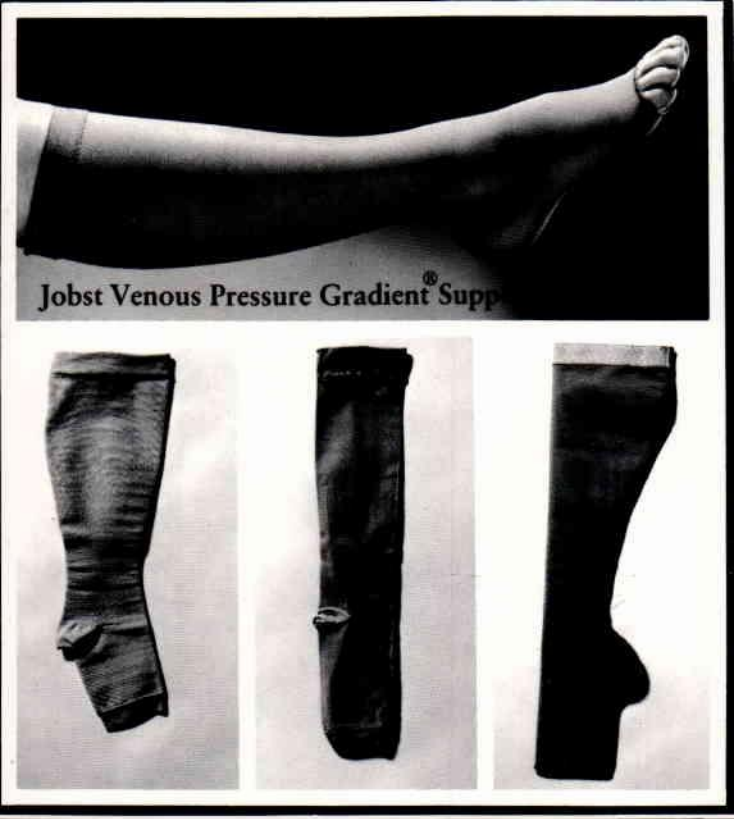
Volume 37
Number 3

Orthotics and Prosthetics

Journal of the American Orthotic and Prosthetic Association



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CONTENTS

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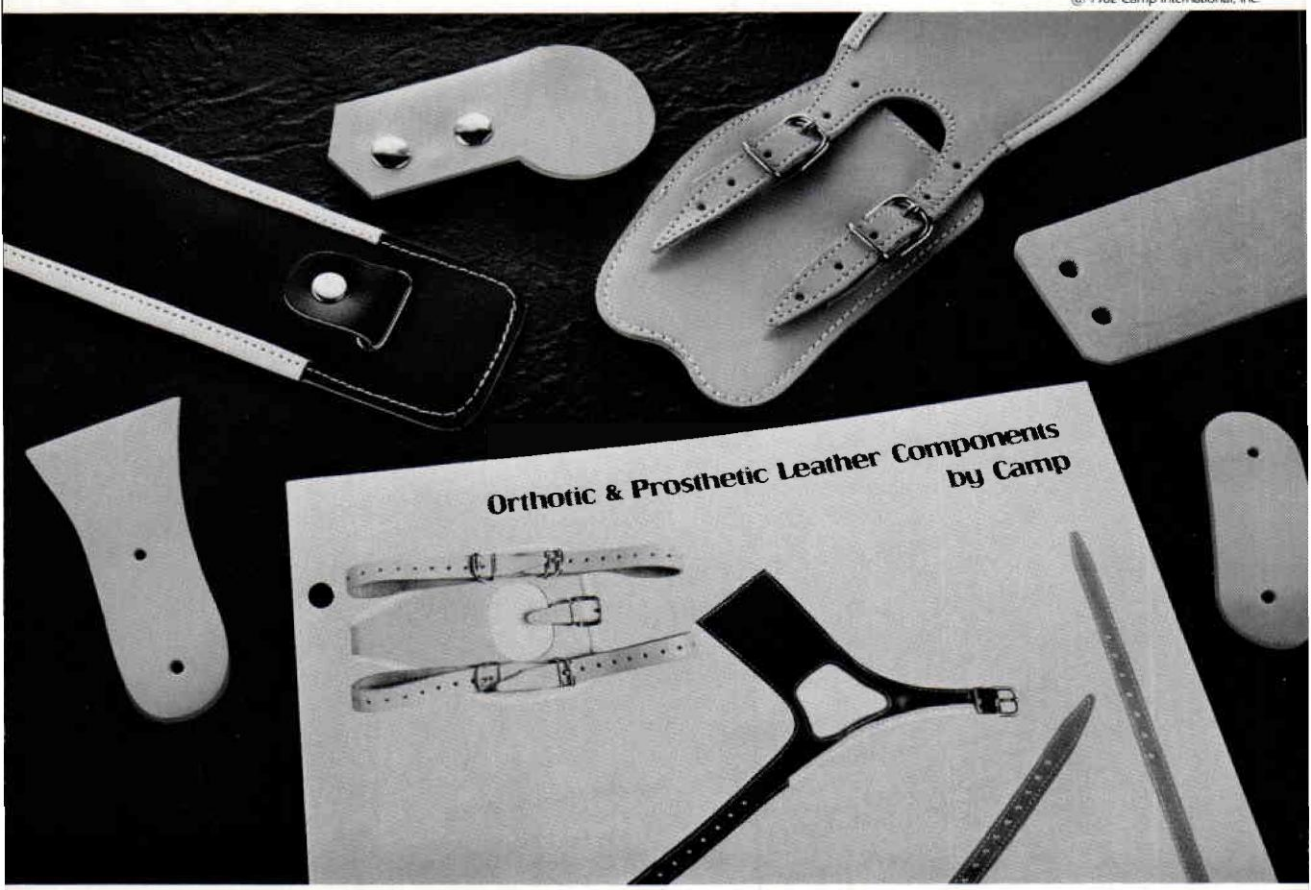

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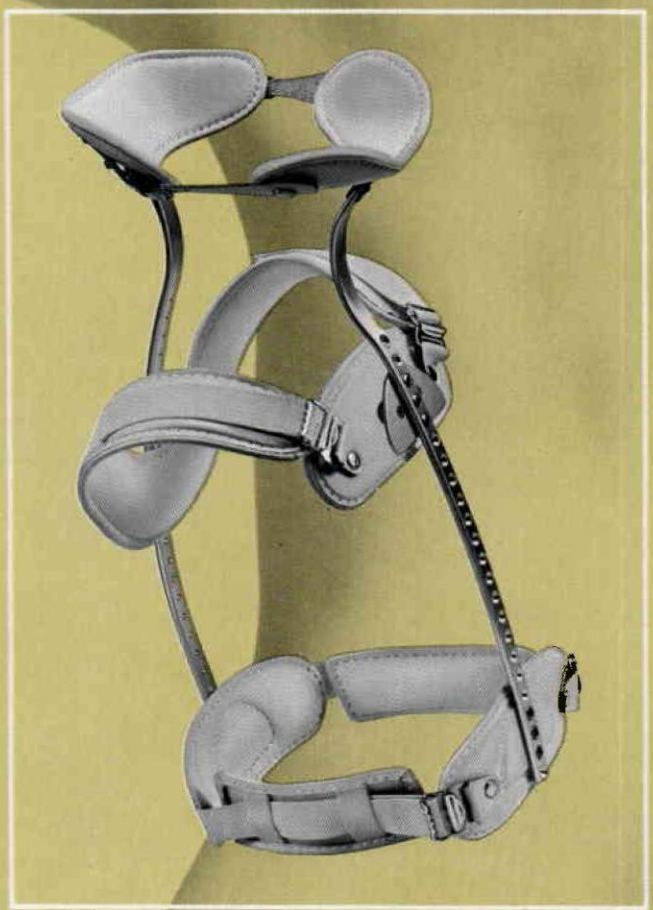

