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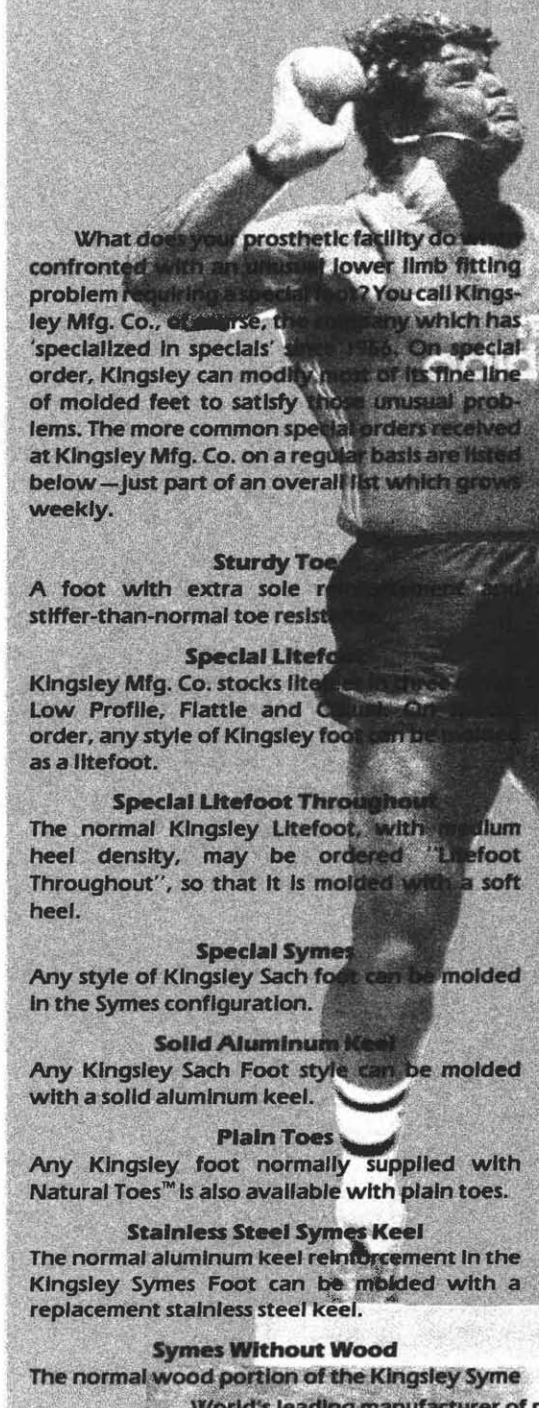

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From the Editor:

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Letters to the Editor

Dear Editor,

I would like to comment on a reference made to the "VANU" hand on p. 70 of John W. Michael's article on "Upper Limb Powered Components and Controls: Current Concepts," *Clinical Prosthetics and Orthotics,* 10:2, pp. 66–77.

The origin of the latter half of the acronym is implied in the NU (Northwestern University), but the author did not clarify the significance of the VA part. This refers to Veterans Administration. The VANU hand, i.e., The Veterans Administration Prosthetic Center-Northwestern University hand, was developed through the cooperation of engineers at both institutions. When our center was designated the VAPC, we had experience with the hand and a hook which was developed by Carl Mason, VAPC Chief engineer, who also developed an electric elbow in 1968. The components illustrated in Figure 5 on page 71 are solely VAPC developed components, developed in fact, by Carl Mason, M.S., B.E.

The drive mechanism for the Liberty Mutual elbow was, I am informed by Mr. Mason, developed and patented by him at the VAPC and given to Liberty Mutual. Liberty Mutual developed the electronics.

I do believe that it is a very important stimulus to research to give credit where credit is due.

Sincerely,
Gustav Rubin, M.D.
Director, S.T.A.M.P., N.Y.
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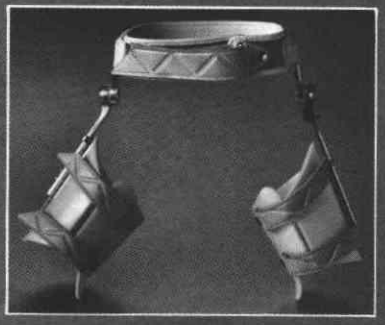

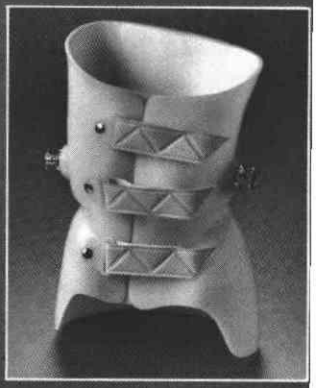

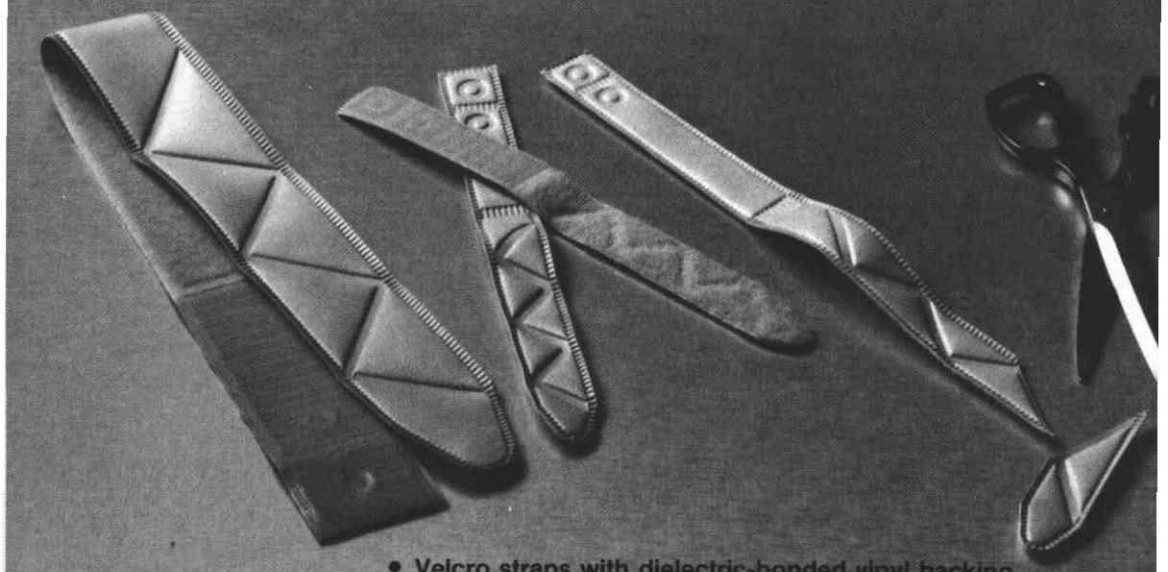

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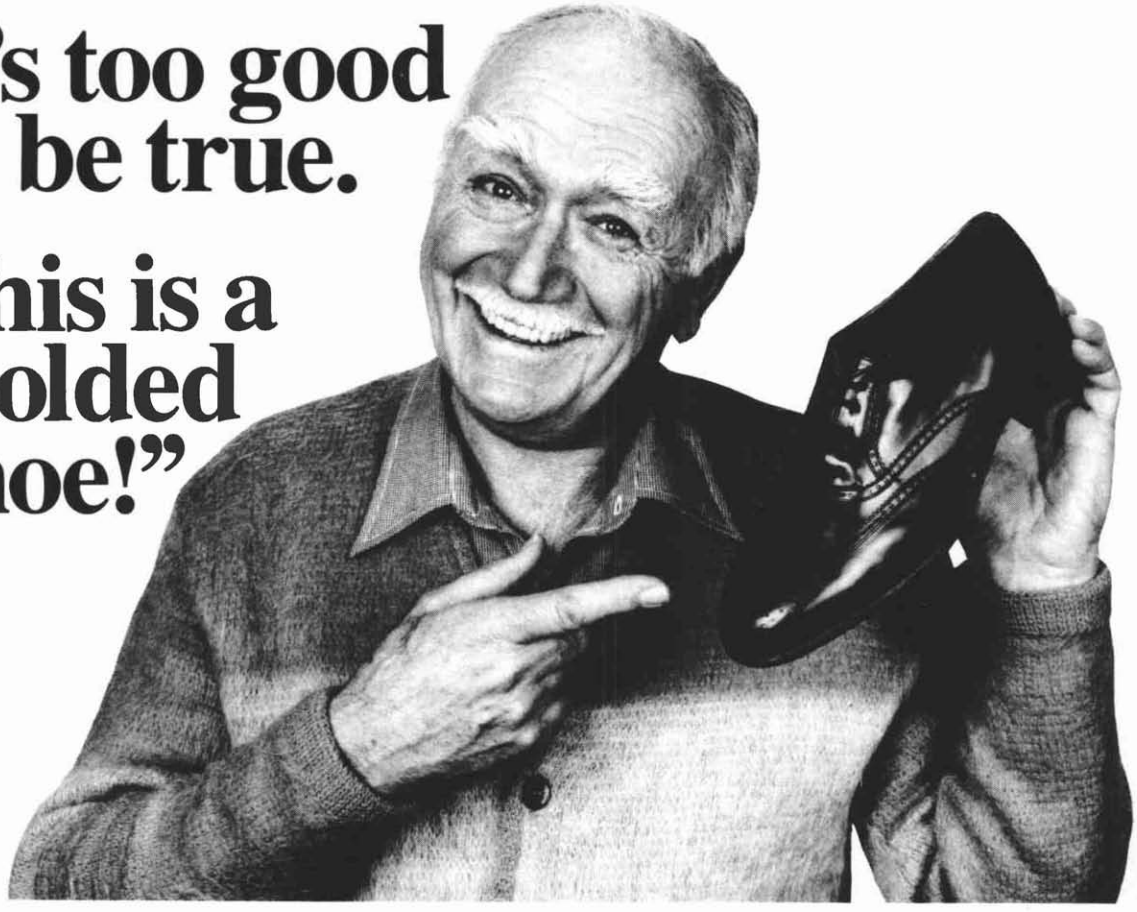

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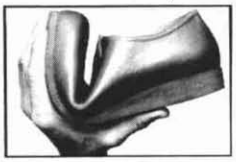

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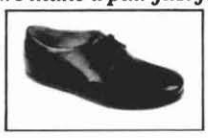

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Clinical Prosthetics and Orthotics, Vol. 10, No. 3, pp. 101–104

Experience with the Use of Alginate in Transparent Diagnostic Below-Knee Sockets

by C. Michael Schuch, C.P.O.
Tony Lucy

Transparent test sockets have been available in various materials for more than ten years,[5,7] but their use has not been as widespread or as routine as one would expect. Only recently has the emergence of new materials and new evaluation techniques, as well as third-party awareness and reimbursement, made the use of test or check sockets more appealing.

The objective of this article is to present a refined technique for using test sockets and aliginate to guarantee that total contact exists between socket and stump. This technique has been developed as a standard procedure for each and every below-knee amputee fitted with a prosthesis at the University of Virginia. We consider it to be the single most important and recent technique for enhancing the fit of prostheses for our below-knee amputees.

