authority (Wilensky, 1964). Within the aspiring profession, reactionary forces come into play and a tendency to undermine the professionalism and espouse return to the traditions of skill and place ensues (Potenberg, 1983). As these resistances are overcome, assistance comes into play with legal responsibility being dictated externally, and with control of entry and association coming from within.[3]

What does this mean to the aspiring health professional? I project increased responsibility resulting from primarily legal requirements. Flores and Johnson (1983, p. 544) described the requirements for responsibility:

> "1. Individuals must have some degree of autonomy in the position that they hold. . . . 2. The individual must have contributed by his action or inaction to the production of the . . . product or service; and 3. the individual must have a duty to protect public safety. It is obvious that by these standards the health professional is "responsible."

The legal requirements of this responsibility will require new emphasis on records (Reiser, 1983) as legal documents and evaluation by external agencies such as JCAH (Joint Commission on Accreditation of Hospitals, 1980) and PSRO's (Reynolds, 1976).

Structurally, administrations must recognize and actively promote the socializa-

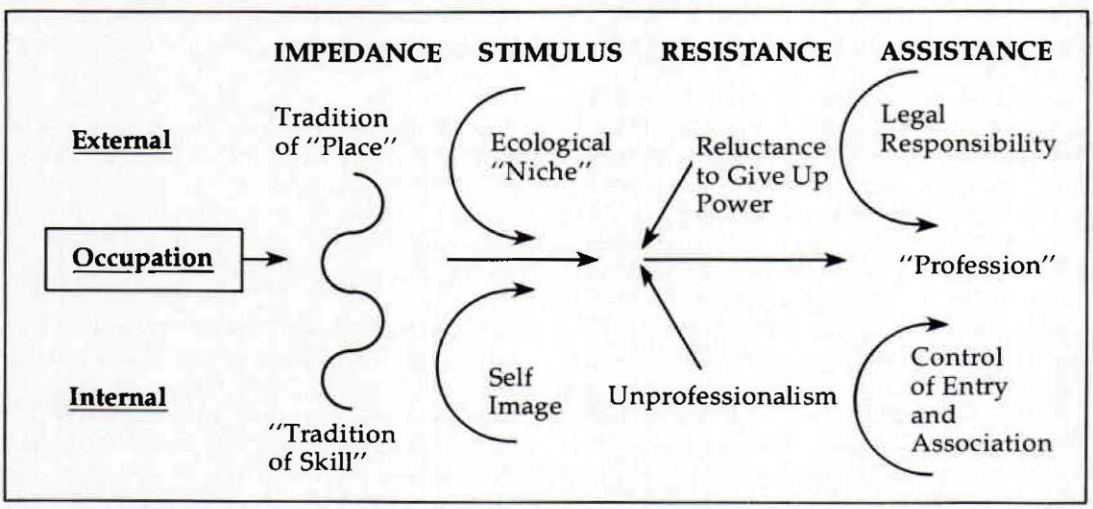

Figure 2. Model of professionalization in health service professions.

tion of emerging professions.[4] The recognition must come if optimum quality of patient care is to be achieved. No "critical person can survive . . . because assessment of one's academic or professional service and related occupational survival requires an ethical stance from others who value that work" (Mason, 1983, p. 133).

Health professionals will be increasingly involved in patient management decisions (Weiler, 1975). The team concept is coming into more widespread use (Engel and Hall, 1971). These trends may be further stimulated by the efficiencies required by DRG's (Bombert, 1984). There is an increased tendency for health care professionals to be in salaried positions (Reiff, 1974) and a tendency for preference of employment in non-profit organizations (Majone, 1984).

What can the health professional do in the throes of all this? First, support education. Moore in 1953 (p. 11) said:

> "We suggest that in the contemporary United States the minimum educational requirement be placed at the equivalent of the college baccalaureate degree. Since nearly all of the older and well-recognized learned professions in fact require training beyond the baccalaureate degree, this minimum may be too low. Second, become involved in PSRO. Your profession must meet the challenge of PSRO and list itself among other concerned and dedicated professions. Now is the time for your own profession to decide: (1) What is and what is not appropriate health care? (2) What is acceptable quality relative to needs of the patient? Can you measure your profession's services in terms of quality and medical necessity?" (Watters and Hall, 1977, p. 264).

Last, demand the best from yourself. "A true professional is, in sum, an ordinary person called to extraordinary duties by the nature of the activities in which he or she has chosen to engage." (Pellegrino, 1983, p. 175).

If you see yourself as a professional, practice your occupation as a professional and conduct yourself as a professional. Who then can doubt that you are one?

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[1]The process and its effects are ongoing as evidenced by the changes in headings in *The Cumulative Index to Nursing and Allied Health Literature*. With Volume 28:6 (1983), ten subjects ranging from "Professional Competence" to "Professional Practice" are noted. Prior to this issue "Professions" said simply—"See occupations."

[2]There have been several who disagreed. See McKinlay (1973), Daniels (1971), Haug (1973), Saks (1983), Dumont (1970), and Begun (1979).

[3]For the sake of this model, I am assuming that schools are already in existence (Wilensky, p. 146).

[4]For a discussion of what may happen if this recognition does not occur, see Haug and Sussman (1971) and Ehrenreich and Ehrenreich (1975).

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Technical Note: Vertebral Compression Fractures—Treatment with a Composite Thoraco-Lumbar Orthosis

Albert L. Howe, C.P.O.