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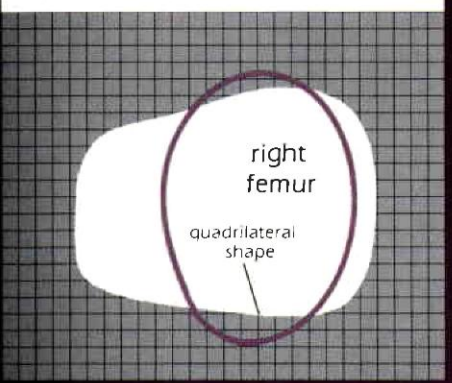

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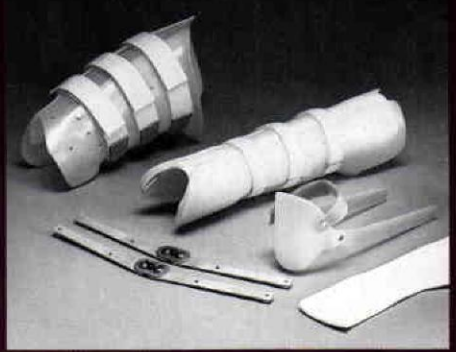

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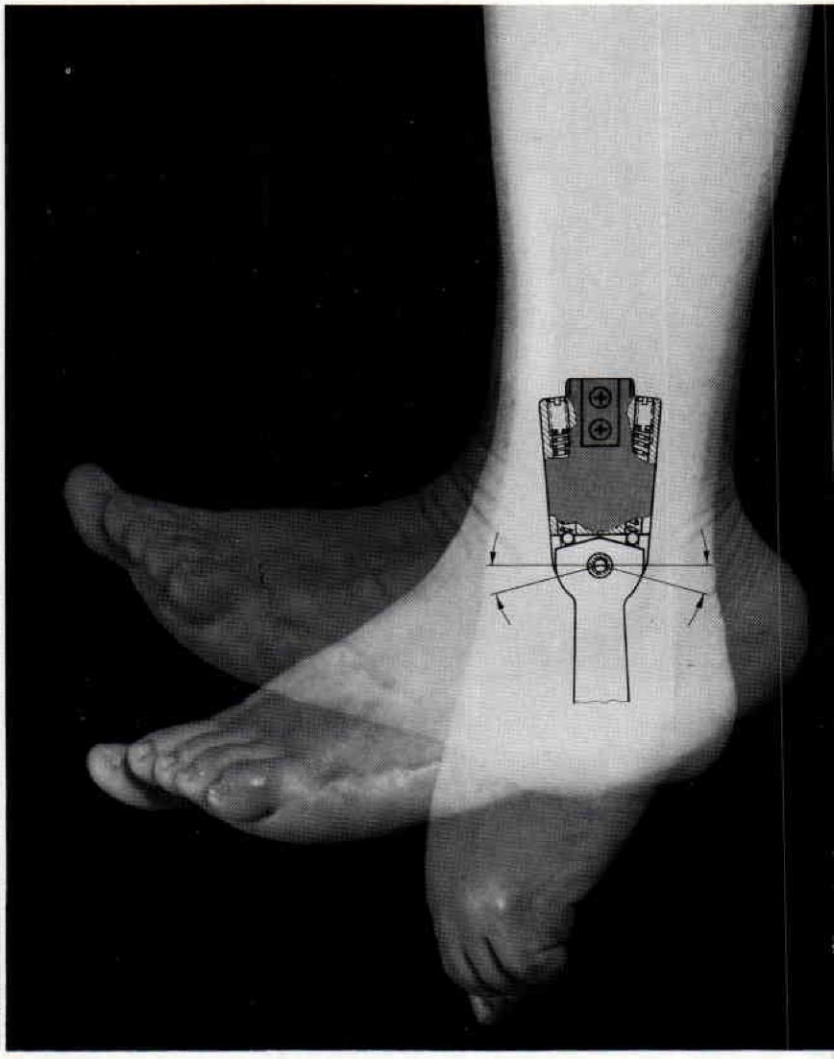

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Please notify the National Headquarters immediately concerning additional meeting dates. It is important to submit meeting notices as early as possible. In the case of Regional Meetings, it is mandatory to check with the National Headquarters prior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

1984

January 25–29, Academy Annual Meeting and Seminar, Dutch Resort Hotel, Lake Buena Vista, Orlando, Florida. Contact: Academy National Headquarters, 703-836-7118.

January 29–February 2, AOPA Business Procedures and Data Committee seminar, Rose Hall Beach and Country Club, Montego, Jamaica. Contact: AOPA National Headquarters, 703-836-7116.

April 1–4, Asian and Pacific Convocation on Rehabilitation, to examine how a wide cross-section of people can work in partnership with disabled people, sponsored by R.I. New Zealand, Rehabilitation League and Accident Compensation Corporation, Wellington, New Zealand. Contact: Accident Compensation Corporation, Private Bay, Wellington, New Zealand.

April 2, Canadian National Society for Prosthetics and Orthotics, Biennial Meeting, Westin Bayshore Hotel, Vancouver, British Columbia, Canada. Contact: Canadian National Society—ISPO, Prosthetics-Orthotics Department, Chedoke-McMaster Hospital, P.O. Box 2000, Station "A," Hamilton, Ontario L8N 3Z5 Canada.

April 3–5, Canadian Association of Prosthetists and Orthotists Biennial National Convention, Westin Bayshore Hotel, British Columbia, Canada. Contact: Box 320-810 West Broadway, Vancouver, B.C. V5Z 4O9 Canada.

April 5–6, New England Academy Chapter Annual Meeting, Worcester Marriott, Worcester, Massachusetts.

April 7–8, ABC Spring Written Examinations, Ramada Inn Old Town, Alexandria, Virginia; Holiday Inn O'Hare Kennedy, Chicago, Illinois; AMFAC Hotel, San Francisco, California. Contact: ABC National Headquarters, 703-836-7114.

April 11–15, The Pacific Rim Orthotics and Prosthetics Conference, Hotel International, Maui, Hawaii. Endorsed by the Academy and INTERBOR.

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

April 19–24, 1st International Meeting on Leisure, Recreation, and Sports, organized by the Rehabilitation International Commission and sponsored by R.I., the Japanese Society for Rehabilitation of the Disabled and the governments of Gamagori City and Aichi Prefecture, Gamagori, Japan. Contact: Japan Sun Industries, Kamegawa, Beppu 847-01 Japan.