Robert Hayes, C.P., described his alginate technique first in 1975 in *Orthotics and Prosthetics*[3] and more recently in an updated version in *Clinical Prosthetics and Orthotics*.[4] In 1984, Timothy Staats, C.P.,[6] described a technique for introducing alginate into the negative cast mold, which is used as a test socket after molding. No doubt there are other prosthetists using similar or variations of these techniques. However, the important point is not who or how many are using the technique, but how many still do not use this technique for refining below-knee socket fit.

Equally important is the fact that any system of diagnostic socket evaluation should be more than just algination. The routine use of multiple, transparent, skin-fit sockets, evaluated both statically and dynamically as a progressive system, will provide assurance of optimum socket fit. It seems rather obvious that if amputees can ambulate successfully with a skin-fit, hard socket, then use of a definitive socket with a minimal number of prosthetic socks, with or without a soft liner, will be that much more comfortable and successful.

A 12″ × 12″ sheet of ⅜″ thick Durr-Plex[1] or Thermocheck[2] is used for the average below-knee socket. This material is transparent, strong and rigid, is easily vacuum formed (Figure 1) using the frame and platen technique, and can be modified later by spot heating. Of course, any other transparent material that can be vacuum formed is equally suitable.

Lubrication of the stump with petroleum jelly, or equivalent lubricant, is necessary for donning the check socket when it is used without a prosthetic sock. The patient then stands bearing weight in the test socket, which rests on a platform or stand that can be adjusted in height so that weight-bearing is the same on each side and the pelvis is level (Figure 2). While the patient continues to stand, the stump in the transparent socket is evaluated by identifying changes in skin color. Blanching, or even whiteness, indicates that the pressure levels are

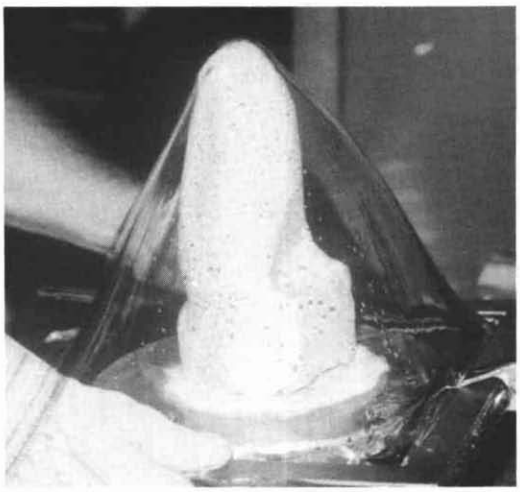

Figure 1. A transparent socket is vacuum-formed over a plaster cast that has been modified in the usual manner.

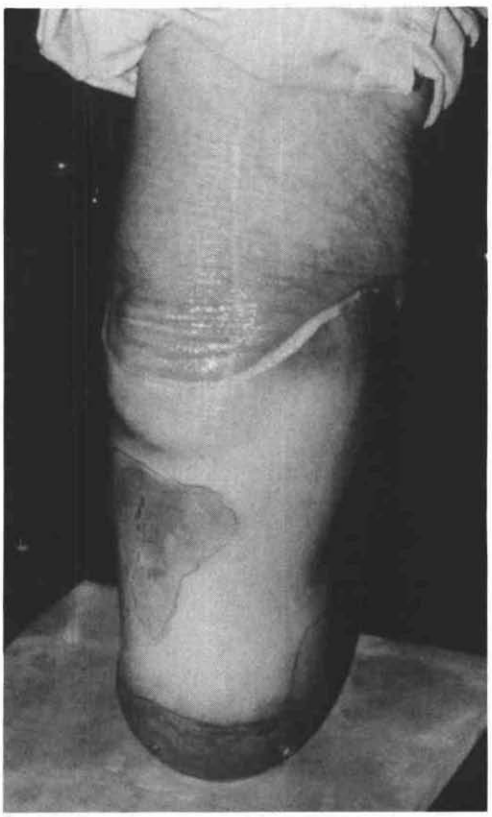

Figure 2. The patient bears one half of his weight in the transparent socket for evaluation of fit by the prosthetist observing the color of the skin.

acceptable. Excessive shiny blanching indicates increased pressure, which is perhaps excessive. Redness indicates voids or lack of total contact. If a patient complains of too much pressure when an area is surrounded by red, then alginate should provide relief by establishing total contact. If the patient complains of too much pressure when an area is surrounded by white and blanching, relief is provided by spot heating and stretching the socket in the area of complaint. A thin flat probe, like a corset stay, is often useful for specifically locating pressure areas for purging small pockets of trapped air, or gauging skin tensions within the socket (Figure 3).

A reliable technique for the evaluation and modification of the fit of below-knee diagnostic test sockets is available using the dental material, alginate. The viscosity and other properties of alginate makes it suitable for: (1) filling any voids between the socket and stump to insure total contact, or total surface bearing; (2) providing proper compression of soft tissues for better distribution of weight-bearing pressures.

A mixture of 20 grams of powdered alginate† and 6 ounces of water provides the proper ratio and amount for most below-knee patients. The water should be lukewarm and dyed with food coloring to provide a definite contrast in color to the skin and socket.

The socket is sanded lightly on the inside to promote adherence of the alginate, and escape holes are drilled medially and laterally approximately one inch proximal to the distal end. Small pin holes are also drilled over void areas to allow air to escape as the alginate fills. The water and powder are mixed with an electric drill and paint stirrer, and then poured into the test socket and slushed around the walls to completely coat the inside of the socket. The patient then enters the socket and stands with equal weight-bearing bilaterally. The alginate fills void areas, establishing total contact. The excess is evacuated, and gelling occurs in one to three minutes (Figures 4 and 5). The patient is

† Type II, Normal Set Alginate, Coe Laboratories, Inc. Chicago, Illinois 60658

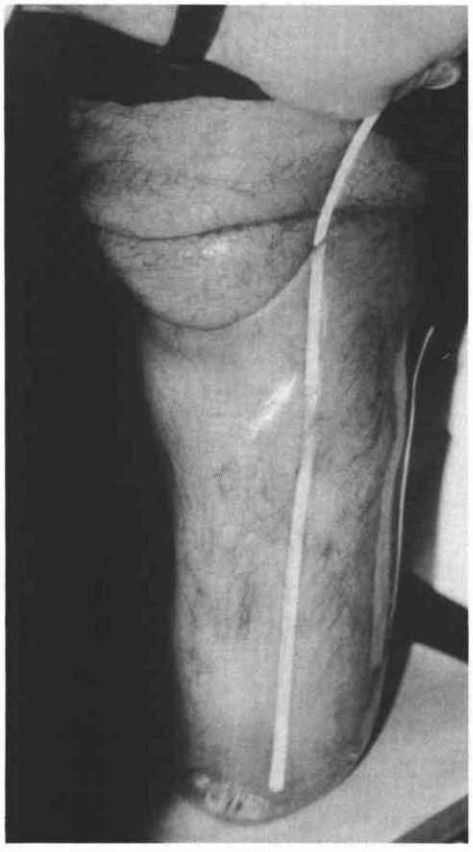

Figure 3. Evaluation of fit by observation can be augmented by use of a flat slender probe.

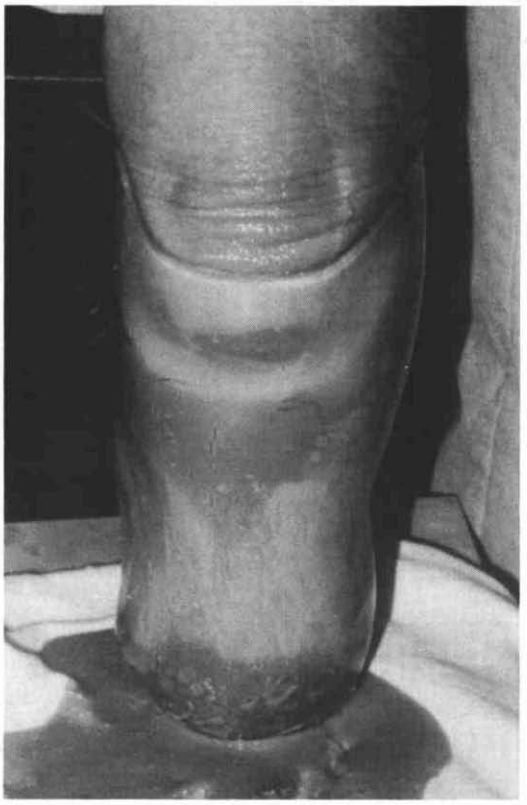

Figure 4. Alginate fills void areas while patient bears one half of his weight into the socket. Excess alginate flows through small relief holes drilled for this purpose.

then seated and the socket is carefully removed, after breaking the suction seal. The alginate will adhere to the inside of the socket.

When the socket is filled with plaster, a positive model that has been redefined by the alginate under weight-bearing conditions is obtained. When the plaster has set, the test socket is removed by cutting it off. The alginate will adhere to the cured plaster model (Figure 6).

The new positive model is now evaluated. Information such as location and thickness of the alginate fill is useful feedback concerning the original casting and model modification. At this point the alginate is removed and the new positive model is smoothed using sand screen. The model is now ready either for use as a follow-up transparent test socket or for fabricating a definitive socket.

If one chooses to proceed with the definitive socket, prosthetic socks are added over the model before the liner or socket is fabricated to allow for the thickness of socks desired in the final fit.

RESULTS

Records were kept and studied for a series of 40 below-knee amputees fitted using the alginate test socket system. The data recorded were: (1) location of areas filled by alginate (i.e. voids in the prealginated socket); (2) thickness of fill with respect to location; and (3) results of dynamic and final fittings (i.e. adjustments required to improve socket fit at post-algination fitting sessions).

Areas filled with alginate were very consistent and included the posterior distal soft tissue area, the tibial tubercle, the lateral tibial flare,

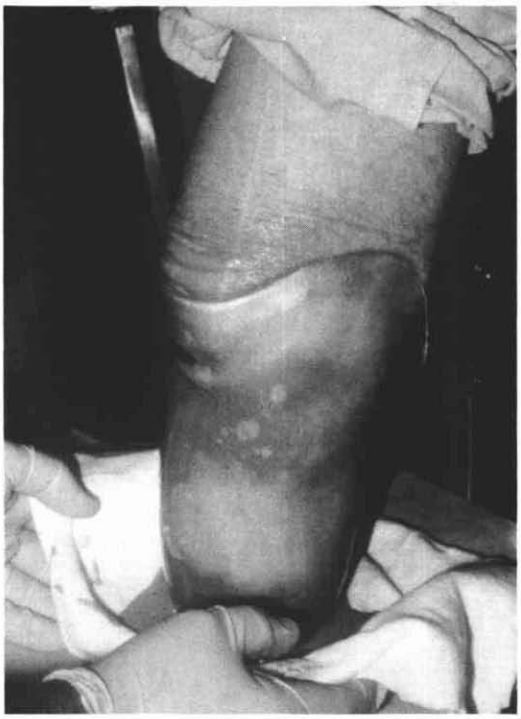

Figure 5. Alginate solution cures between one and three minutes.