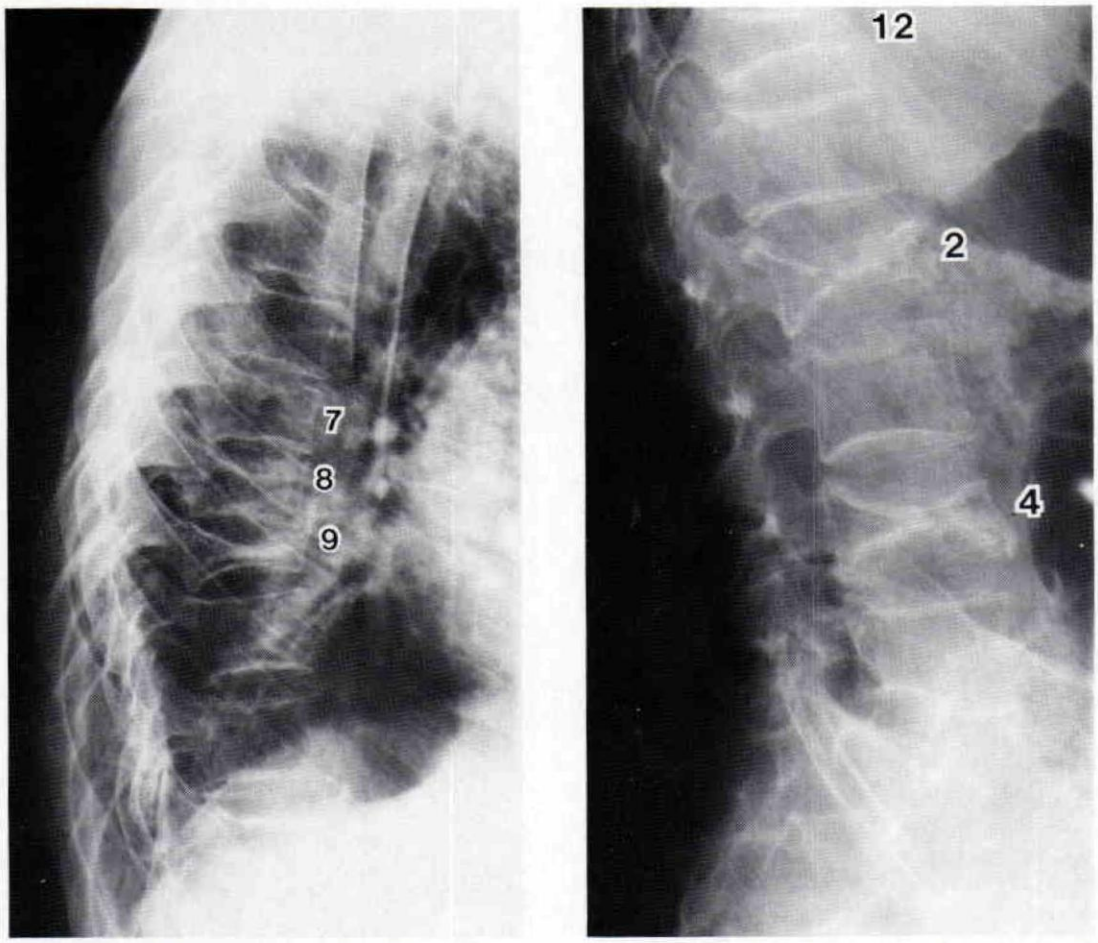
INTRODUCTION

Stable compression fractures of the thoraco-lumbar spine are a problem in long-term pain management. Traumatic compression fractures may remain symptomatic for over a year, while pathologic compression fractures may remain symptomatic for the remainder of the patient's lifespan. External support, either in the form of a cast or an orthosis, remains the mainstay of non-operative treatment. Although total immobilization of the spine is not possible with external devices only, significant relief of axial skeletal pain can be achieved with firm truncal support.

It has been well documented that mechanical load on the spine is lessened when intra-abdominal pressure is increased (Figure 1). It is by this mechanism that abdominal binders provide spinal support and hence relieve back pain. It has been further shown that an abdominal support combined with a rigid spinal support relieves back pain better than an abdominal support alone (Figure 2). Currently available orthoses which combine both abdominal and rigid spinal supports include the Dorsal-Lumbo-Sacral orthosis and the thoraco-lumbar corset. These orthoses are often poorly accepted by the patient because they are difficult to don, uncomfortable when the patient is in any but the erect position, and are bulky under clothing. The Veteran's Administration Medical Center in Nashville would like to report their experience with an orthosis which combines the comfort of an abdominal binder, with the firm support of a thoraco-lumbar corset.

MEASUREMENT AND FABRICATION

The composite orthosis is made in the following manner: A circumference measurement is taken of the hips, waist, and just below the nipple line on the chest. The hip measurement usually dictates the size of the thoraco-lumbar corset selected. Draw laces are removed and the front panels are cut off approximately one inch anterior to the back panel eyelets. An elastic abdominal binder is then cut and sewn to the posterior thoraco-lumbar corset panels just anterior to the eyelets. The total circumference of the finished orthosis should be about two inches more than the patient actually measures. Two heavy steel stays are added, one on each side of the spinal column. Slide buckles and hooks are

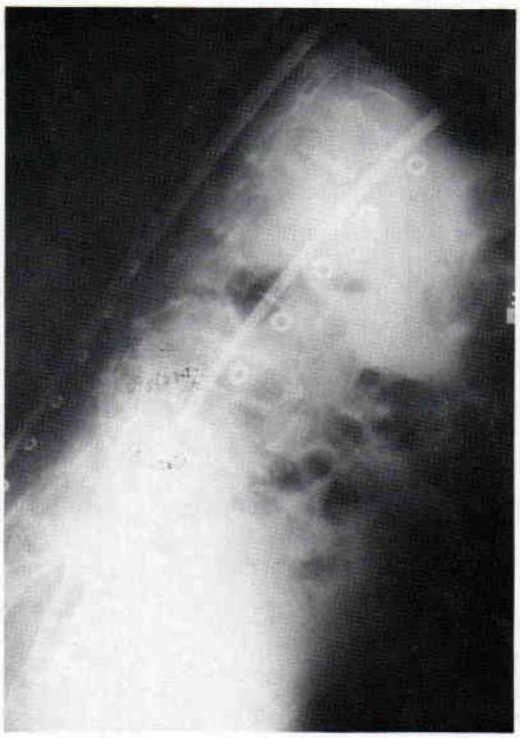


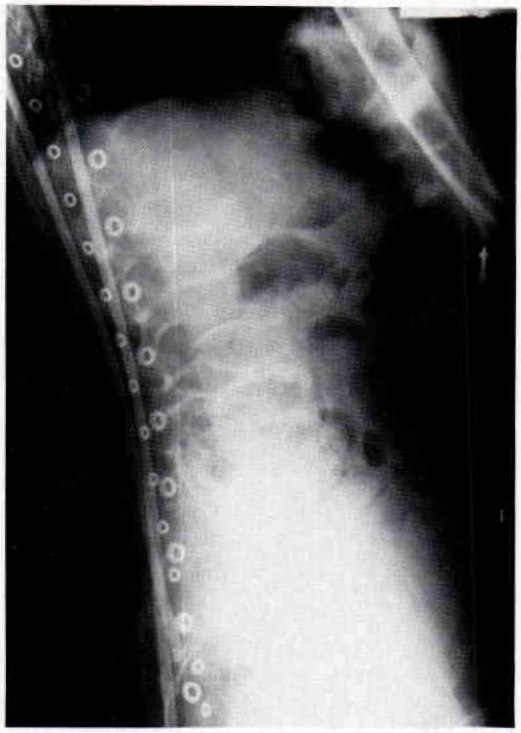
Figures 1A & 1B. Lateral thoracic (A)and lumbar (B) x-rays of a patient with multiple compression fractures due to osteomalacia. Bracing with the combined orthosis provides him with good pain relief.

added to the shoulder straps so they will fasten in front of the chest rather than in the less convenient posterior position.

During a period of six months, the VA Medical Center in Nashville applied eleven thoraco-lumbar corsets combined with elastic abdominal binders to treat vertebral compression fractures. Seven of these fractures were traumatic and four were pathologic (two osteoporosis, one amyloidosis and one metastatic tumor).