May 3–5, AOPA Regions I, II, and III Combined Annual Meetings, Concord Hotel, Kiamesha Lake, New York.

May 13–18, 9th International Congress of Physical Medicine and Rehabilitation, Jerusalem, Israel. Contact: Kenes, 29 Mamred Street, P.O.B. 29784, 61297 Tel-Aviv, Israel.

May 24–26, AOPA Region V Annual Meeting, Amway Grand Plaza Hotel, Grand Rapids, Michigan.

June 1–3, AOPA Region IX, COPA and the California Chapters of the Academy Combined Annual Meeting, Lake Arrowhead, California.

June 4–8, 15th World Congress of Rehabilitation International on theme, "Information, Awareness and Understanding for Integration of Disabled Persons and Society," Lisbon, Portugal. Contact: (Program) Rehabilitation International, 432 Park Avenue South, New York, New York 10016.

June 12–July 4, 7th World Wheelchair Games (formerly Paralympics), University of Illinois, Champaign, Illinois. Contact: Prof. Timothy Nugent, Rehabilitation Education Center, 1207 South Oak Street, Champaign, Illinois 61820.

June 16–28, 1984 International Games for the Disabled, sponsored by the International Sports Organization for the Disabled, Nassau County, Long Island, New York. Contact: Mr. Michael Mushett, Director, 1984 International Games for the Disabled, c/o Special Populations Unit, Eisenhower Park, East Meadow, New York 11554.

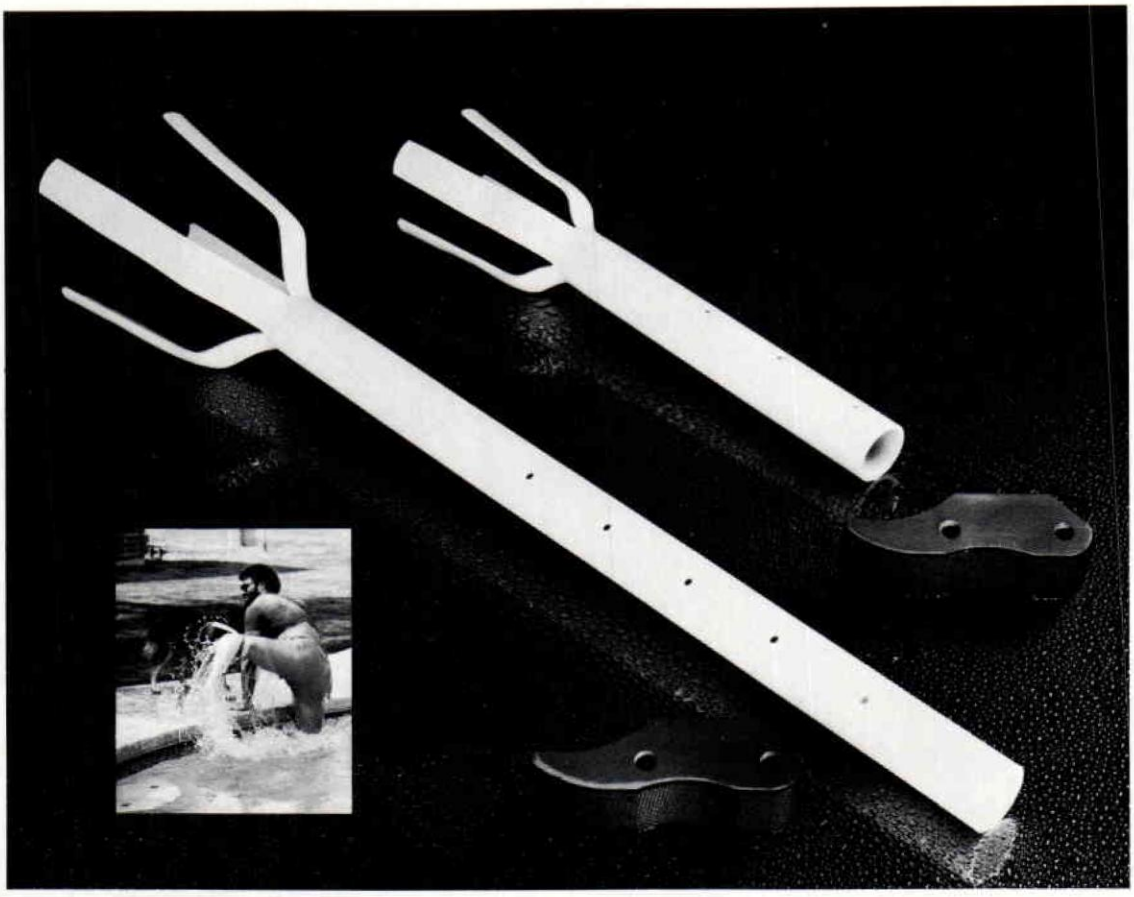
June 17–22, "1984—The Bright Side," The Second International Conference on Rehabilitation Engineering, combined with the 7th Annual Conference on Rehabilitation Engineering, Congress Centre, Ottawa, Ontario, Canada. Sponsored by the National Research Council of Canada, the Rehabilitation Engineering Society of North America, and the Canadian Medical and Biological Engineering Society. Contact: Conference Services, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.

June 21–24, AOPA Region VI and the Academy Midwest Chapter Annual Combined Meeting, Holiday Inn, Merriville, Indiana.

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

September 30–October 5, 16th Congress of the International Society for Orthopedic Surgery and Traumatology (SICOT), London, England. Contact: Conference Services, Ltd., 3 Bute Street, London, SW7 3EY, United Kingdom.

October 16–21, AOPA General Assembly and International Congress, Fontainebleau Hotel, Miami Beach, Florida. Contact: AOPA National Headquarters, 703-836-7116.