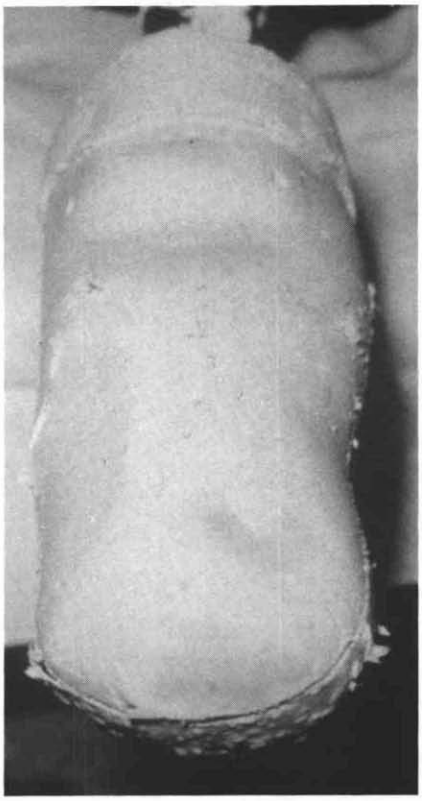

Figure 6. Alginate is removed from new positive model before smoothing and vacuum-forming definitive socket or a new check socket.

and the anterior distal tibia. As the series progressed, the model modification technique changed based on this previous experience. As a result, the thickness of the alginate fillers gradually decreased, as did the plaster build-up over bony prominences on the original model. None of the 40 subjects required socket adjustments to improve comfort or fit at the time of dynamic alignment, delivery alignment, or delivery of the prosthesis.

We have been involved, either directly or indirectly, with fitting more than 150 patients in this manner. The use of alginate with multiple transparent test sockets is a valuable tool in patient management and helps provide better below-knee sockets through improved weight-bearing pressure distribution.

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AUTHOR

C. Michael Schuch, C.P.O., and Tony Lucy are with the Department of Orthopedics and Rehabilitation at the University of Virginia.

Clinical Prosthetics and Orthotics, Vol. 10, No. 3, pp. 105–110

The Use of Surlyn® and Polypropylene in Flexible Brim Socket Designs for Below-knee Prostheses

by C. Michael Schuch, C.P.O.
A. Bennett Wilson, Jr.

The need for improved prosthetic socket designs to increase amputee comfort and function has long been recognized by prosthetists and other health care professionals involved in amputee rehabilitation. Reduction of the hardness and stiffness of wood and plastic laminate sockets has been addressed with various soft liners or inserts in an attempt to improve comfort and function. The subject is well covered in literature from Radcliffe's and Foort's initial description of leather and Kemblo® liners in 1961,[5] through Leon Bennett's work with gel liners in 1974,[1] to Tim Staats' description of multi-durometer liners in 1984.[6] Liners have no doubt been useful in below-knee prosthetics, but the proponents of soft liners seem to have overlooked the potentials offered by flexible brims.

At least two engineers active in prosthetics research have for some time raised questions concerning socket brim stiffness as a negative factor with respect to socket comfort. Dr. Eugene Murphy first considered this theme as early as 1957[3] when he proposed, "minimize the stiffness gradient between the rigid socket wall and the flexible skin, i.e., taper flexibility of the socket brim." As Dr. Murphy[3] later relates:

> "This theme was eventually published as the introduction to an extensive series of theoretical and experimental papers by Bennett. The series ended with limited clinical trials of sockets with flexible brims made of plastic laminates. These sockets appeared to be helpful for patients previously troubled by chronic or recurrent cysts, but the mechanical durability of the laminate was so poor that the sockets often lasted only six months."[4]

In the course of developing the ultralight weight below-knee prosthesis at Moss Rehabilitation Hospital,[8] A. Bennett Wilson, Jr. recognized the possibilities afforded by the use of thermoplastics to achieve flexible brims that would be sufficiently durable. During the past year, we have been funded by the Veterans Administration Rehabilitation Research and Development Service to carry this idea further.

After reviewing the theories set forth previously and considering the properties of new materials and techniques now available, a set of criteria for socket design was established:

1. Flexible brim
2. Tapering flexibility of the socket in the brim area
3. Flexibility options in other areas of the socket
4. Light weight, but durable
5. Thermoplastic and modular (i.e. no lamination, no epoxy, no glue, etc.)
6. Compatibility with existing modular component systems

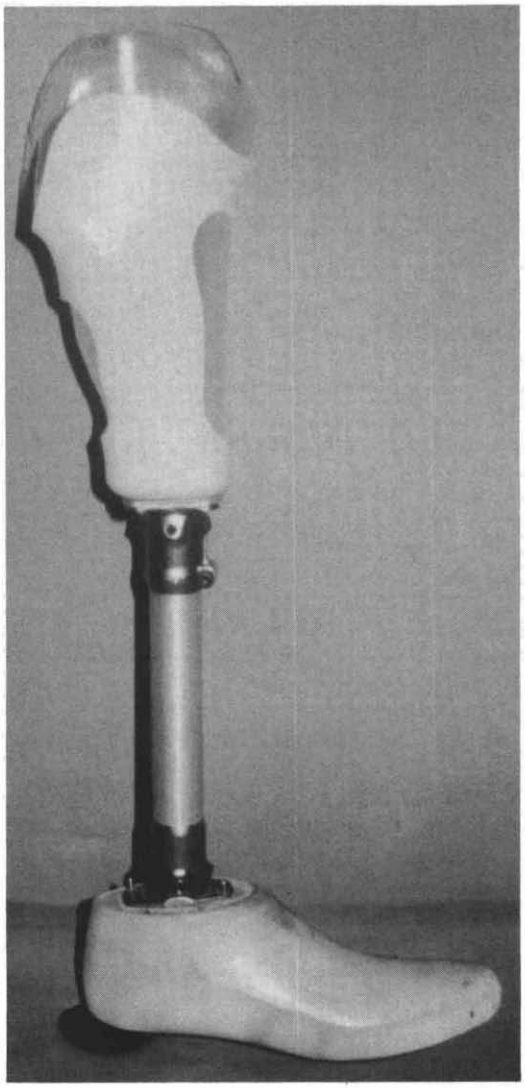

Figure 1. Complete prosthesis, except for cosmesis and suspension, incorporating a socket with flexible brims.

The resulting socket design (Figure 1) consists of the following components: (1) a Surlyn® inner socket or liner; (2) a polypropylene frame for socket support and attachment; (3) silastic foam soft end pad for establishing total contact; (4) United States Manufacturing Company[7] adaptor hardware† for attachment to Otto Bock[2] modular systems; and (5) neoprene sleeve suspension.

Fabrication of this socket system is as follows:

1. The cast is modified for a PTB-supracondylar socket design, and the distal end of the model is extended approximately one inch to allow for a silastic foam end pad and the modular adaptor (U.S. Mgf. Co.) for connection of the pylon to the socket (Figures 2 and 3).

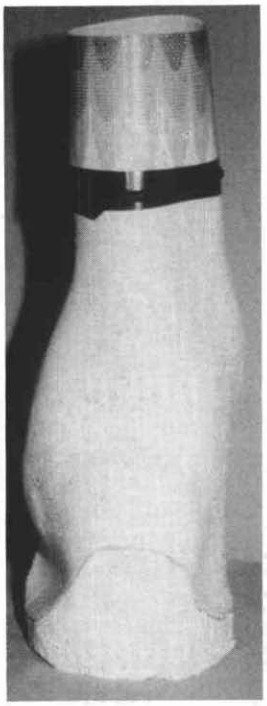

Figure 2. The modified plaster model of the stump is extended to allow for location and alignment of the U.S.M.C. adaptor connector plate for the pylon.

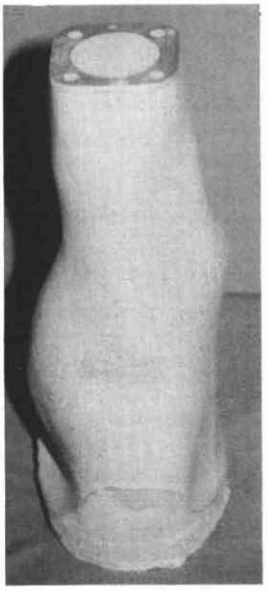

Figure 3. The modified plaster model complete with adaptor, ready for vacuum-forming of the Surlyn® inner socket.

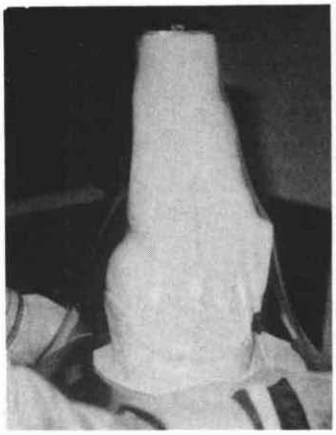

Figure 4. Vacuum-forming the Surlyn® inner socket.

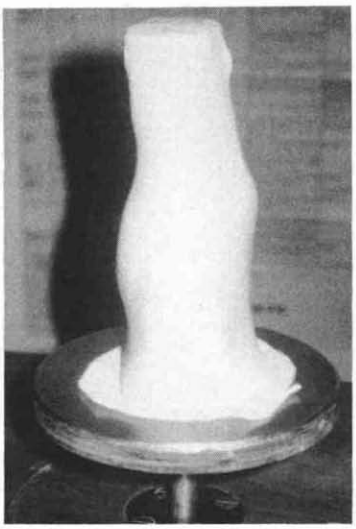

Figure 5. Application of stockinette and nylon sock over Surlyn® inner socket to provide for separation of the polypropylene outer socket to be vacuum-formed over it.

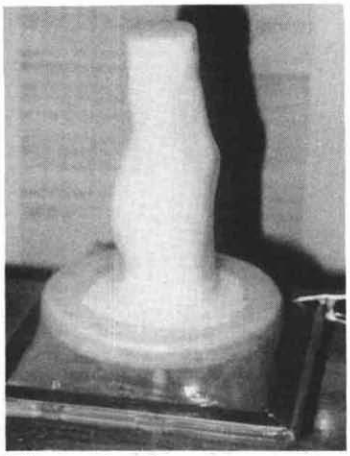

Figure 6. The outer socket frame is vacuum-formed over the inner socket.

2. An inner liner of Surlyn® is vacuum formed using either 12″ × 12″ × 3/16″ Surlyn® for light to regular duty sockets, or 12″ × 12″ × 1/4″ Surlyn® for heavy duty sockets (Figure 4).
3. One layer of thick stockinette and a nylon stocking are applied over the vacuum-formed Surlyn® liner to facilitate separation of socket frame and liner (Figure 5).
4. The socket frame is vacuum formed of polypropylene directly over the inner socket. A piece 12″ × 12″ × 3/8″ is suitable for light duty while a piece 1/2″ thick is usually adequate for heavy duty (Figure 6).
5. After the final vacuum forming stage, the socket liner and socket frame are separated from each other and from the cast model (Figure 7).
6. The Surlyn® liner is trimmed for a PTB-SC design and the polypropylene frame is trimmed for a PTB socket design and is fenestrated over the tibial crest anteriorly and the gastrocnemius area posteriorly (Figure 8).
7. The Surlyn® liner is now inserted into the polypropylene frame (Figure 9).
8. The U.S. Manufacturing Co.[7] adaptor hardware is used to attach the socket to the Otto Bock[2] titanium modular endoskeletal components and an appropriate foot.
9. During initial fitting, the distal end pad is foamed in place while the patient stands to provide total contact.