Even patients with compression fractures as numerous and as severe as those shown in Figure 1 obtained relief with this orthotic variant. All patients have remained satisfied with the pain relief the orthosis affords. Five patients who had been previously treated with other orthoses (i.e., lumbo-sacral corset, Dorso-lumbar orthosis, and an elastic abdominal binder) found the composite orthosis more effective than their previous support in relieving their back pain. It was also considered comfortable even when they were reclining, easy to don, and cosmetically acceptable. One patient who could not tolerate a Taylor style spinal orthosis, because it rubbed his iliac crest graft donor site, found relief with the soft elastic support of the combined orthosis.





Figures 2 and 3. Same patient as shown in Figures 1A & 1B. Lateral flexion-extension x-rays show good immobilization in the combined corset.

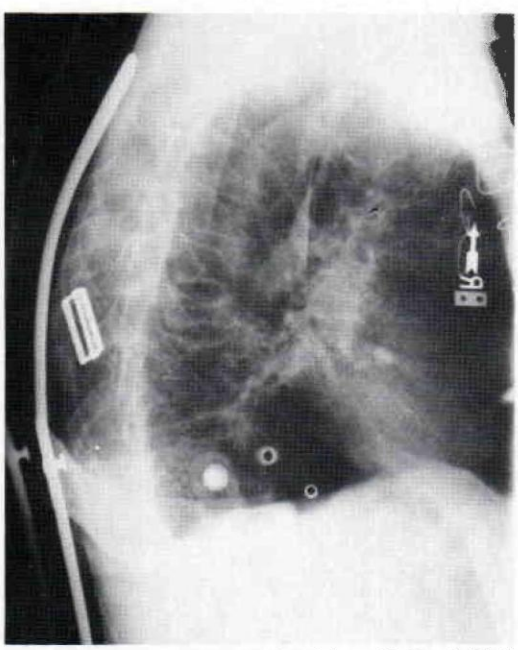


Figure 4. Support obtained with well-fitted High Taylor Spinal Orthosis is shown.

CONCLUSION

The thoraco-lumbar corset with an elastic apron provides maximum abdominal and spinal support without sacrificing comfort.

The composite orthosis provides as much support as does a Taylor style spinal orthosis (Figure 4). Good immobilization is achieved both in flexion and extension (Figures 2 & 3). Because the garment is comfortable, orthotic treatment of thoraco-lumbar compression fractures is not thwarted by patient non-compliance. The Nashville VA Medical Center recommends the use of this orthosis on patients with spinal pain secondary to thoraco-lumbar compression fractures, when operative intervention is not indicated.

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Dr. Cynthia A. Schneider, M.D., Orthopedic Resident, Vanderbilt University Hospital, Nashville, Tennessee.

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Orthotics and Prosthetics, Volume 38, No. 4, pgs. 79–85.

Technical Note: A Case Study— Special Choparts Prosthesis with Custom Molded Foot

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

INTRODUCTION

The patient for whom this prosthesis was made had a severe problem that needed to be contended with: fixed equino-varus condition that was present in the amputated side (plantarflexion and inversion). This is a condition normally present in this level of amputation due to loss of the dorsiflexors and both longitudinal and transverse arches. This allows the calcaneus to collapse because the plantarflexors are still intact and unopposed. This problem was more pronounced and more rigidly fixed in this patient than in most.

The patient was hemiparetic with accentuated proprioceptive deficiency on the contralateral limb, making the amputated limb the better of the two. Age is also a factor to be considered in overall prosthetic treatment.

The prosthesis needs to be lightweight, as thin as possible, contoured to offer the greatest amount of stability possible in the shoe, accommodate the equino-varus condition in the residual foot, and be as cosmetic as possible. It was determined that the best way to meet all these criteria was to use special materials and to custom fabricate a foot to fit the shoe as intimately as possible.

Fabrication of the custom foot was fairly complex. An impression of the patient's residual limb was taken, utilizing the anterior-posterior splint technique and a foot board under partial weight bearing. The positive model was made, and a normal cast modification and trim lines for a posterior opening, patellar tendon height chopart prosthesis, were utilized.

A PPT® foam pad was prepared to cover the anterior of the residual foot. To allow sock room in the prosthesis, an orlon postoperative sock was put over the plaster positive before the inner PVA bag was applied.

IPOS-Ipocast System® using carbonacryl resin and carbon fiber and fiberglass stockinette (Figure 1) is the material used to add strength without weight or thickness in the socket. A layup of one layer of dacron felt, two layers of the Ipocarbon® stockinette, and four layers of nylglass® stockinette was used. The Ipocarbon® stockinette is coarse textured and black, so the socket was roughed up for good bonding, and two

Figure 1. I.P.O.S. Carbonacryl® resin and carbon fiber and fiberglass stockinette.

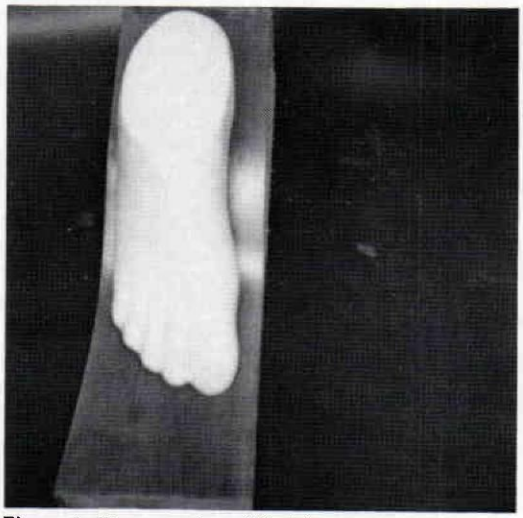

Figure 3. Dorsum of modified foot.

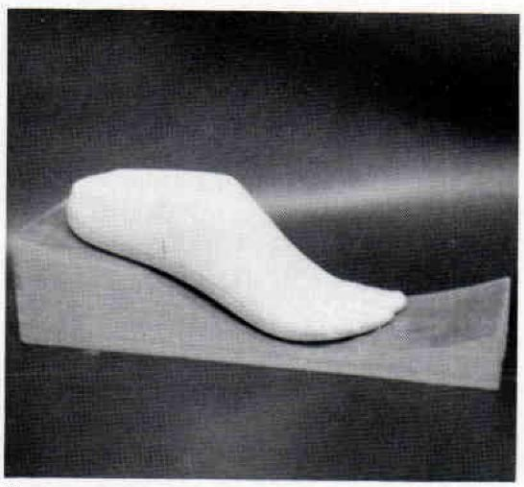

Figure 5. Lateral modified foot.