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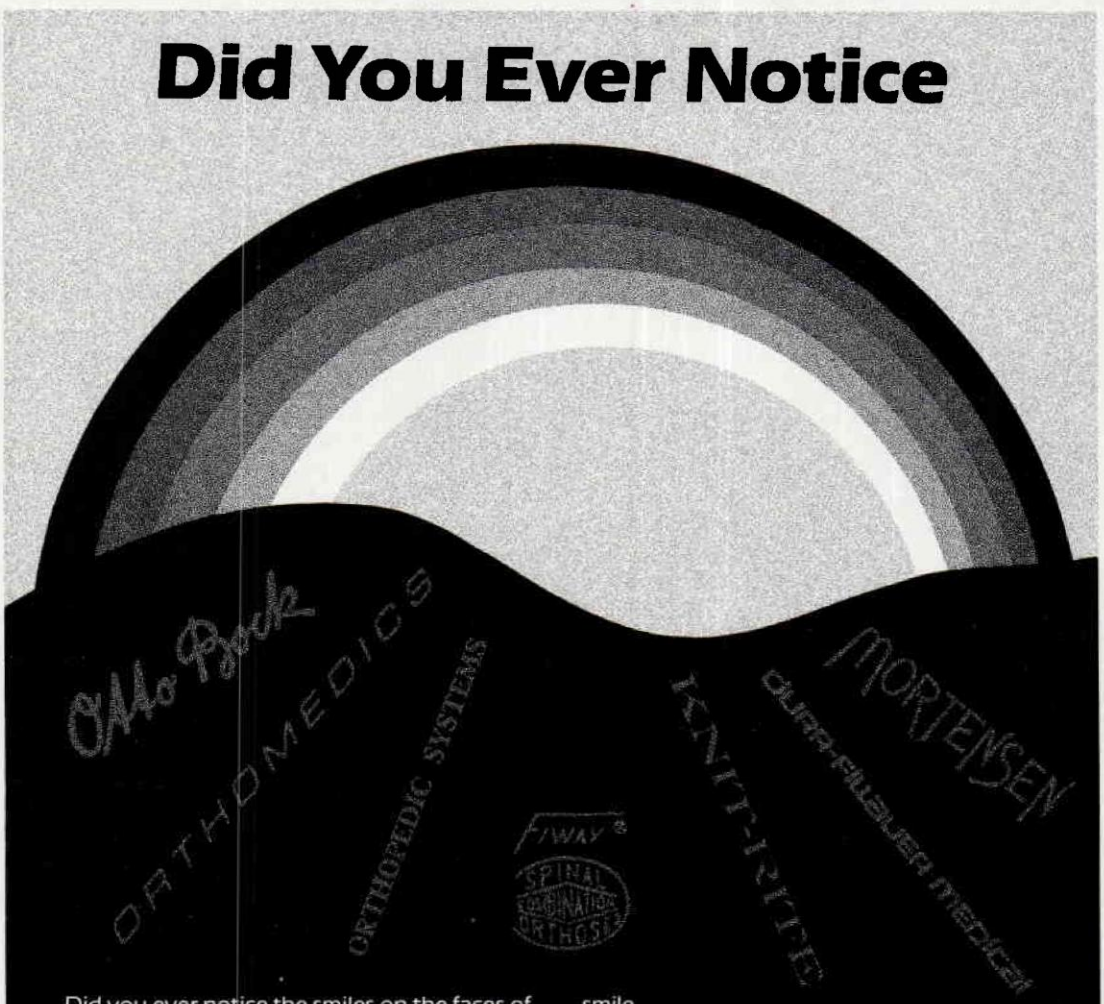

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A Below Knee Vacuum Casting Technique

Drew A. Hittenberger, C.P.
Kenneth L. Carpenter

INTRODUCTION

Accurate casting is thought by many to be the single most important factor in the successful fabrication and performance of the below knee prosthesis. Fitting is becoming increasingly accurate with improved socket materials (polyester resins, acrylic resins, and silicone compounds) and more sophisticated fitting techniques (total contact sockets, and check sockets). This article presents a below knee casting technique which utilizes vacuum pressure to draw the plaster against the patient's skin. This procedure produces negative impressions which duplicate residual limb contour and shape with a high degree of accuracy. The purpose of this research is to obtain the best possible method of casting for improved socket fit and increased comfort and control of the prosthesis for the patient.

HISTORY

At present, the most common casting technique involves wrapping the residual limb with plaster of paris and then molding it against the skin by hand until the desired negative impression is obtained.[1,9] To distribute the pressure equally around the residual limb, Gardner (1968)[3] described a technique using a pneumatic sleeve while Murdock (1968)[6] developed the Dundee socket which used fluid pressure to compress the plaster against the skin. Fillauer (1971) developed the two and three stage casting technique which duplicates the boney anterior prominences and soft posteriolateral tissue areas separately.[2] Other multistage techniques were developed by Gleave (1972)[4] and Rice (1979).[8] In 1971, Zettl and Traub reported a premodified casting technique[10], and, in 1982, Hanger presented a technique which used positive pressure provided by a controlled environment treatment (CET) machine to compress a bag over the plaster wrapped residual limb.[5] All of these techniques have attempted to accomplish the same result; that of creating as accurate a negative impression as possible.[7]

VACUUM CASTING

The below knee vacuum casting technique uses vacuum to draw the plaster against the patient's skin. This process ensures equal distribution of pressure around the residual limb, thus eliminating the need to mold the negative impression by hand. The amount of vacuum pressure applied to the extremity can be varied depending on the amount of detail desired. This technique is compatible with, and improves the accuracy of, existing casting techniques such as the two and three stage procedures of Fillauer. The vacuum casting technique utilizes standard equipment

Figure 1. Materials required for the vacuum casting technique.

which is widely available in prosthetics facilities.

The materials and equipment required for this technique are as follows (Figure 1):

1. Portable vacuum (Hosmer Cat. No. 51277)
2. ¼ inch wound tubing
   (Heritage Cat. No.430-04)
   (Zimmer Cat. No.1500-13)
   (Depuy Cat. No.5420-78)
3. Universal connector
   (Heritage Cat. No.460-01)
   (Zimmer Cat. No.1500-15)
   (Depuy Cat. No.5420-95)
4. 1 roll, 1 inch Microfoam tape
   (3M Cat. No.1528-1)
5. 1 roll, 2 inch Microfoam tape
   (3M Cat. No. 1528-2)
6. 1 roll, 1 inch double-faced tape
   (3M Cat. No.950)
7. 1½ inch × 14 inch Plastisol sealing band
8. Cast sock
9. Indelible pencil
10. 1 to 2 rolls standard plaster of paris bandage
11. 10 inch × 14 inch Zip-Lock® plastic bag
12. 1 Yates clamp
13. One pair scissors
14. Plaster parting cream
    (Otto Bock Cat. No.64025)

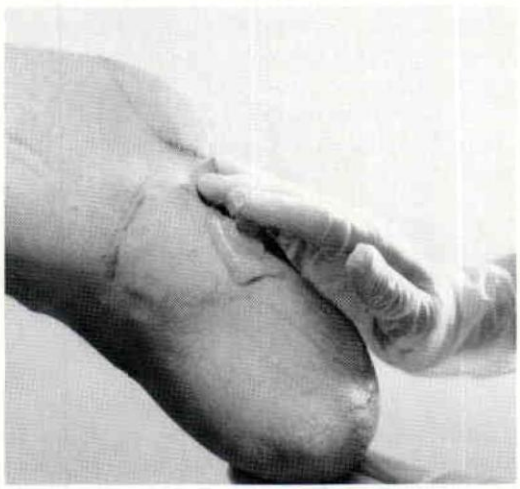

Figure 2. Apply plaster parting cream to the residual limb.

Procedure

The below knee vacuum casting technique is as follows:

1. Apply plaster parting cream on the patient's residual limb to facilitate easy removal of the cast (Figure 2).

2. Apply a wet cast sock to the residual limb. Draw the sock tightly against skin to eliminate any wrinkles (Figure 3).

3. Secure the cast sock with one inch Microfoam tape three to four inches above the Patella (Figure 4).

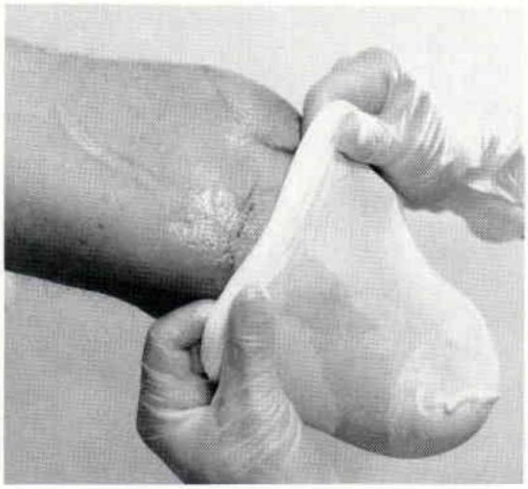

Figure 3. Apply the cast sock.