The Otto Bock modular system has sufficient range of adjustment to suffice for alignment of prostheses for most geriatric patients. However, the use of the Berkeley BK alignment device might be desirable for some of the more active patients (Figure 10). A special adaptor plate is made of 1/8″ aluminum sheet so the Otto Bock 4R22 adaptor component can be used between the socket and the alignment device.

Cosmetic finishing may make use of any of several foam cover systems available, such as the round styrofoam cover available from the U.S. Manufacturing Company (Figure 11).

Below-knee patients fitted at the University of Virginia during the past two years, who voluntarily agree, are being refitted by their original prosthetist with the flexible brim thermoplastic system described here. Our initial conclusions are very positive. To date, eight flexible brim thermoplastic sockets have been fit on seven patients, with one patient having worn his for over one year. There have been six

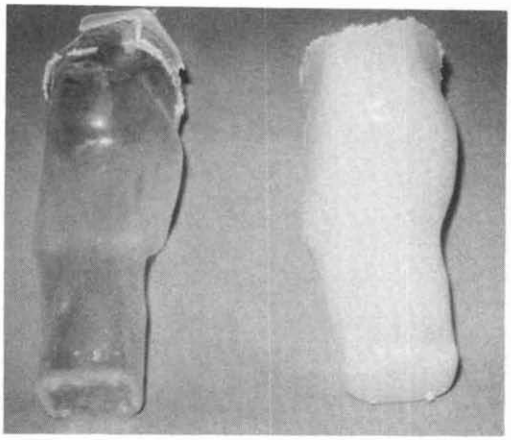

Figure 7. The inner socket and socket frame before trimming.

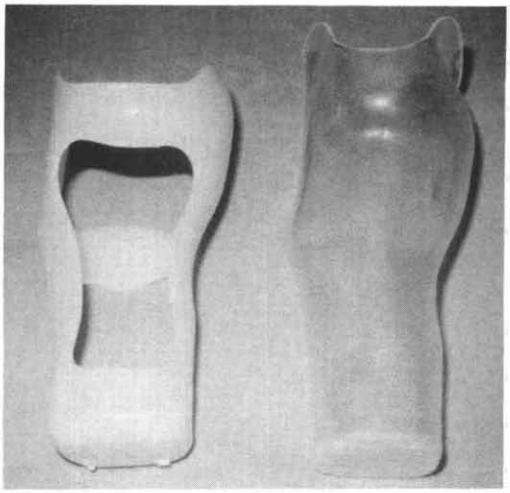

Figure 8. The socket frame and inner socket after trimming.

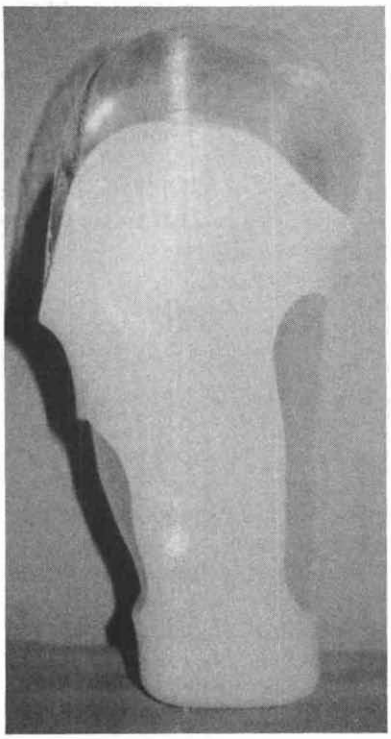

Figure 9. The socket frame and inner socket assembled.

fittings since February, 1986. Only one socket failure has been noted, that of the Surlyn® inner flexible socket which split along the tibial crest on a patient weighing over 350 pounds. That particular socket lasted approximately four months. Though not indicated for use on someone of this weight, we were interested in determining its durability limits.

Subjective evaluation includes patient questionnaires and comments, comparing their existing prosthesis with the new flexible brim thermoplastic socket system. Patient reaction, thus far, indicates enhancement of patient comfort and awareness of reduced prosthesis weight, especially with our geriatric subjects. Although not originally designed for geriatrics, this patient population has specific needs that can be met by this socket design, such as socket flexibility, less confining brim, reduced proximal shear forces, and extreme light weight. When used with Otto Bock titanium modular components and a "Lite" SACH foot, this system weighs between one and a half and two pounds.

Current objective evaluation includes collecting heart rate and step count data in the patient's home environment, using a newly developed ambulatory physiological monitoring system. This includes physiological data with the patient's existing prosthesis in addition to that collected with the flexible brim thermoplastic socket system. This system of patient monitoring, or surveillance, electronically records heart beats (EKG), standing versus sitting posture, and step count, plotted against

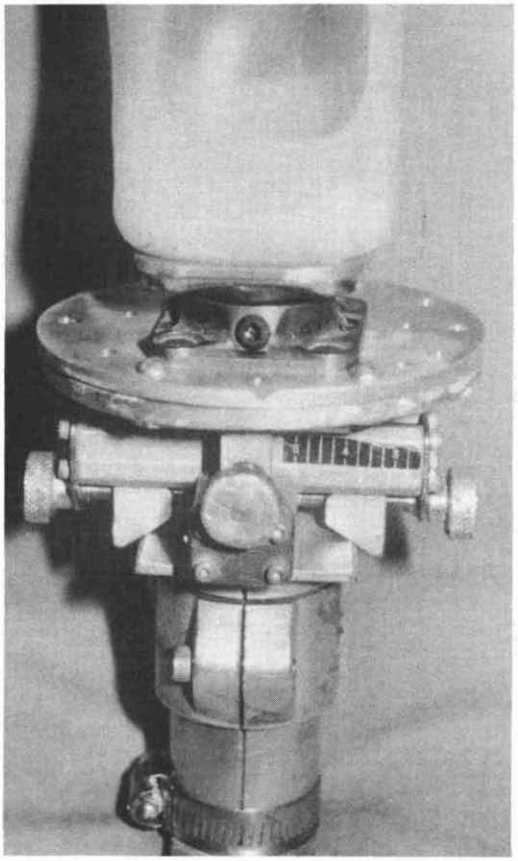

Figure 10. View showing adaptor needed when the UCB adjustable below-knee "leg" is used for alignment trials.

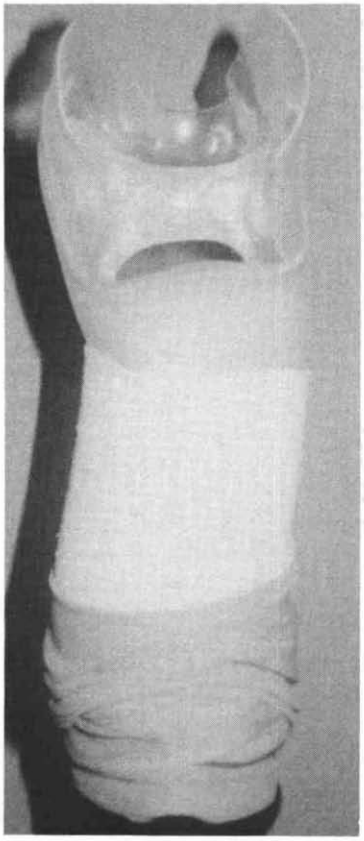

Figure 11. The completed prosthesis with cosmetic stocking pulled down to show the carved styrofoam cover.

time up to 24 hours. The goal is to document any changes in activity level and energy expenditure that occur with use of new prostheses, such as the flexible brim thermoplastic socket system presented in this paper.

In conclusion, a new socket design rationale and system utilizing existing thermoplastic materials has been presented. Patients fit with this system are currently being evaluated both subjectively and physiologically. Fittings and evaluations will continue until a significant number are completed and related data gathered. A follow up report will follow with final conclusions and statistical data presented.

† USMC Part Nos. 41014, 42012, 43026, and 29316

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Clinical Prosthetics and Orthotics, Vol. 10, No. 3, pp. 111–114

Restoration of Walking in Patients with Incomplete Spinal Cord Injuries by Use of Surface Electrical Stimulation—Preliminary Results†

by T. Bajd
B.J. Andrews
A. Kralj
J. Katakis

INTRODUCTION

A group of patients who are good candidates for the application of Functional Electrical Stimulation (FES) to restore reciprocal walking is described. They have incomplete lesions of the spinal cord. Because of the degree of preserved voluntary control, proprioception and sensation, some of these patients can achieve crutch assisted walking by means of multichannel electrical stimulation. In a number of cases the patient has sufficient strength and voluntary control in the upper limbs and at least one leg to provide safe standing for short periods in forearm crutches. For these patients a two channel stimulator controlled by a handswitch was applied to achive safe and practical crutch assisted walking in a relatively short period of time.

BACKGROUND

A new group of patient which can benefit from the orthotic use of functional electrical stimulation (FES) has been identified. These are incomplete spinal cord injured patients. This group of patients is increasing in numbers mainly due to improvements in primary care.

The clinically incomplete lesion of their spinal cord results in preservation of some voluntary movements of the lower extremities. Some of these patients are able to walk with the help of various short-leg or long-leg orthoses which fix the knee and ankle joints. Support of the foot is often provided by the addition of a toe spring. Locomotion of most other incomplete spinal cord injured (SCI) patients is performed with the help of a wheelchair. They can walk only for very short distances, usually in their homes. Some tetraplegic patients are totally confined to a wheelchair. The reason is often very strong spasticity or developed contractures. The upper extremities are also partially paralyzed. Nevertheless, the arms and hands are strong enough to provide support on crutches. Wrist and finger movements are often limited and the grip is rather weak. However, the patients are in most cases able to hold the handle of the crutch.

It was found that a minimum of four channels of FES was required for synthesis of a simple reciprocal gait pattern in the complete

thoracic patient (Bajd et al., 1983; Kralj et al., 1983). During the stance phase, knee extensor muscles are stimulated, while the swing phase is accomplished by eliciting a synergistic flexor response in hip, knee and ankle joints through electrical stimulation of an afferent nerve. It was observed in the present study that in most of the incomplete tetraplegic patients one leg was almost completely paralyzed while the other leg was under voluntary control and sufficiently strong to provide safe standing for short periods using only crutches. Unilateral stimulation of knee extensors and an afferent nerve was helpful in these patients. Less frequently it was found that the patients could stand but were unable to take a step with one or both legs. Unilateral or bilateral stimulation of afferent nerves proved helpful for them. There are also patients whose extension and flexion capabilities in both lower extremities are so poor that they need three or even four channels of stimulation.

THE FES ORTHOSIS

From the point of view of control of the patient, the gait cycle was divided into stance and swing phase. The transition from one phase to another was achieved by pressing a hand switch mounted on the handle of the crutch. When the switch was not pressed, knee extensors were stimulated. When the switch was pressed, the afferent nerve was excited, resulting in the swing phase of walking. The duration of the swing phase was regulated by the time of pressing the switch. In the present investigation the peroneal nerve was stimulated near fossa poplitea. The stimulation of this mixed, sensory and motor, nerve provided direct dorsiflexion and eversion of the foot and simultaneously also the reflex knee and hip flexion.