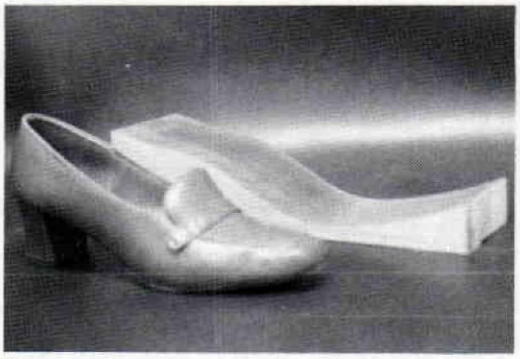

Figure 2. Shoe with custom foot plate.

Figure 4. Plantar surface of modified foot.

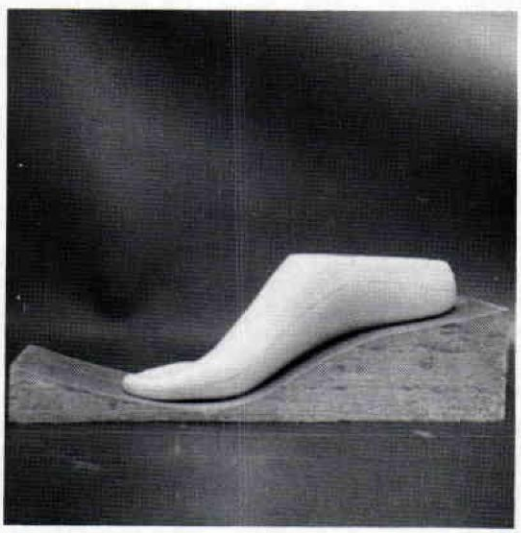

Figure 6. Medial modified foot.

layers of nylglass® were laminated over the socket to give it a smooth finish and cover the dark color.

Since intimate fit in the patient's shoe was a major concern, it was important to make a foot plate that matched the shoe sole contour (Figure 2) of the shoe provided. A partial weight bearing alginate impression of a similar sized-foot was made on the custom foot plate. This impression was then filled and modified by smoothing, filling in the plantar toe spaces and between the toes (Figures 3 & 4), and modifying toe lengths and widths for a better fit in the toe area of the shoe. The modified foot was then allowed to dry and coated with a plastic parting lacquer before making a three-piece mold. The peak width was drawn around the entire foot to locate the trim lines for the mold (Figures 5 & 6).

The bottom portion of the mold (Figures 7 & 8) was made first by using a sand casting technique. The modified foot was placed on a platform upside down and sand contoured to the lines drawn around

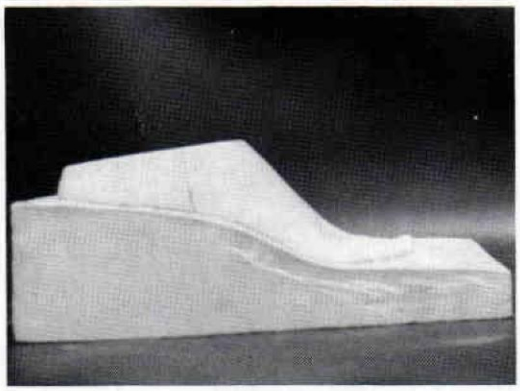

Figure 7. Lateral foot in mold base.

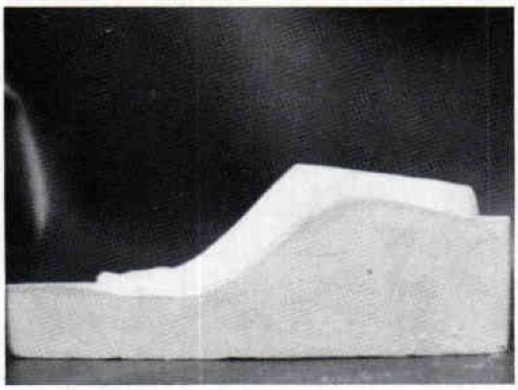

Figure 8. Medial foot in mold base.

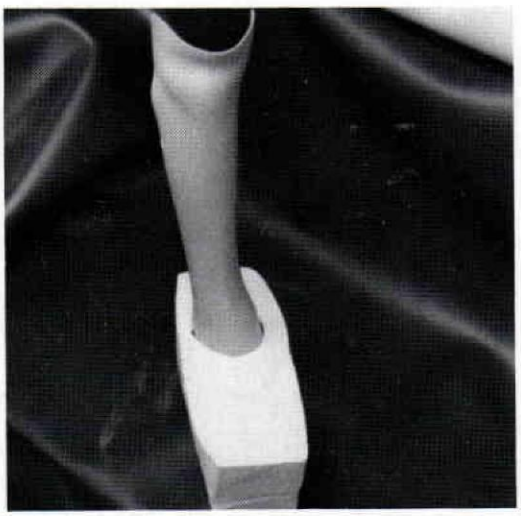

Figure 9. Adduction alignment of socket in mold.

Figure 10. Flexion alignment of socket in mold.

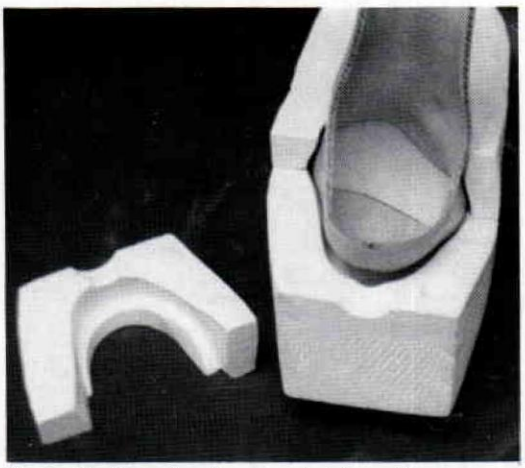

Figure 11. Posterior view—socket in mold.

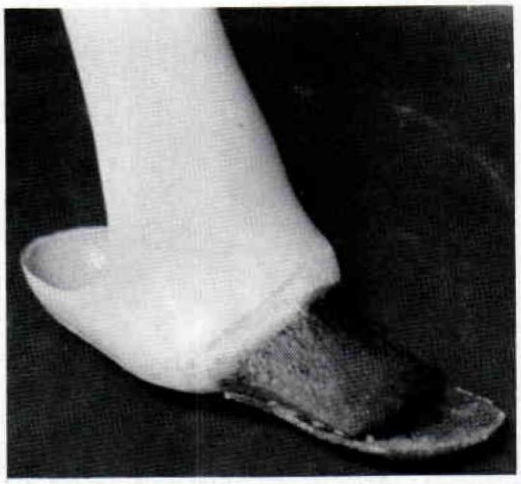

Figure 12. Socket with keel and belting attached.