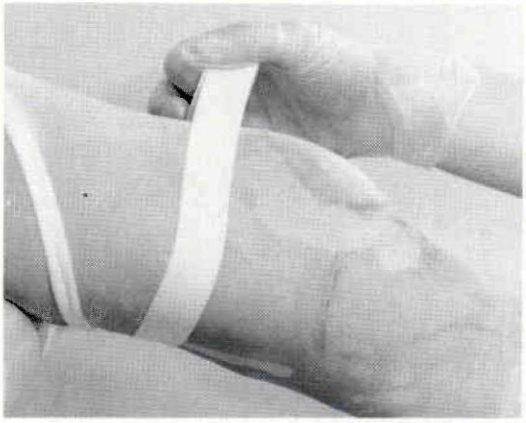

Figure 4. Seal the cast sock proximally using one inch Microfoam tape.

4. Cut off the excess stockinette and seal the entire proximal edge against the skin with two inch Microfoam tape. One or two layers is sufficient. This will create an air-tight seal against the skin (Figure 5).

5. Mark the boney prominences with an indelible pencil.

6. Feed the vacuum tube through the Plastisol sealing band until the perforated holes are all on the distal side of the band (Figures 6 & 7). Then place the sealing band on the two-inch Microfoam tape with the perforated side projecting distally. Lay the tubing down the residual limb and trim off the excess at mid-patella (Figure 8 & 9).

7. Cut a small hole in the stockinette just superior to the patella and feed the perfo-

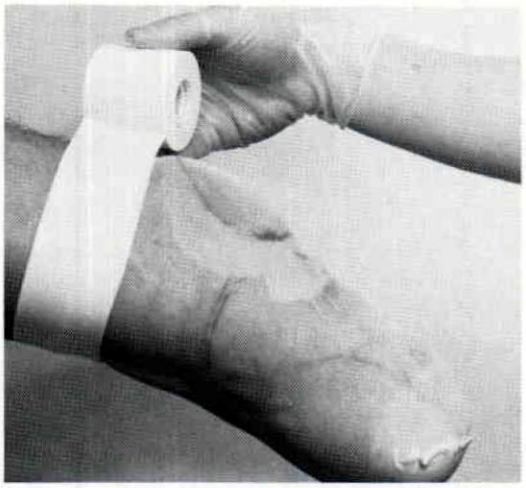

Figure 5. Seal the cast sock to skin using two inch Microfoam tape.

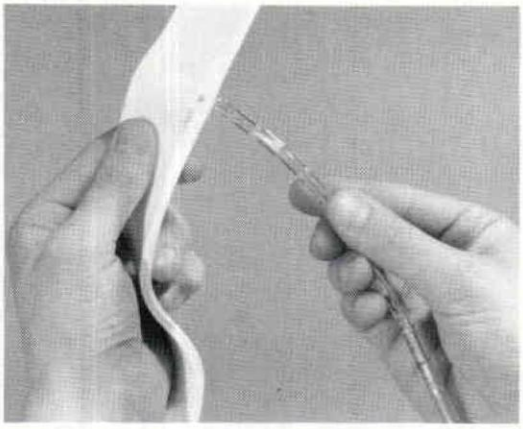

Figure 6. Feed the tubing through the flexible Plastisol band. Note: Silicone lubricant may be required.

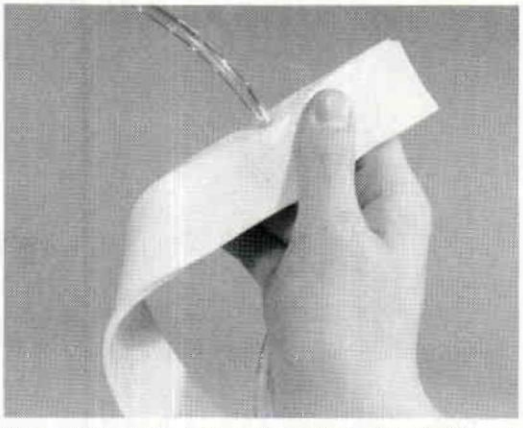

Figure 7. Feed the tubing through the Plastisol band until the perforated holes are on one side of the band.

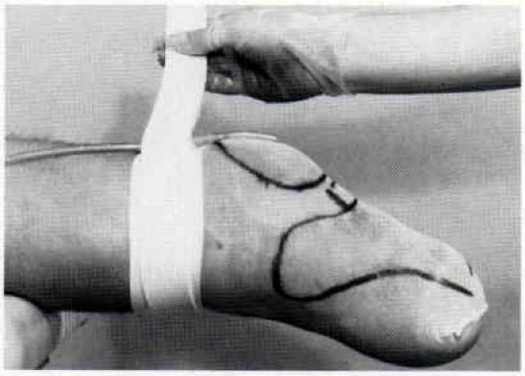

Figure 8. Seal the Plastisol band to the Microfoam tape. Note: If sealing becomes a problem, use double-faced tape.

rated tubing underneath the stockinette to the middle of the patella. The tubing must be under the stockinette to create an air passage during vacuum evacuation. Wrap the Plastisol band snugly around the Microfoam tape to create an air-tight seal (Figure 10).

8. Apply plaster of paris bandage over the patient's residual limb, being careful not to cover the Plastisol sealing band. Avoid wringing the water-saturated plaster bandages. They must remain wet to allow the vacuum pressure to draw the plaster against the skin. Wrap the bandage loosely to avoid distortion from roping.

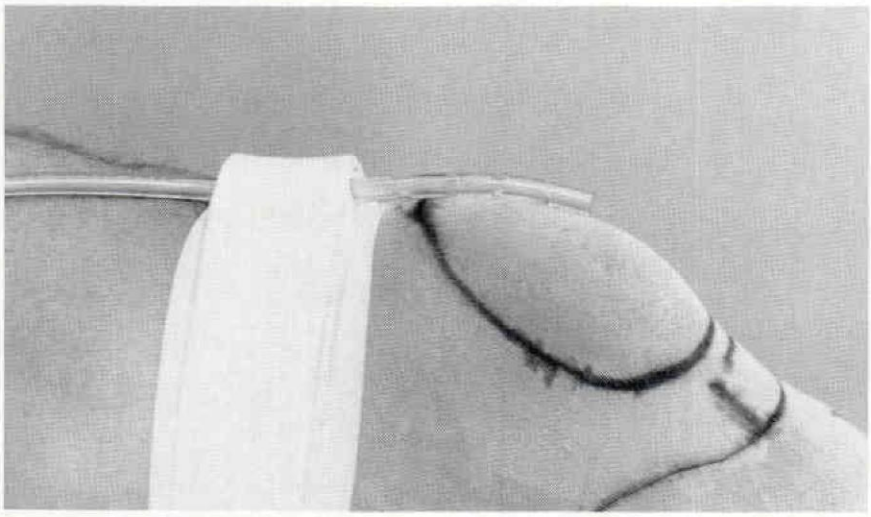

Figure 9. Trim off the excess tubing.