The gait of most of the incomplete SCI patients can be restored by the two-channel stimulator only. Any stimulator can be used for the described application where the stimulation parameters can be adjusted close to the following values: 0.3 ms pulse duration, 20 Hz pulse repetition frequency, and an amplitude up to 120 volts (measured with a 1k Ω load). Surface electrical stimulation of the knee extensors was delivered to the muscles through large (6 × 4 cm) sheet metal electrodes covered with water soaked layers of gauze. When stimulating the common peroneal nerve, two small round electrodes (diameter 2.5 cm) made of sheet metal and covered by gauze saturated with water were used. The interconnection of the hand switch with the outputs of the stimulator to the electrodes can be readily accomplished. The hand switch was attached to the handle of the crutch by adhesive tape for trial purposes.

PATIENT TESTS

Five patients with incomplete spinal cord lesions have so far been included in the program of FES assisted walking. Only a short strengthening program was required for disuse atrophy of their thigh muscles. The learning program of walking was extremely fast and simple. After the first few days the patients were able to go

Figure 1. Paraplegic subject with incomplete lesions at T6/7 walking on a level surface.

Figure 2. Tetraplegic subject with incomplete lesion at C6 negotiating uneven steps.

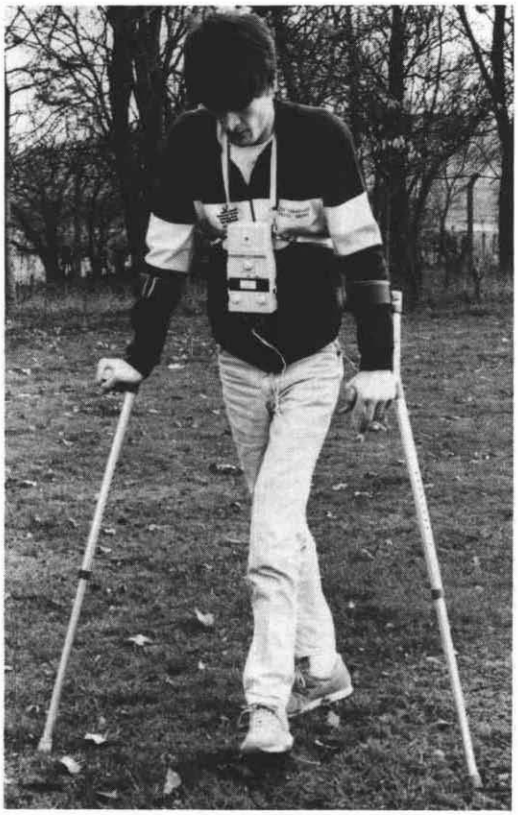

Figure 3. Patient walking on uneven ground; end of swing phase for the paralyzed leg.

from mobile parallel bars to crutches (Figure 1). The difference between walking with and without FES was evident. The patients were not able to take a single step with their severely paralyzed extremity when the stimulator was switched off. After a few days of training they were able to rise from the sitting to the standing position independently with the help of the crutch support and knee extensor stimulation only. Soon they were able to walk on uneven ground (Figure 3) and go up and down steps (Figure 2). The subject shown in Figure 3 has an incomplete lesion at the level T6/7 (age 36 yrs., height 168 cm., mass 61 kg., 7 yrs. post injury). The subject shown in Figures 1 and 2 has an incomplete lesion at the level C6 (age 21 yrs., height 188 cm., mass 70 kg., 3 yrs. post injury). In both cases one leg was paralysed while the other had sufficient voluntary control to maintain safe standing with crutches without stimulation.

DISCUSSION

Such activities can only be achieved in a few completely paraplegic patients after many months in the training program. These differences between incomplete and complete spinal cord injured patients are due not only to the remaining voluntary movements of their lower extremities, but also to the preserved sensation and proprioception. The present FES orthotic systems provide active movements at the joints of the limbs, but no feedback is available in practical clinical systems. The patients feel safe and secure when unattended because in the event of a failure of the orthosis, they are able to support themselves. For these reasons the incomplete SCI patients appear to be the most appropriate candidates for FES. The FES assisted walking may require less energy from the SCI patients with incomplete lesions than walking with passive mechanical knee and

ankle orthoses, because no hip hiking is necessary with active FES systems. Finally, FES assisted walking is much more aesthetic to the observer than orthoses assisted and is preferred by the patients. There may be a number of therapeutic benefits to be gained from the use of FES orthoses such as the prevention of pressure sores, contractures, muscle atrophy and bone demineralisation.

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Clinical Prosthetics and Orthotics, Vol. 10, No. 3, pp. 115–118

An Alternative Technique for Fabricating Flexor Hinge Hand Orthoses Using Total Contact Molded Plastic Finger Pieces

by Greg Moore, R.T.O.

The flexor hinge hand orthosis is one of the most demanding orthoses for the orthotist to fit properly. The slightest error can result in failure of the orthosis and loss of patient confidence in the orthotist. Presented here is a technique for fabricating the orthosis with increased fitting accuracy and reduction of patient-practitioner contact time. The procedures presented here have been accumulated from the measurement and fabrication techniques of various practitioners (see acknowledgments) and assimilated into this single technique.

HISTORY

The flexor hinge hand splint was originally based on the principle of the flexor hinge hand as described by Nickel, Perry, and Garrett in 1955.[1] In the years that followed, it was developed by them and their co-workers, using the principle of the modified three-jaw chuck, in which the index and middle fingers move together towards the thumb. This is accomplished by immobilizing the thumb in a position of opposition and placing the index and middle fingers in a position of semiflexion at the interphalangeal joints. To prevent slippage of the object grasped, the thumb pad must oppose the pads of the two fingers.

The flexor hinge is that part of the orthosis which hinges at the MP joint and holds the index and middle fingers in a functional position. The range of motion is from a position of full extension of the MP joints to a point where the finger pads contact the thumb. The orthosis is operated in one direction by internal or external power under voluntary control, and returned to the starting position passively, usually by a spring or gravity.

The orthosis was originally developed to restore upper extremity function of patients with poliomyelitis. As the incidence of poliomyelitis decreased, the orthosis was used with other patients with severe upper-extremity paralysis such as cervical spine injury, hemiplegia, and brachial plexus injury. The results of treatment in these patients indicated that it is the degree of functional loss rather than the diagnosis that is significant. To a large degree, management of upper-extremity paralysis is the same regardless of the cause.[2]

FABRICATION TECHNIQUE

After the patient has been assessed by the rehabilitation team and the orthotic design has been determined, the patient is seen by the orthotist.

Appropriate measurements are taken and recorded for fabrication of the forearm and/or palmar pieces. Following this initial visit, the orthotist shapes and assembles the pieces ac-

cording to the measurements, with special attention to accurate placement of the MP mounting plate for the flexor hinge finger piece. Temporary straps are also attached to the orthosis to eliminate migration of the orthosis during trial fitting. Other fabrication steps that can be completed at this time are the placement of temporary padding (if used) and the attachment of the adjustable actuating lever kit (Rancho style wrist-driven). The thumb post can be shaped, but should not be attached to the palmar piece until it has been properly fitted to the patient on the second visit.

With the patient's second visit, the forearm and/or the palmar pieces should be fit to the patient and necessary adjustments made to provide for optimal fit and function. The thumb post is fit and attached to the palmar piece in the normal manner at this time. With this accomplished, the orthosis is placed on the patient's hand and secured with the temporary straps.

The index and middle fingers are taped together at the distal phalanges using ¼″ masking tape, so as to keep the middle finger slightly longer than the index finger. A position of 35–40° of flexion at the MP joint, 30° of flexion at the proximal interphalangeal joint, and 5–10° of flexion of the distal interphalangeal joint is needed to position the fingers in opposition with the thumb.[3] When the positioning of the fingers has been accomplished to the satisfaction of the orthotist, the fingers and thumb are coated with a thin layer of petroleum jelly in preparation for casting.

Four layers of 4″ plaster bandage material are measured and cut so that the ends of the bandage extend over the ends of the fingers by ¾″ and at the other end over the proximal edge of the MP mounting plate by ¾″ (Figure 1). The plaster bandage is then dipped in water and with the fingers held in a position of opposition to the thumb, the plaster bandage is placed over the dorsal aspect of the fingers. The edge of the bandage extends distally so that the tip of the thumb is included in the impression. Proximally, the bandage extends over the MP mounting plate so that an impression of this is included. The bandage should not cover the volar (palmar) side of the fingers. The bandage is rubbed into the fingers, tip of the thumb, and the MP mounting plate to obtain a clear impression, and the edges of the bandage should

Figure 1. Preparation for casting fingers.

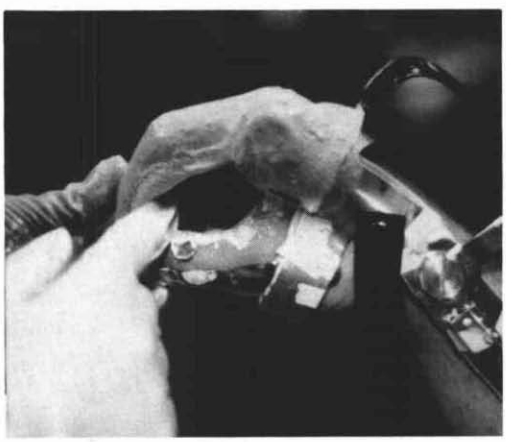

Figure 2. Cast impression incorporating MP joint plate and fingers.

Figure 3. Shows ease of aligning MP joint and finger pieces with MP joint included in the cast.

be folded back approximately ¼" to reinforce the borders (Figure 2). After the bandage has hardened, it can be removed without the use of a cast saw by gently disengaging it from the MP mounting plate area and tilting it up over the fingers.

The proper length of the temporary straps should be marked and the fitted forearm and palmar pieces removed. The patient's hand can now be cleaned, and he/she can be scheduled for a final return visit.

The impression is prepared for filling by enclosing it in plaster bandage and coating the inside with a thin layer of liquid soap. A small mandrel should be contoured to fit the inside of the impression, extending as far distally as the tips of the fingers to prevent fracturing of the positive model (a length of ½" O.D. aluminum tubing works well for this). The impression is filled with plaster of Paris and stripped, using great care not to fracture the positive model. The model will have good detail, showing the contours of the finger nails, skin lines, and MP mounting plate.

The positive model is prepared for vacuum forming, using a length of nylon stocking as the interface for the ⅛" polyethylene. If Surlyn® is used, the Surlyn® is vacuum formed directly over the lightly smoothed impression without an interface. The clarity of Surlyn® facilitates visual assessment of pressure distribution when used with a sensation impaired hand. The plastic should be vacuum formed and not drape formed to insure an exact fit. Once the vacuum forming has been completed, the plastic piece can be removed by using a cast saw and carefully avoiding excessive damage to the impression. The finger piece is now ready to be trimmed using the following general guidelines.

The distal border should be ⅛" distal to the proximal edge of the fingernails of the index and middle fingers. The proximal border should be trimmed to the proximal aspect of the proximal phalanges. In the coronal plane, the plastic piece is trimmed along the midline of the fingers. The plastic finger piece is then placed back on the positive impression and a stainless steel superstructure is fabricated using the MP mounting plate impression as the reference for the MP operating lever (Figure 3). This saves an enormous amount of time since the reference between the palmar piece and

Figure 4. Complete orthosis wih polyethylene finger piece.