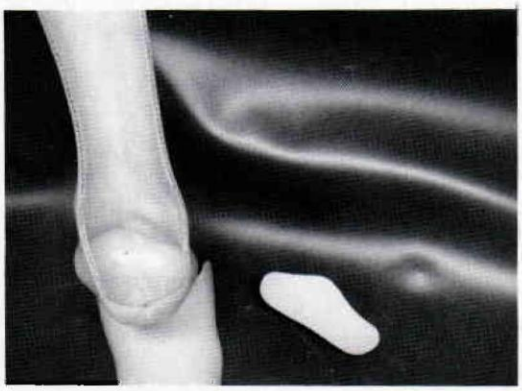

Figure 13. Posterior socket showing screws and P.P.T. pad.

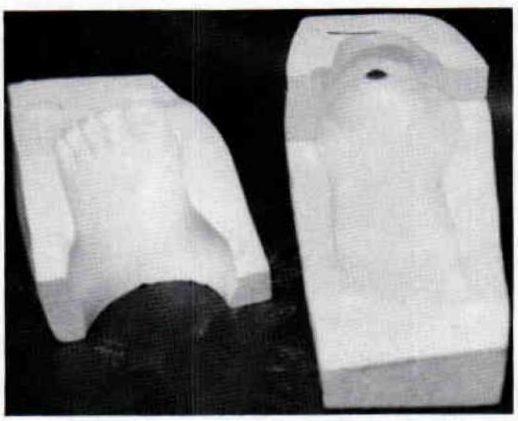

Figure 14. Partially assembled mold.

the foot. Plaster was then mixed thinly and carefully poured over this arrangement, avoiding displacement of sand. Pouring the plaster in this manner allows all bubbles to rise away from the modified foot. When set, this section was trimmed to the peak lines and trued up. Key marks were carved into the base of the mold for locating the other mold sections. A water-soluble wax of the type used by pottery makers was used as a mold release agent. The anterior dorsal portion of the mold was done next, followed by the posterior section.

To achieve full functional and cosmetic integrity, the three-piece mold was carved to accept the socket in correct adduction and flexion alignment for the heel height of the shoe provided (Figures 9 & 10). Just

Figure 15. Mold partly assembled over modified foot, showing areas removed to fit socket.

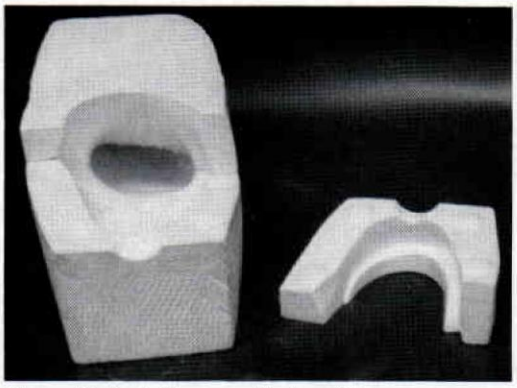

Figure 16. Partially assembled mold.

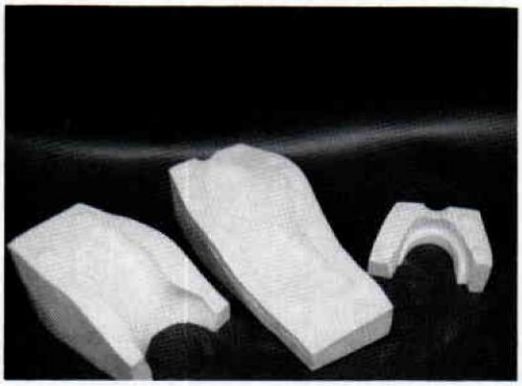

Figure 17. Dissembled three piece mold.

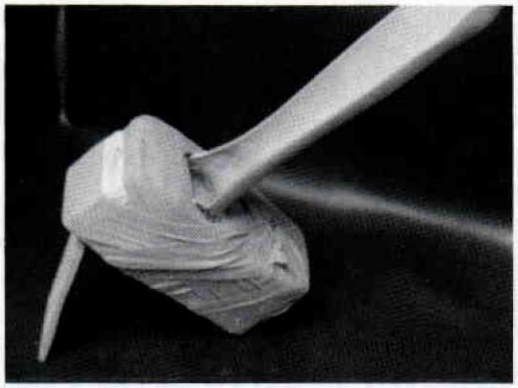

Figure 18. Socket and mold in position for pouring Calthane®.

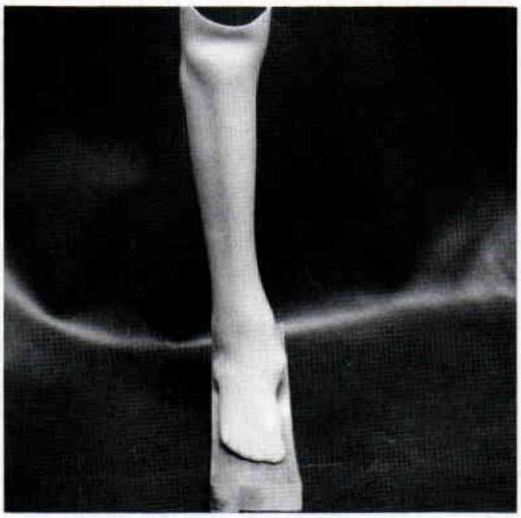

Figure 19. Anterior view of prosthesis.

enough plaster was removed around the sides of the socket to allow the foot to flow into the socket (Figure 11). In order to provide functional stability to the prosthetic foot, a wooden keel was attached to the anterior socket (Figure 12). It was affixed with epoxy and screws extending through from the inside of the socket (Figure 13).

A piece of belting was attached to the plantar surface of the keel extending into the toe area of the foot (Figure 12). Calthane® foam was used to mold the foot directly into the socket. The Calthane® was poured into the mold through a sprue provided in the heel area of the mold (Figures 14, 15, 16, & 17) at an angle to allow any bubbles to rise into areas of least importance.

When completed, this prosthesis offered complete contact with the sole of the shoe over its full length, providing a very stable base of support. The foot is integrated into the overall lines of the socket and doesn't require additional covering to be cosmetically acceptable (Figures 19, 20, 21, 22). The appearance and volume of the foot is closer to normal in the toe area because it was modified from a real foot instead of a prosthetic foot.

Total weight of the prosthesis including all straps (Figures 23, 24, 25) is 2¼ pounds. Thickness of lamination was kept to a minimum even around the cutout area (Figures 11, 13, 26) because of the extra strength of the carbon acrylic materials in the socket. Taking into consideration the special problems listed in the beginning of the article, the extra time and special mate-

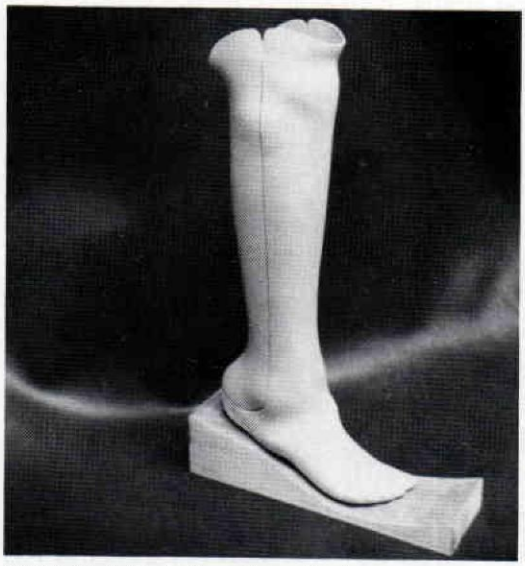

Figure 20. Lateral view of prosthesis.