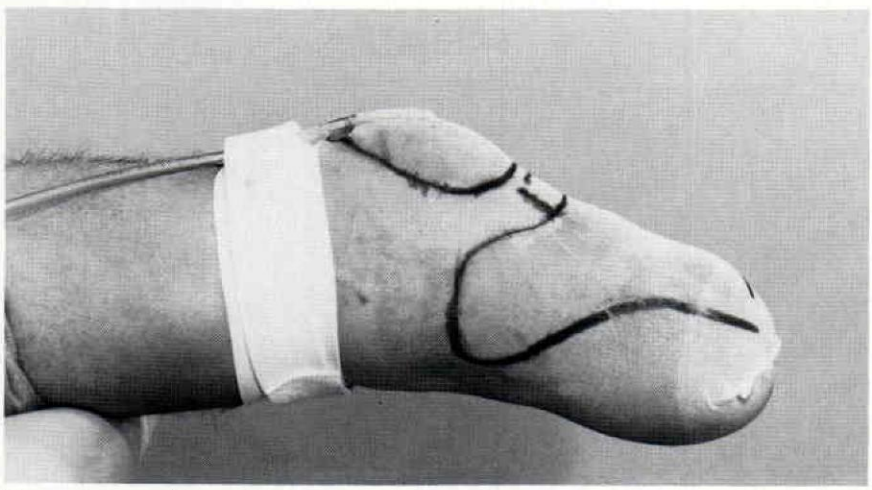

Figure 10. Lay tubing under the cast sock.

Figure 11. Apply plaster bandage loosely around the residual limb. Note: Do not exceed five layers in thickness.

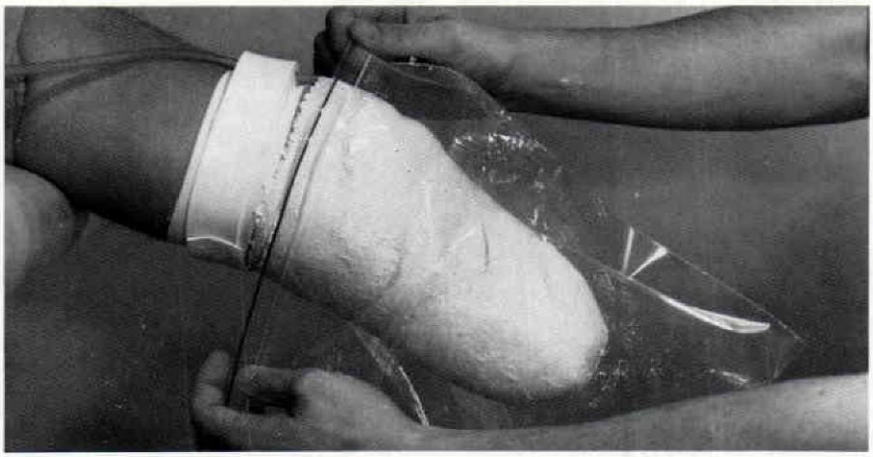

Figure 12. Apply the vacuum bag over the negative impression.

Figure 13. Seal the bag to itself and the Plastisol band.

Figure 14. Apply vacuum (20 to 30 inches of mercury).

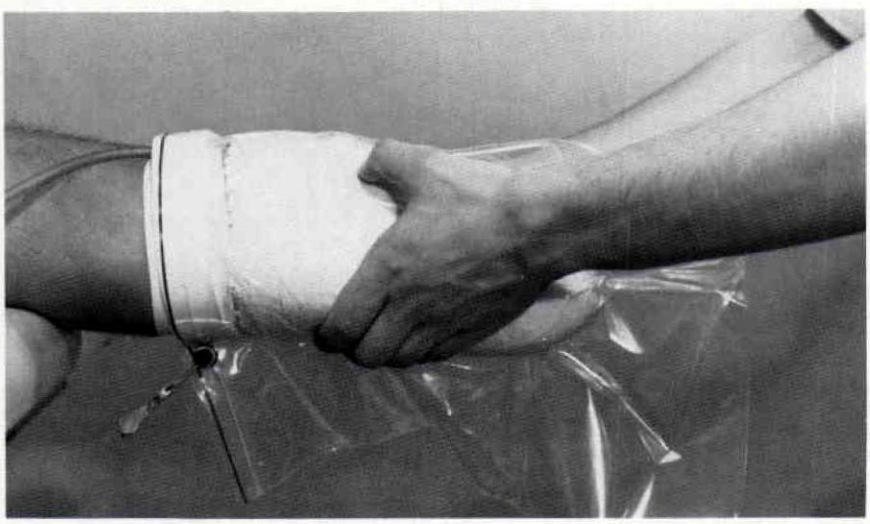

Figure 15. Hand molding of the negative impression is optional but can be applied in critical areas if desired.

Standard bandages rather than elastic plaster bandages are used due to their greater strength. Three to four layers are sufficient. An excess of five layers cannot be drawn against the skin accurately because of the excessive vacuum pressure required (Figure 11).

9. Apply the Zip-Lock® plastic bag over the plaster wrapped limb, keeping the fastener in contact with the Plastisol sealing band (Figure 12). Using the Zip-Lock® fastener, seal the bag and secure with a Yates clamp (Figure 13). An effective seal is important; without it the vacuum casting technique will not work.

10. Apply vacuum pressure to the bag, drawing between 20 to 30 inches of mercury (Figure 14). While under vacuum, the negative impression may be molded by hand if desired, but this is not necessary. If molding is required, the vacuum casting technique has a unique tendency to hold the specified shape molded into the negative impression in position (Figure 15).

11. Once the plaster has hardened, the negative impression can be removed fol-

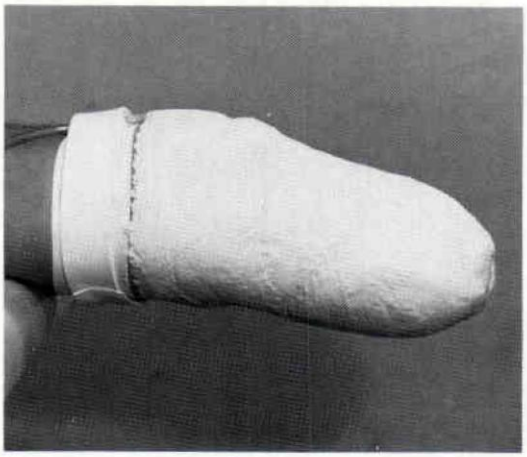

Figure 16. The vacuum bag is removed.