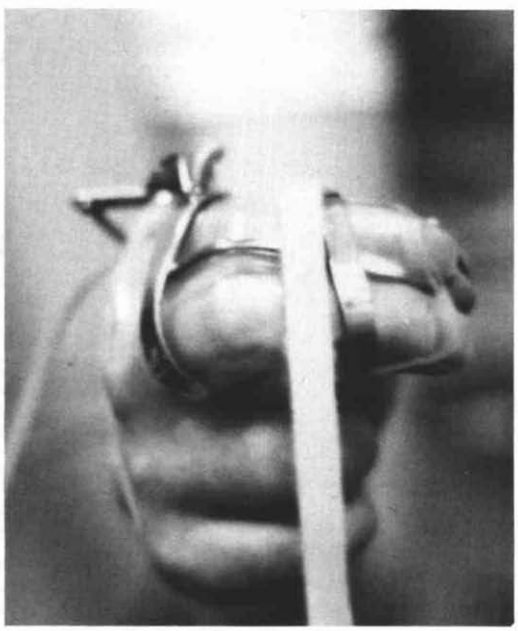

Figure 5. Orthosis showing use of Surlyn® fingerpiece for observation of the skin.

finger piece is part of the positive impression. A regular Jaeco style proximal finger piece is used for the proximal bar of the superstructure, and a 3/32" rod connects it to a distal stainless bar located at the middle of the middle phalange. Both of the bars are silver soldered to the 3/32" rod and simply bent to the contours of the plastic finger piece.

The proximal finger piece is connected to the MP operating lever in the usual manner. A Velcro® closure can be attached to the distal superstructure bar on a stainless steel closure

and can be fabricated using the bar as the dorsal half of the closure. With the finger piece completed and the remainder of the orthosis finished, the patient can be fitted and the orthosis delivered (Figures 4 and 5). Patient training and minor adjustments are done following regular rehabilitation procedures.

SUMMARY

Fabrication of the intimate fitting flexor hinge component of the flexor hinge wrist hand orthosis can be tedious. The procedure detailed here can facilitate fabrication of a more accurately fitting flexor hinge. The use of a vacuum formed finger section assures a total contact fit resulting in fewer pressure problems on the fingers. The optional use of Surlyn® for fabrication of the plastic finger piece permits direct skin observation when deemed beneficial.

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I would like to express my special thanks and admiration to Jack E. Greenfield, C.O. at Rancho Los Amigos Hospital and David Bird, C.O. at University of Michigan Hospitals for their willingness to share their experience and knowledge.

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[6] Redford, J.B., ed. *Orthotics Etcetera*. Baltimore, Md. Williams and Wilkins, 1980, pp. 238–248.

AUTHOR

At the time of writing, Greg Moore, R.T.O., was a student in the Long Term Orthotic Practitioner Program at 916 Vo-Tech. He may be reached at: c/o Bill Moore, 7366 S. Bannock Drive, Littleton, CO 80110.

Clinical Prosthetics and Orthotics, Vol. 10, No. 3, pp. 119–121

Technical Note: RMB Reinforcement

by Robert O. Gooch, C.P.

Because of the humid climate, the Department of Prosthetics and Orthotics at Duke University Medical Center receives many prescriptions for hard socket below-knee prostheses. The great majority are supracondylar wedge suspension, utilizing the Removable Medial Brim (RMB) concept. For the past several years, we have designed and fitted approximately 150 such prostheses annually.

Based on this experience, we have developed a method to reinforce the RMB structure and prevent gradual loss of alignment under the constant pressure of the femoral condyles. We now use this technique routinely, and find it greatly enhances the stability of the removable brim.

METHOD

Fabricate the socket in the conventional manner, following the instructions supplied by the hardware manufacturer.[1] Rather than packing the mechanism with clay, we prefer to substitute Johnson's Stik-Wax,[2] which is easier to work with and lubricates the assembly, allowing easier removal. Once the lamination is fully cured, break out the positive model.

At this point, the medial brim is cut away from the socket. Although a variety of tools can be used for this operation, we prefer a simple modification of an ordinary hacksaw blade.

Grind the fine-tooth hacksaw blade into the contour shown in (Figure 1). This is preferable to a commercial sabre saw blade, because its wide, thin shape creates a smoother, less irregular cut.

Using the sabre saw, cut the anterior and posterior portion of the brim free, being careful not to nick the metal upright. Cut the area adjacent to and over the metal upright with a cast saw or sharp knife. Carefully pry the medial brim free with a thin-bladed screwdriver.

Grind the distal end of the upright an amount equal to the saw kerf, to insure the wedge will seat fully (Figure 2). Place the brim back onto the socket to be certain it fits properly, with minimal gapping along the cut edge.

REINFORCEMENT

Remove the brim and apply PVC tape[3] to the lateral surface and distal trimline. This serves as a parting agent, and prevents the resin used in subsequent steps from bonding the wedge back onto the socket.

Roughen the socket immediately beneath the cut-line, to insure good adhesion for the reinforcement lip (Figure 3). Lubricate the cut edge with petroleum jelly and reapply the wedge carefully to avoid gapping.

Cut three 1½″ wide strips of Xynole-polyester[4] fabric long enough to cover the saw cut. This material saturates readily when used with polyester resin and forms a thin, strong, and rigid reinforcement.

Promote a small amount of pigmented polyester 4110 (rigid) resin. Paint the roughened area of the socket with resin, and apply one layer of Xynole reinforcement extending at least ½″ onto the wedge (Figure 4). Brush additional resin onto the Xynole until it is fully saturated, and apply the second layer. Fully saturate this layer and apply the final layer. Sat-

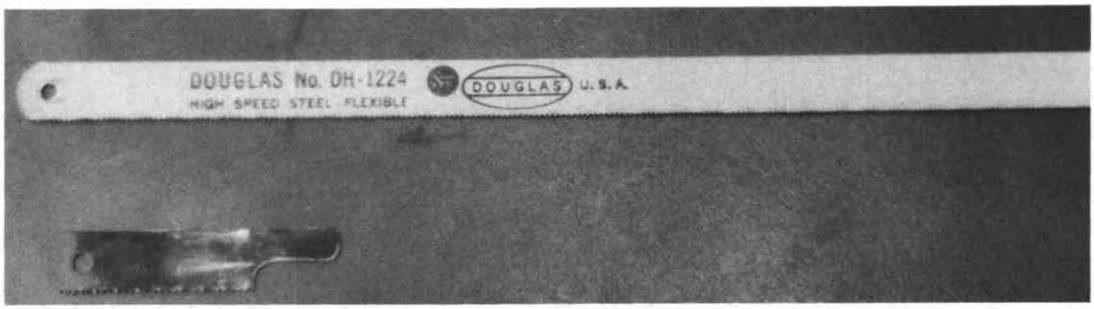

Figure 1. Fine-toothed hacksaw blade, modified to fit sabre saw.

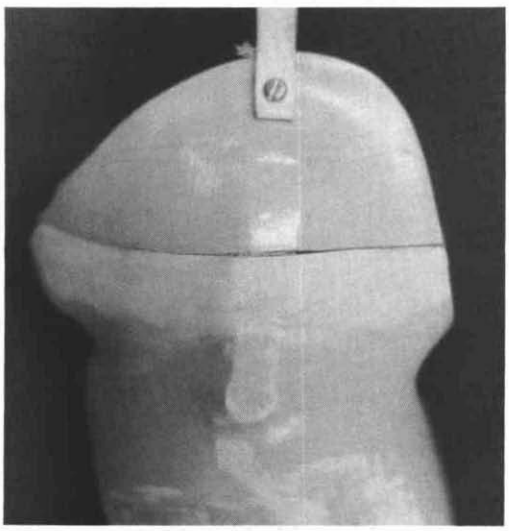

Figure 2. Grind distal upright to insure the wedge fits without gapping.

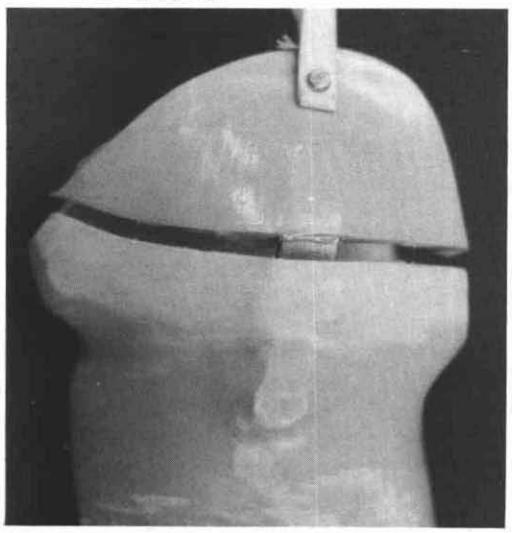

Figure 3. Tape wedge and roughen socket prior to lamination of lip.

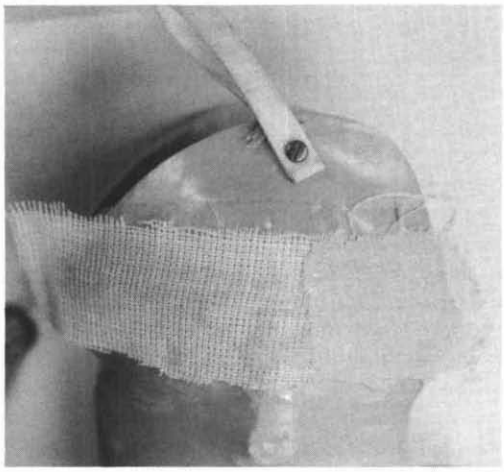

Figure 4. Saturate Xynole layers individually with the polyester resin.

urate this in a similar manner.

When the resin has gelled, but not fully set, remove the wedge. This insures that the wedge will insert smoothly, without binding, in the finished prosthesis.

Once fully cured, trim the reinforcement to form a 3/16" lip (Figure 5). Using a felt arbor, bevel the inside edge of the lip and the outside edge of the wedge (Figure 6). This unobtrusive lip will significantly reinforce the wedge, particularly against malrotation.

FINISHING

Once dynamic alignment and transferring are completed, the prosthesis is ready for the finish lamination. We typically set the wedge aside and relaminate the prosthesis without the proximal brim in place.

An old RMB upright can be inserted into the

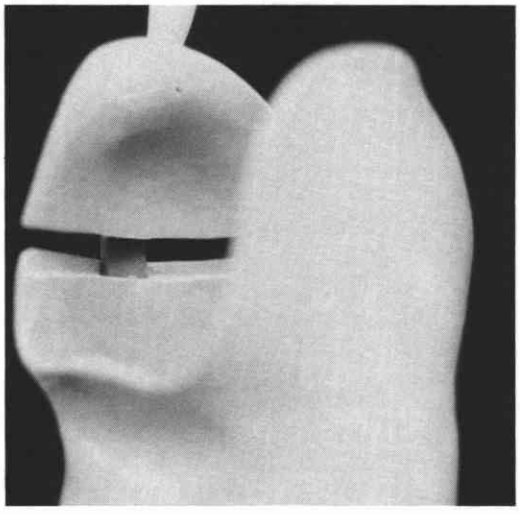

Figure 5. Trim lip to 3/16" above socket edge.