Figure 22. Postero-lateral view of prosthesis.

Figure 21. Medial view of prosthesis.

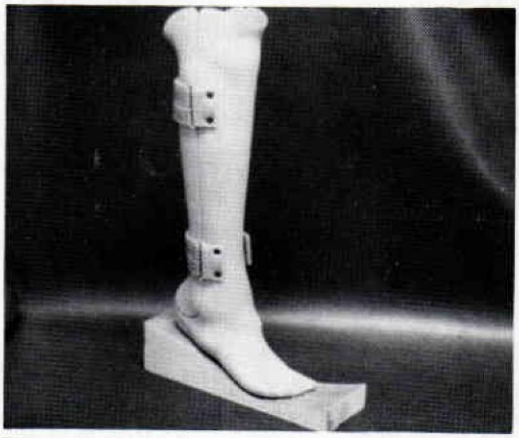

Figure 23. Antero-lateral view of prosthesis complete with straps.

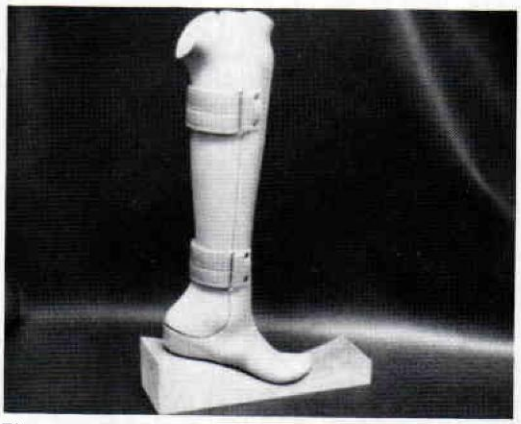

Figure 24. Postero-lateral view of prosthesis complete with straps.

Figure 25. Medial view of prosthesis complete with straps.

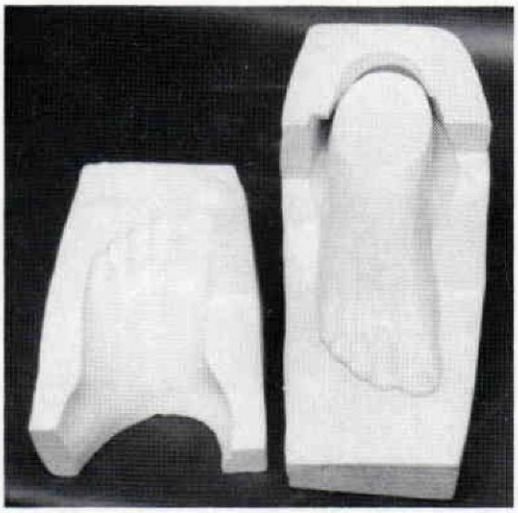

Figure 27. Partially assembled mold with modified foot in place.

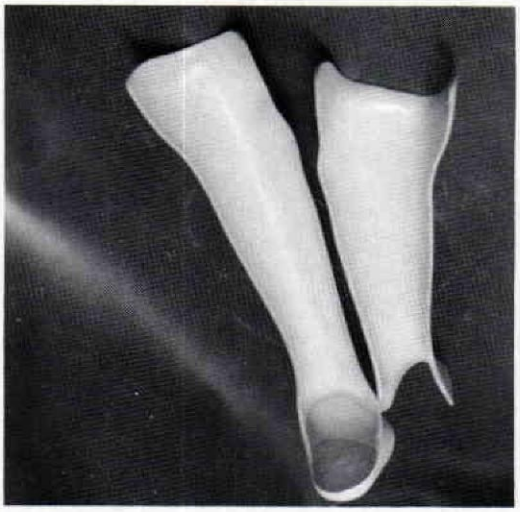

Figure 26. Socket halves.

rials' expense was warranted for this patient (Figures 14 & 27 show relationships between the modified foot and mold sections).

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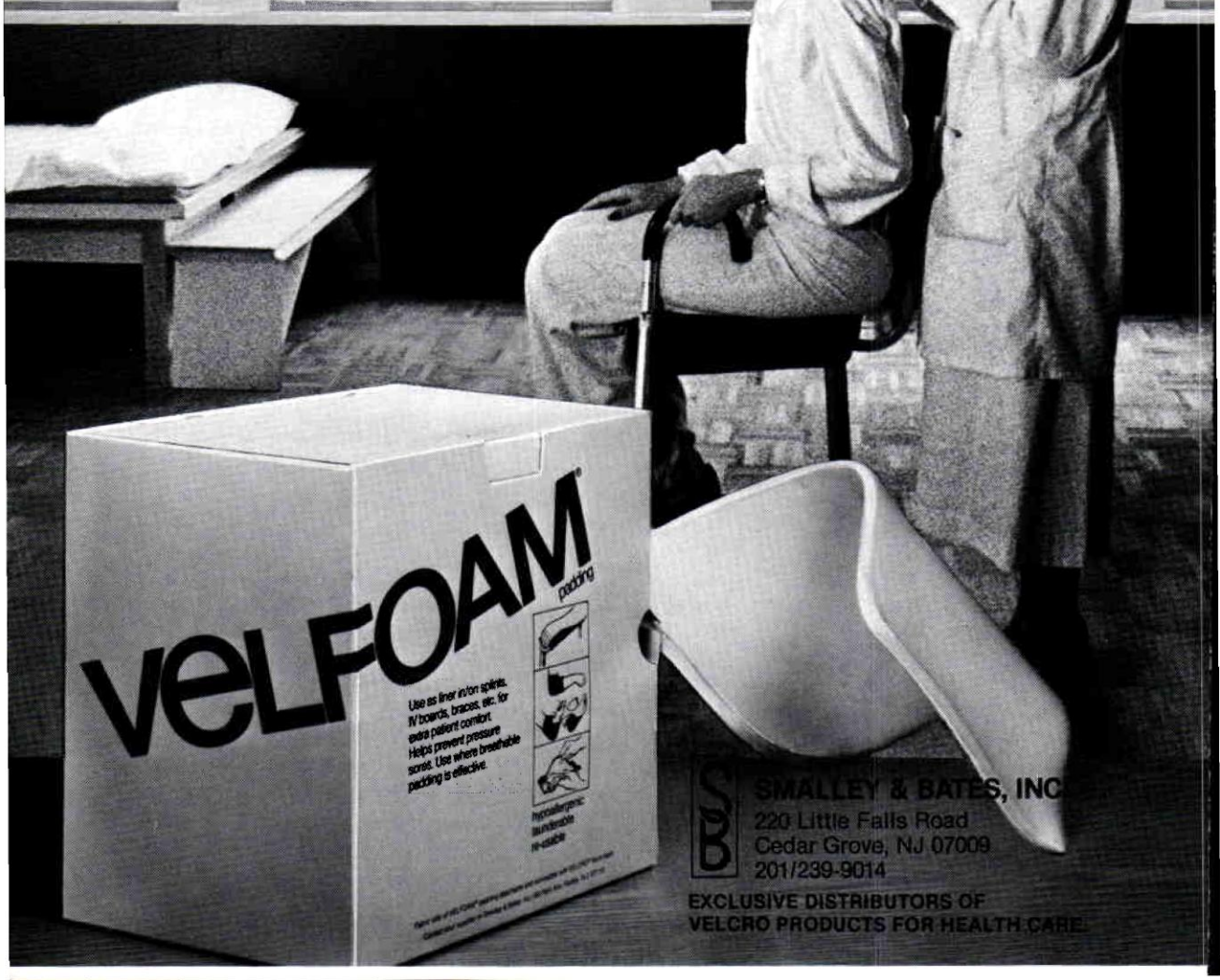