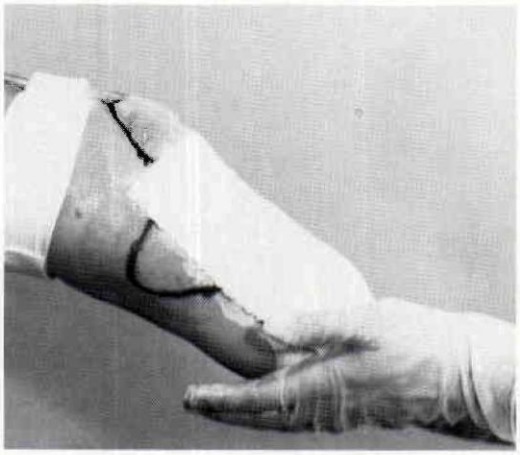

Figure 17. Application of the anterior splint.

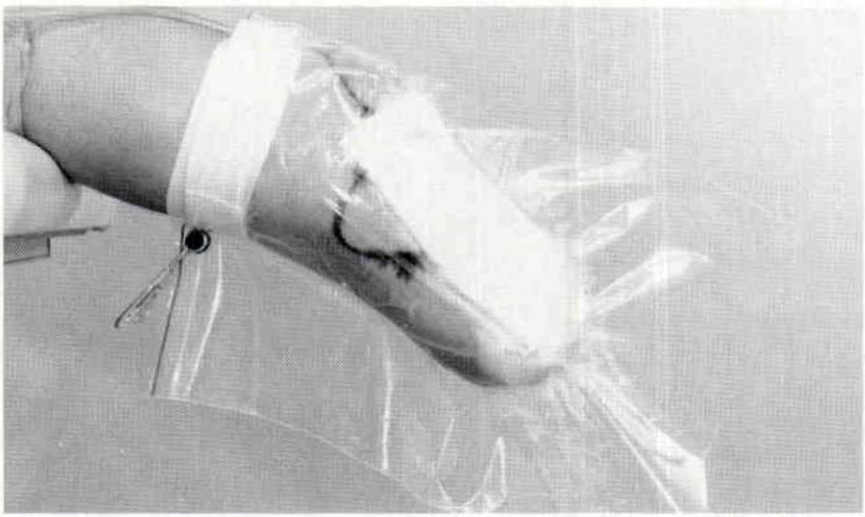

Figure 18. Vacuum is applied after first stage.

lowing removal of the bag, Plastisol sealing band, Microfoam tape, and finally the negative impression (Figure 16).

If a multistage cast (Fillauer's two and three stage technique) is used, the vacuum is applied after each wrap (Figure 17). Once the plaster has hardened, the vacuum bag is removed and the patient is ready for the next stage (Figure 18). Again, it is important that the wrap or splints (anterior or supracondylar) not exceed five layers in thickness. When using the three stage technique for supracondylar suspension, it is important that the Plastisol band be repositioned proximally to allow sufficient room for the proximal splint.

CONSIDERATIONS

While the below knee vacuum casting technique ensures equal pressure distribution, certain precautions should be taken:

1. Always use a clean tube. If a clean tube is not used, there is a greater chance that it will become clogged and the vacuum will be insufficient to draw the plaster against the skin.

2. Placing the tubing underneath the stockinette will function as: (a) a filter to prevent large plaster particles from being drawn into the tube and, (b) to keep the plastic vacuum bag from sealing directly

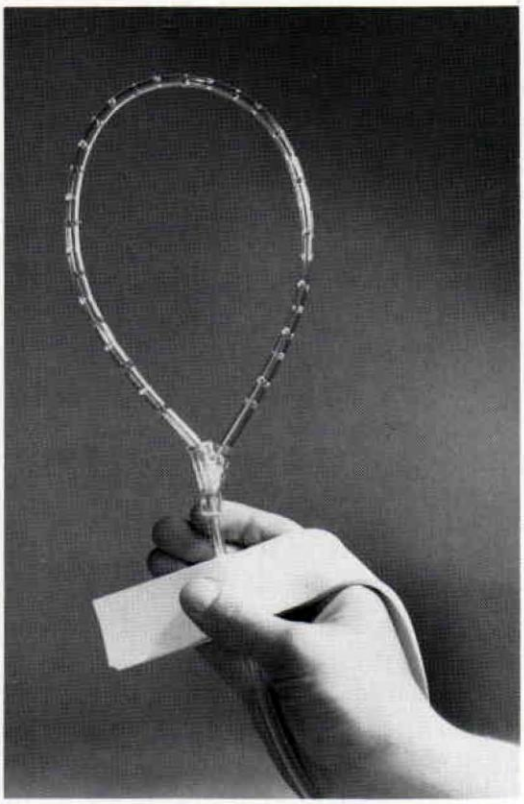

Figure 19. The tubing is connected back to itself using a "Y" connector.

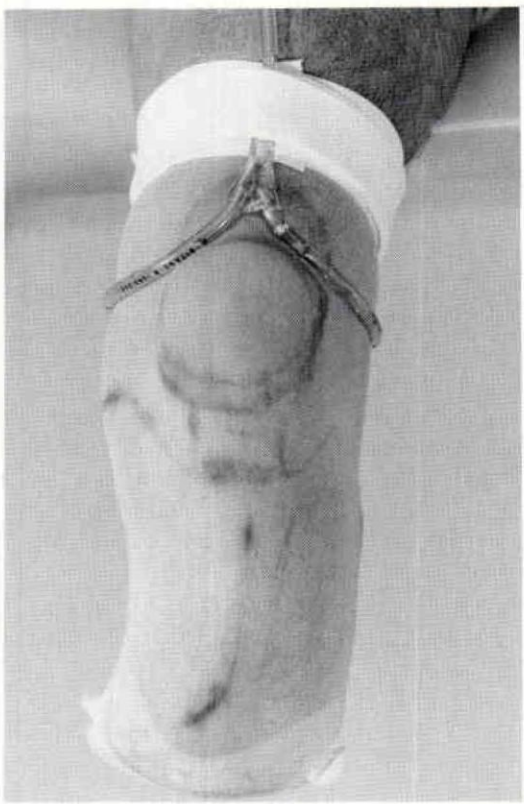

Figure 20. The tubing is then inserted through the Plastisol band and wrapped around the residual limb.

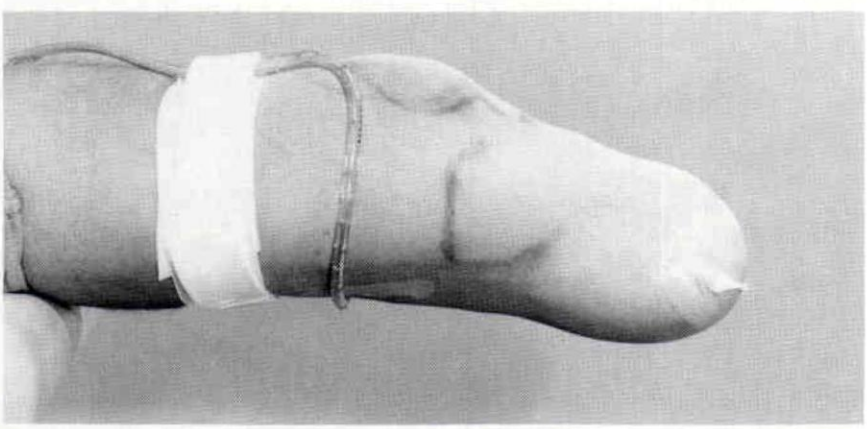

Figure 21. Lateral view. Note: The tubing should run under the sock before casting.

against the tubing and thus blocking the vacuum holes.