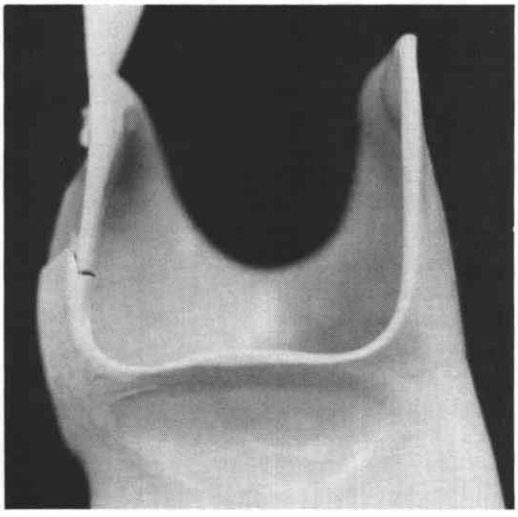

Figure 6. Posterior view of lip with wedge in place. Note bevel on inner edge of lip and outer edge of wedge.

channel and clamped in a vise. This prevents resin from filling the channel and provides a mandrel to secure the prosthesis during the lamination procedure. Lubricate the upright with Stik-Wax[2] to fully seal the channel.

SUMMARY

Fabrication of a Xynole reinforcing lip significantly improves the stability of the supracondylar wedge when using the Removable Medial Brim procedure. Based on the Duke experience with hundreds of RMB prostheses, we recommend this be done routinely.

AUTHOR

Robert O. Gooch, C.P., is with the Department of Prosthetics and Orthotics at the Duke University Medical Center.

APPENDIX

[1] Durr-Fillauer Medical, Inc.
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Catalog #127001 (Standard Duty)

[2] S.C. Johnson & Sons, Inc.
Racine, WI 53403
#140 Stik-Wax—15 oz. container

[3] Otto Bock Industries
4130 Highway 55
Minneapolis, MN 55422
Coroplast PVC tape
Catalog #616F8

[4] Durr-Fillauer Medical, Inc.
P.O. Box 5189
Chattanooga, TN 37406
Xynole-Polyester cloth
Catalog #211094

Calendar

1986

July 18—19, American Academy of Orthotists and Prosthetists Continuing Education Conference 3-86. "Disarticulation Prosthetics," Milwaukee, Wisconsin. Contact: Academy National Headquarters, 703-836-7118.

August 5–7, Canadian Association of Prosthetists and Orthotists Biennial National Convention, World Trade Centre, Halifax, Nova Scotia, Canada. Contact: Nova Scotia Rehabilitation Centre, Orthotics/Prosthetics Unit, 1341 Summer Street, Halifax, Nova Scotia B3H 4H4, Canada.

August 11–15, 1986 UNB Myoelectric Controls Course and Symposium, Fredericton, New Brunswick, Canada. Contact: Director, Bio-Engineering Institute, University of New Brunswick, Fredericton, New Brunswick, Canada E3B 5A3; tel. 506-453-4966.

August 18–21, UCLA Total Surface Bearing Suction Below Knee Prosthetics Course, Los Angeles, California. Contact: Timothy B. Staats, MA, CP, UCLA POEP, Room 22-46, 1000 Veteran Avenue, Los Angeles, California 90024.

August 22–23, American Academy of Orthotists and Prosthetists Continuing Education Conference 4-86, "Pediatric Prosthetics," Newington, Connecticut. Contact: Academy National Headquarters, 703-836-7118.

September 10–12, Hosmer Electric Systems Workshop and Seminar, Hosmer Dorrance Corporation, 561 Division Street, Campbell, California 95008. Contact: Catherine Wooten, Hosmer Dorrance Corporation, tel. 800-538-7748; 408-379-5151.

September 10–12, 6th Annual Advanced Course in Lower Extremity Prosthetics, East Meadow, New York. Contact: Daniel Shapiro, M.D., Department of Physical Medicine & Rehabilitation, Nassau County Medical Center, 2201 Hempstead Turnpike, East Meadow, New York 11554.

September 12–13, Ohio Chapter of the Academy/Ohio Orthotic & Prosthetic Association Combined Fall Meeting, "Light Touch . . . Light Tech," Sheraton Columbus, Columbus, Ohio. Hosts—Mike Russell, CPO, and Bill DeToro, CO. Contact: Ohio Orthotic & Prosthetic Office, 4355 N. High Street, #208, Columbus, Ohio 43214; tel. 614-267-1121.

September 13–16, The 39th Annual Conference on Engineering in Medicine and Biology, Omni International Hotel, Baltimore, Maryland. Contact: The Alliance for Engineering in Medicine and Biology, Suite 700, 1101 Connecticut Avenue, NW, Washington, DC 20036.

September 15–19, Training Course: Fitting Procedures for the Utah Artifical Arm, Newington Children's Hospital, Newington, Connecticut. Contact: Harold Sears, Ph.D., Motion Control, Inc., 95 S. Elliott Rd. #105, Chapel Hill, North Carolina 27514; tel. (919) 968-8492.

September 19–20, American Academy of Orthotists and Prosthetists Continuing Education Conference 4-86, "Powered Limb Prosthetics," Albany, New York. Contact: Academy National Headquarters, 703-836-7118.

October 22–31, UCLA Advanced Prosthetics Techniques, Los Angeles, California. Contact: Timothy B. Staats, MA, CP, UCLA POEP, Room 22–46, 1000 Veteran Avenue, Los Angeles, California 90024.

October 24–25, American Academy of Orthotists and Prosthetists Continuing Education Conference 5-86, "Spina Bifida," Cincinatti, Ohio. Contact: Academy National Headquarters, 703-836-7118.

October 27–31, UCLA International Prosthetics Techniques Seminar, Los Angeles, California. Contact: Timothy B. Staats, MA, CP, UCLA POEP, Room 22–46, 1000 Vet-

eran Avenue, Los Angeles, California 90024.

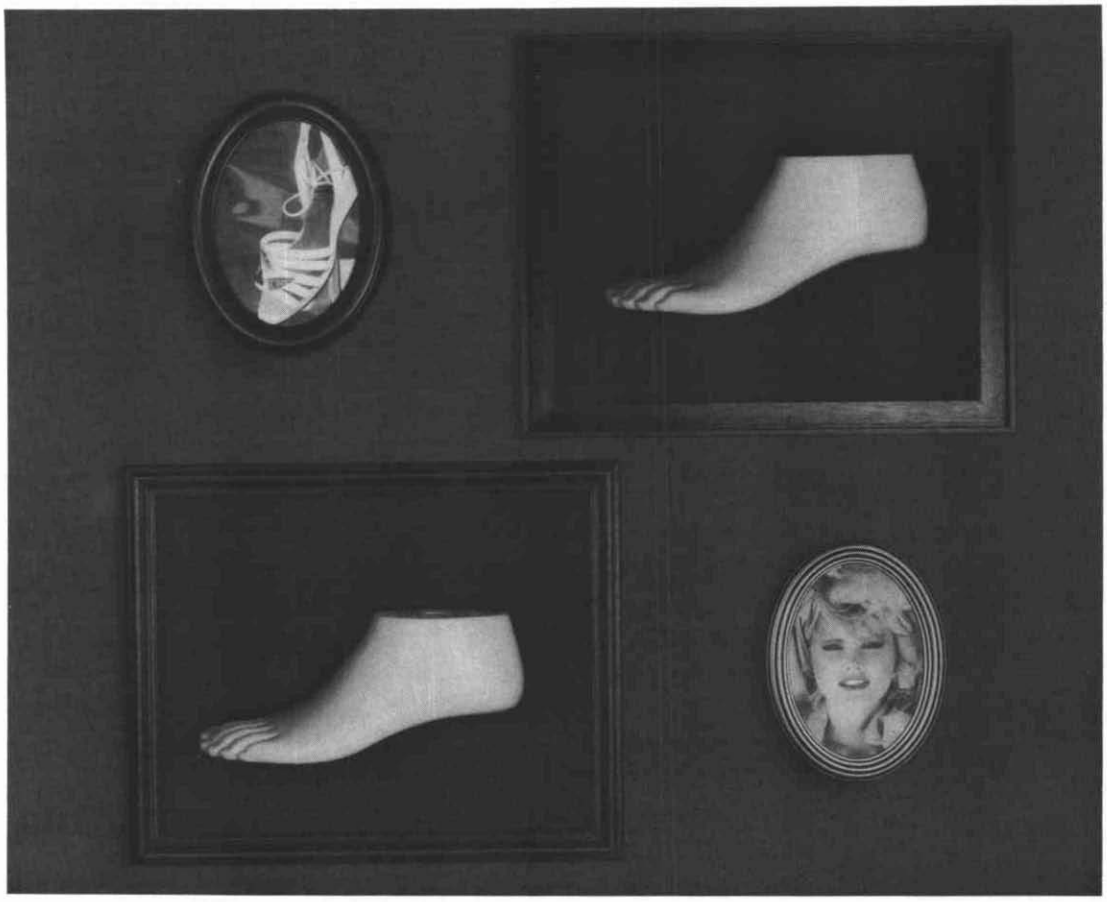
November 10–12, Hosmer Electric Systems Workshop and Seminar, Orlando, Florida. Contact: Catherine Wooten, Hosmer Dorrance Corporation, 561 Division Street, Campbell, California 95008; tel. 800-538-7748, 408-379-5151.

1987

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

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

September 11–12, Ohio Orthotics and Prosthetics Association/Ohio Chapter, American Academy of Orthotists and Prosthetists combined meeting, "Bridging the Profession," Dayton, Ohio. Contact: Norma Jean Finissi, Executive Director, O.O.P.A./Ohio A.A.O.P., 4355 North High Street, #208, Columbus, Ohio 43214; tel. (614) 267-1121.