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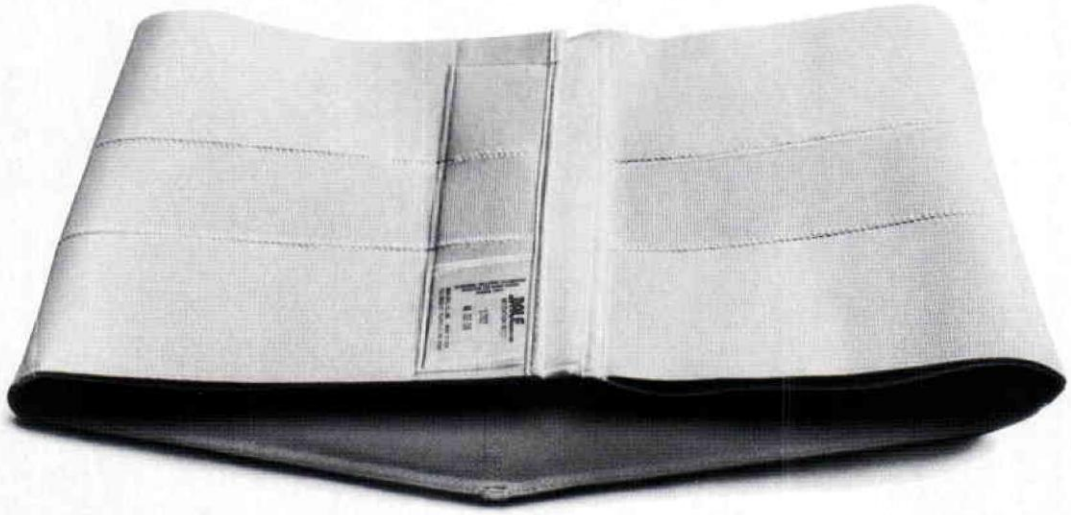

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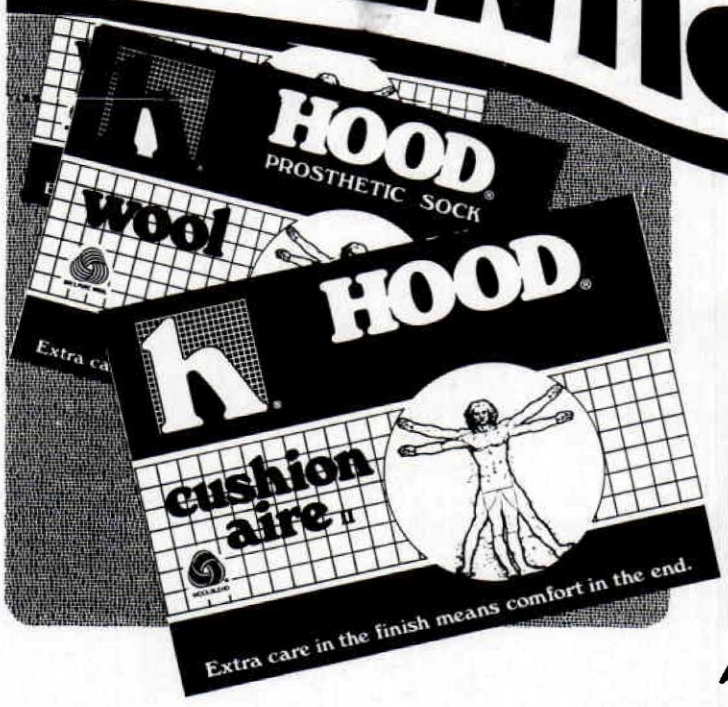

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REVIEWS

Fabrication Procedures For The ISNY Above Knee Flexible Socket, Prosthetic Orthotic Education Department in collaboration with Ossur hf, Iceland, and Een-Holmgren AB, Sweden, Orthotics and Prosthetics, New York University Post Graduate Medical School, 317 E. 34th Street, New York, N.Y. 10016. 18 pages, 1984, $7.50.

As is pointed out early in the introduction to this manual, the information contained within is not meant to serve as a "how-to-do-it" manual, but is meant to serve as an instructional aid in the courses taught on this above knee prosthetic alternative. The authors review the fabrication technique of developing the socket and support frame from the modified plaster positive model. There is no bias with regards to cast modification, as the manual concerns itself only with a fabrication technique.

The manual refers to many items and procedures throughout the text without adequately illustrating or providing photographs of the item or step in the process. As an instructional aid, the manual serves quite nicely, but without having taken the course, or having familiarity with the technique, the person using this manual might have to go through some trial and error before arriving at a satisfactory product. Inclusion of more photographs and illustrations would make this a better reference source, and easier to follow.

Lawrence R. Lange, C.P.O.

Wheelchair Posture and Pressure Sores, Dennis Zacharkow, RPT, Charles C. Thomas, 2600 South First Street, Springfield, Illinois 62717. 99 pages, bibliography and index, $16.75.

In this volume, the author, from the Mayo Clinic, is concerned with modifications to the basic wheelchair to improve patients' posture and hopefully prevent pressure sores. The author proceeds by first describing some basic characteristics of sitting posture and factors involved in chair design that contribute to it. He then discusses what he considers to be problems of wheelchair design and essential modifications to address them. The rest of the book is devoted to such specific topics as pelvic obliquity, cushion selection, acute care considerations, and the particular problems of various patient populations.

This book is well-researched with an extensive bibliography, and the author's presentation is quite clear. It is perhaps best considered as an intermediate text. On the one hand it presumes the reader is familiar with the factors involved with properly selecting a wheelchair for a particular individual; on the other hand it does not discuss the fabrication of customized seat inserts for the most severely involved.

Charles H. Pritham, C.P.O.

Traction and Orthopedic Appliances, 2nd edition, John D.M. Stewart and Jeffery P. Hallett, Churchill Livingstone, Inc., 1560 Broadway, New York, N.Y. 10036, November 1983. 316 pages, index and two appendices, $24.00.

The authors describe this book as being intended for the guidance of junior residents and other staff members of an orthopedic or trauma unit. It covers traction methods and equipment, assistive devices, tourniquets and orthoses. It includes descriptions of components and directions for how to use and apply specific devices. It is well thought out and should prove useful as a ready reference and quick guide.

It must be borne in mind, however, that the authors are British and discussing matters as they pertain to the situation in the United Kingdom. The unwary American reader unfamiliar with the topics discussed may well find himself lulled into a false sense of security by the use of a common language.

Charles H. Pritham, C.P.O.

Rehabilitation Management of Amputees, edited by Sikhar Nath Banerjee, Williams and Wilkins, 428 E. Preston Street, Baltimore, Maryland 21202. 1982, 456 pages, index, and bibliography.

This book is an addition to the Rehabilitation Medicine Library which also includes *Orthotics Etc.* It is multidisciplinary in scope and boasts a broad range of distinguished and experienced contributors. It is strongest in its consideration of the problems of adult amputees who lose a limb as a result of trauma or disease. The material on child amputees is rather brief. A particular member of a prosthetic clinic team will undoubtedly consider the material devoted to his area of expertise sketchy. The intent of the book, however, is to touch upon the full range of activities of a clinic in at least an introductory fashion, and thus to serve as a medium for orientation and communication among the members of the clinic team.

Several extensive chapters are devoted to physical and occupational therapy of lower and upper extremity amputees. In this regard the book redresses a common deficiency in books of this nature dealing with the subject. The chapter on modified tools and devices to be fit in a wrist unit of an upper extremity prosthesis is especially interesting. Most prosthetists, however, will object to the emphasis placed on therapists "checking out" prostheses and the inclusion of even abbreviated checkout lists. James Foort, as usual, provides an interesting and provocative overview of lower limb prosthetic components.

Charles H. Pritham, C.P.O.

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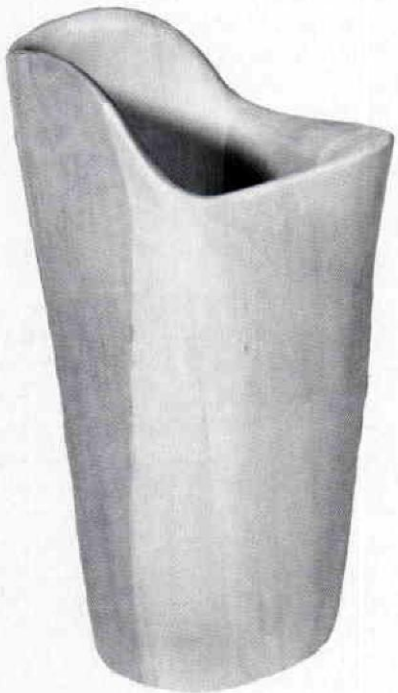

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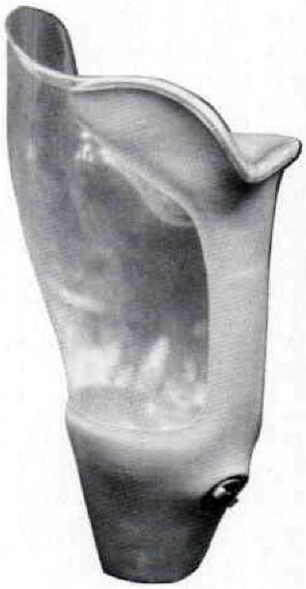

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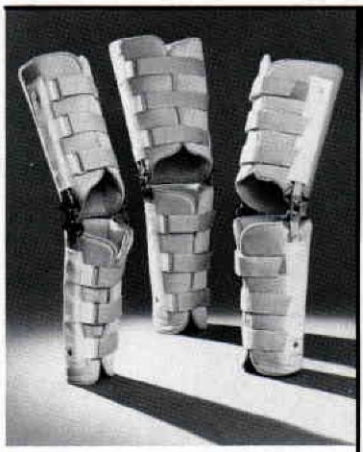
PEL NEWS

Vol. 1, No. 4

PEL SUPPLY CO. Cleveland, Ohio 44135 Prosthetic and Orthotic Parts and Supplies



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Proteor Alignment Device

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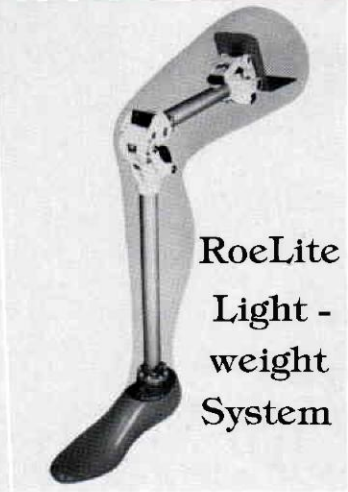

RoeLite Light-weight System

HOSMER has just introduced a modular system that is specifically designed for both geriatric and youthful amputees who require a lightweight prosthesis. This lower extremity endoskeletal system is 50% less weight than other modular systems, yet is strong and durable. RoeLite is based on a strong structural tube with a proven 4-bar linkage knee. A friction alignment device that is fitted either at the knee, socket attachment, or at the ankle, allows fast and simple adjustments of the alignment during trial fitting. A complete AK and BK system is available.

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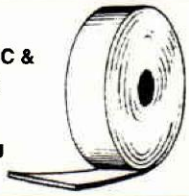

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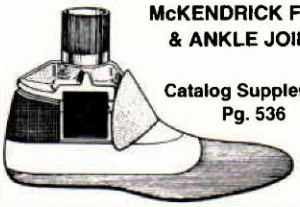

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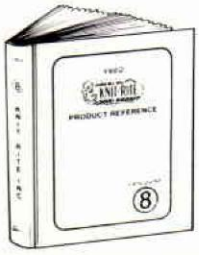

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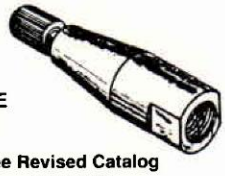

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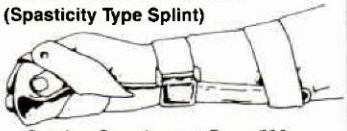

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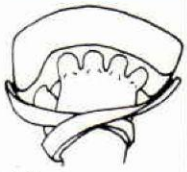

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