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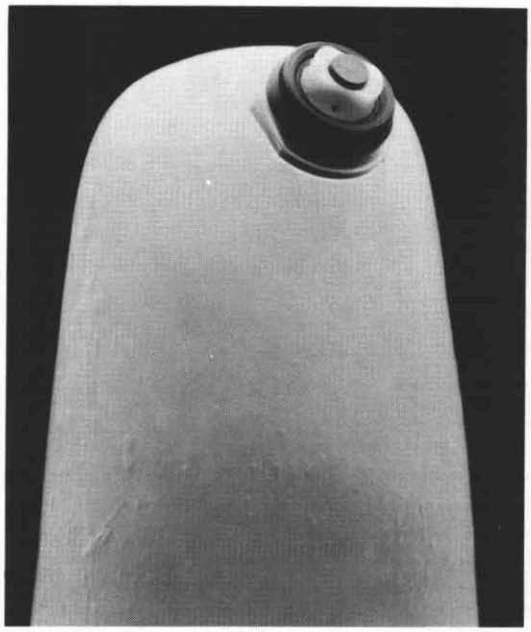

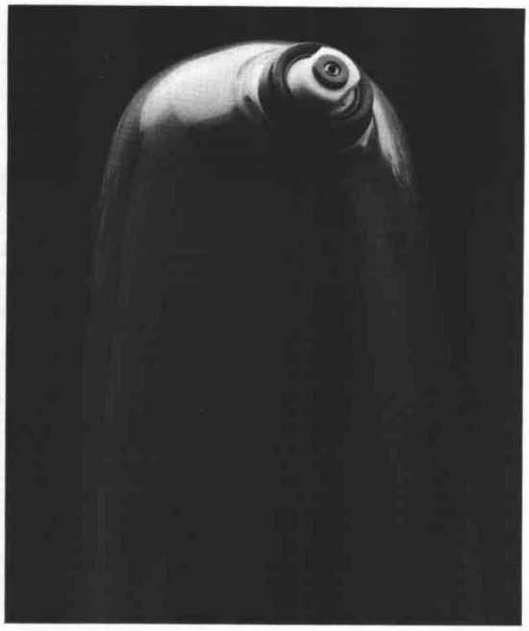

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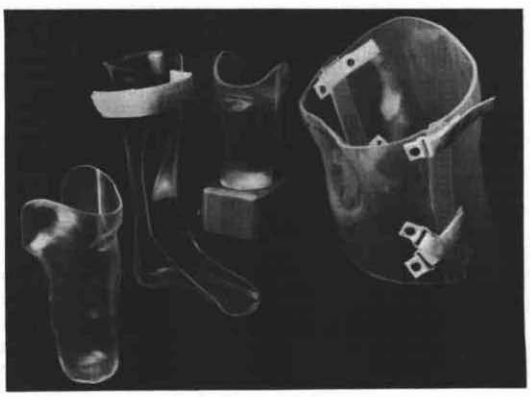

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AUTHOR INFORMATION

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Clinical Prosthetics and Orthotics addresses broad, philosophical issues, and as such invites a more subjective style. Each issue of *C.P.O.* centers on a main topic. Usually, an issue will contain a lead article, an editorial, and one or more technical articles pertaining to the topic. Authors are solicited by the Academy editorial board; however, *C.P.O.* also accepts unsolicited articles. Unsolicited articles need not cover the topic at hand and may be of a more technical and objective nature. All articles are submitted to the editor, a professional in the field, who checks every article for accuracy, terminology, format, and references. The articles are then forwarded to the publications staff at the Academy National Office for production and printing.

The chosen topics for *Clinical Prosthetics and Orthotics,* Volume 10, Number 4 through Volume 11, Number 3 and deadlines for submission are as follows:

Volume 10, Number 4	"Seating"	Deadline: August 1, 1986
Volume 11, Number 1	"Early Post-surgical Prosthetic Management"	Deadline: November 1, 1986
Volume 11, Number 2	"Orthotic Management of Paraplegia"	Deadline: February 1, 1987
Volume 11, Number 3	"Sports Prosthetics"	Deadline: May 1, 1987

Please remember that although these are the chosen topics for these particular issues, we gladly welcome submissions on other topics. Please feel free to contact the National Office if you have any questions on whether your article would be appropriate for *C.P.O.*

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   b. Journal Article
      Panton, Hugh J., B.S., C.P.O., "Considerations for Joints and Corset," *Newsletter . . . Amputee Clinics,* 8:3: June, 1975, pp. 1–3, 6–7.
   c. Lecture or Verbal Presentation
      1. Holmgren, Gunnar, "The PTB Suction Prosthesis" from the written material of a lecture delivered at the third of the "Strathclyde Bioengineering Seminars," 8–11 August, 1978.
      2. Wagner, F.W., Jr.: "Classification and treatment for diabetic foot lesions"; Instructional Course, American Academy of Orthopedic Surgeons, New Orleans, Louisiana, February, 1976.
   d. Personal Communication
      Irons, George, C.P.O., Personal communication, June 1977. Presently, Director of Research, United States Mfg., Glendale, California. Formerly, Research Prosthetist, Patient Engineering Service, Rancho Los Amigos Hospital, Downey, California.

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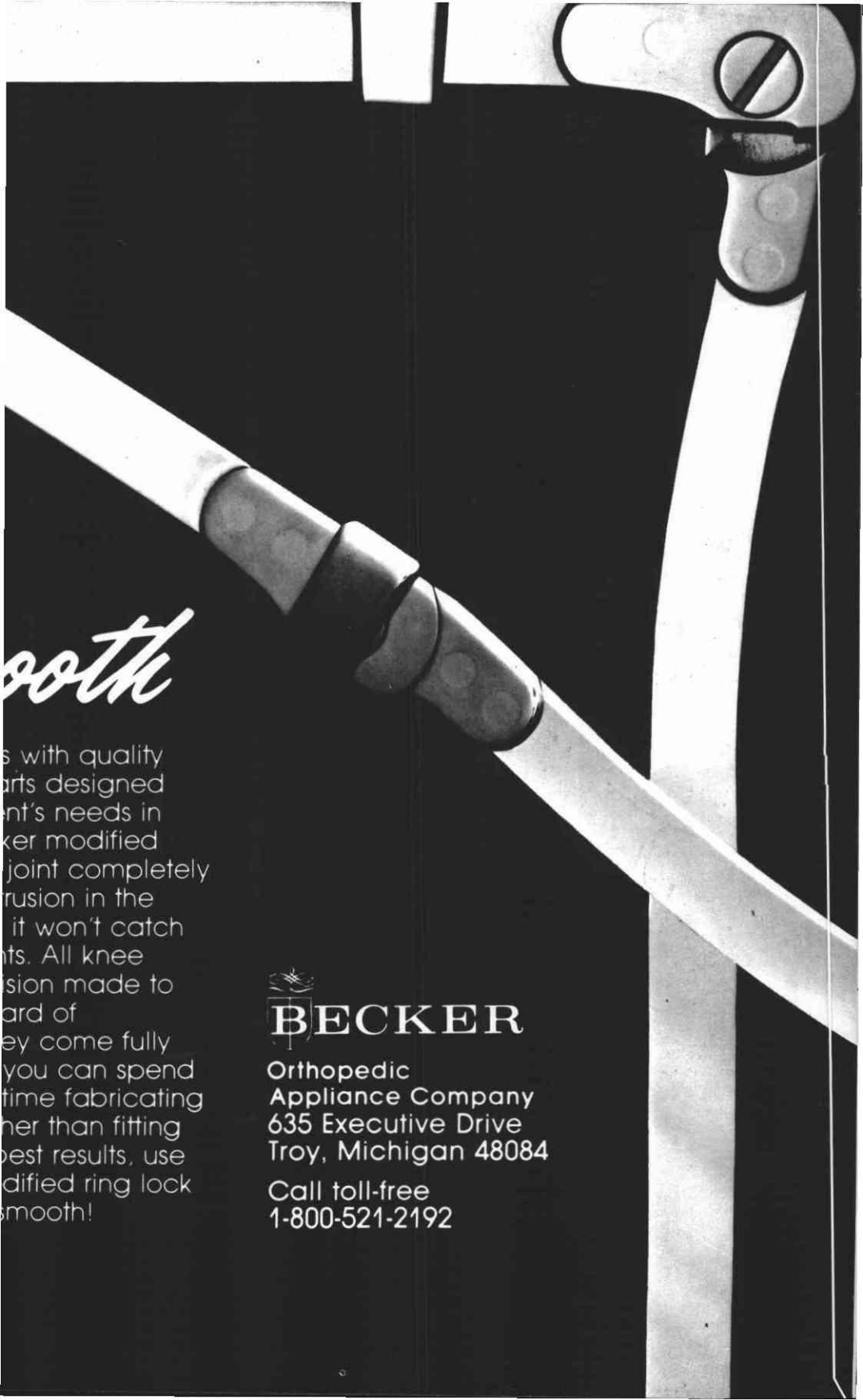
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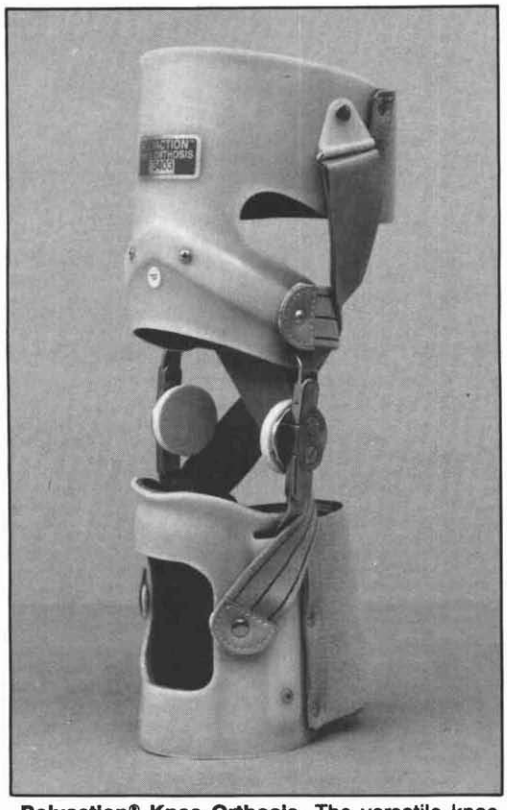

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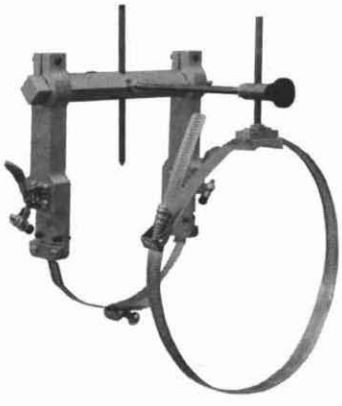

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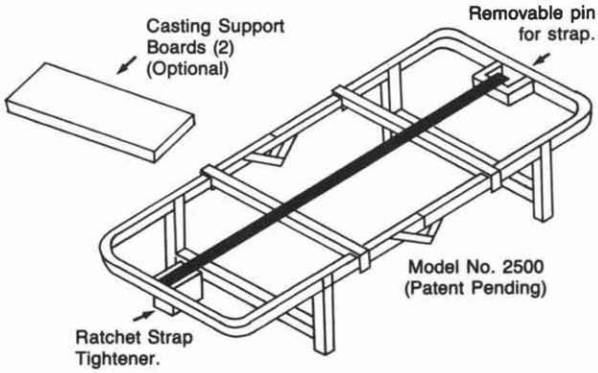

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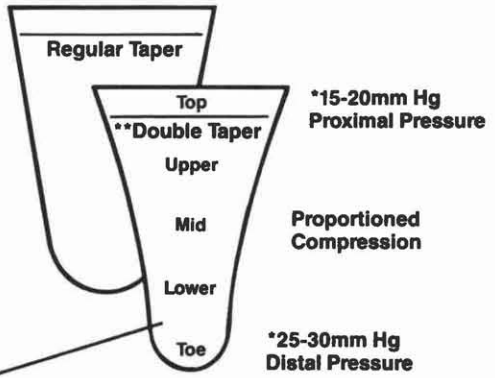
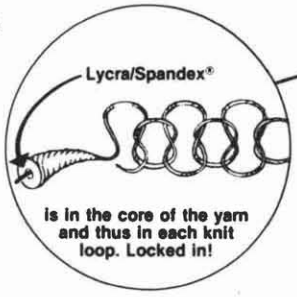
Medium Compression (gray top) 10-15mm Hg at 50% stretch
CAUTION: Compression proximally should not be greater than compression distally.



Rounded Shape and Elastic to the Very End Assures Compression and Better Control Distally



Specify the KNIT-RITE Stump Shrinker™ and Companion Products

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- **PP/L SOFT-SOCK®** made from Polypropylene/Lycra®. Dry because it wicks moisture. May be worn as a liner, filler, or spacer.
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