3. Seal the vacuum bag tightly against the Plastisol band. A good seal must be obtained or maximum pressure will not be achieved. If sealing does become a problem, wrap double-faced tape around the Plastisol band before applying the vacuum bag.

4. For improved posteriodistal vacuum pressure on the residual limb, the tubing may be wrapped proximally around the

extremity and connected back to itself using a universal connector (Figures 19, 20, & 21).

DISCUSSION

The vacuum casting technique is more efficient, and actually takes less time, than more conventional techniques when considering setup, application, and removal.

1. Less time is needed to mold the plaster in place because the vacuum creates the general contour.
2. The plaster sets quicker because vacuum removes water from the mold, which promotes setting and reduces the time required on the patient.

The vacuum casting technique is very accurate. Unlike existing hand molding techniques, the vacuum casting technique was developed for the specific purpose of eliminating impression variations, such as those encountered in serial casting a patient by the same practitioner and casting a patient by different practitioners. The prosthetist can now regulate and visually monitor the amount of pressure applied to the plaster negative. The resulting accuracy makes this technique easy to teach.

As many prosthetists are aware, exact duplication in conventional hand molding techniques is difficult because casting requires distorting tissue in some areas, and not in others, while maintaining total contact. However, the vacuum casting technique does exactly this. It provides total contact under equal pressure, and allows the prosthetist to mold the impression in particular areas if necessary. The vacuum casting technique has proven so far to be the most efficient system to offer both of these capabilities. This system can also be modified for use in orthotics, which will be discussed in a subsequent article.

CONCLUSION

The success or failure of any casting technique depends on its accuracy, but accuracy cannot be obtained without the ability to regulate and monitor the amount of pressure while casting. Under existing casting techniques, hand molding takes place which is dependent on the subjective judgment of the practitioner. This explains why variations occur between the same patient, different patients, and between practitioners.

The vacuum casting technique was developed for the specific purpose of minimizing impression variations by allowing the prosthetist to regulate and monitor the amount of vacuum pressure to achieve the detail desired. This technique also enables the prosthetist to modify certain areas simultaneously if desired. The vacuum casting technique appears to reduce time, be more efficient, and increase the comfort and control of the prosthesis due to the improved accuracy of this fitting system.

ACKNOWLEDGMENTS

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The Negative Anatomically Modified Foot Orthosis (NAMFO)

Ray Marvin, C.P.O.
Philip Brownrigg

INTRODUCTION

A method of taking a non-weightbearing impression, during which considerable modifications may be achieved, has been developed to produce a corrected foot orthosis. Significant advantages include enhanced skeletal stabilization, correction, and shock absorption. The term Negative Anatomically Modified Foot Orthosis (NAMFO) has been coined to differentiate between this and other methodology.

The procedure involves taking a non-weightbearing impression, which has two important effects:

1. It allows ready access to the complete foot in order to achieve an accurate, intimate impression with desired correction.
2. The plantar surface soft tissues including the hydrostatic pads under the heel and the metatarsal heads are not displaced medially or laterally.

The University of California Berkeley Laboratories (UCBL) shoe insert and subsequent adaptions to the original model are well-documented. Traditional attempts are to achieve a flattening under the calcaneal and metatarsal head areas by taking the negative impression in weightbearing and by affecting positive impression modifications. It would appear that the primary concern is on fitting the orthosis to the shoe (truly a "shoe insert") with orthotic management fairing a poor second. Two articles are of particular note. Campbell and Inman (1977) describe a method of tibial rotation, weightbearing casting in which tension on the plantar aponeurosis and longitudinal arch is avoided. Colson and Berglund (1979) proposed the removal of plaster from the positive impression under the Sustentaculum tali to try to achieve greater calcaneal control. The shoe is dictating and limiting the potential of foot orthoses.

It is proposed by the authors to take a different perspective on foot orthoses, to fit a corrected orthosis to the foot, by designing a Negative Anatomically Modified Foot Orthosis (NAMFO). The system has two significant advantages:

1. The retention of the natural soft tissue cushioning promotes shock absorption.
2. As there is less interposing soft tissues between the sides of the orthosis and the underlying boney configuration, there can be enhanced skeletal stabilization and correction, enabling an intimate orthotic fit. There is little emphasis on relief. There is little need for anything but the most stringent buildups over boney prominences on the positive impression (Figure 1).

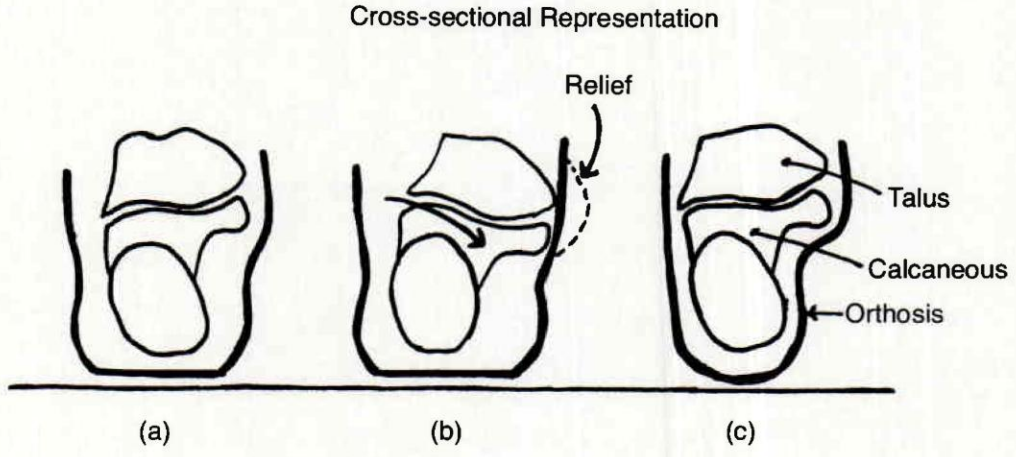

Figure 1. Diagram (a) demonstrates poor skeletal stabilization, resulting in excessive boney movement, necessitating reliefs (b). Improved stabilization end control makes reliefs unnecessary (c).

One of the concerns regarding an impression taken in non-weightbearing is that it should be rounded on the heel and over the metatarsal heads. Traditionally, these areas are flattened parallel to each other to minimize "rocking" and motion of the orthosis within the shoe.

However, slight movement of the orthosis relative to the shoe is not necessarily undesirable. During normal locomotion for the normal person, about six degrees of inversion/eversion occurs at the subtalar joint. Complete skeletal stabilization is only possible by surgical fusion. There will be some extra soft tissue compression before skeletal stabilization occurs, even with the best designed orthosis, as complete preloading of the soft tissue would not be tolerated. The plastic is not completely rigid, therefore, there will still be slight inversion/eversion of the foot within the orthosis and simulated inversion/eversion of the orthosis within the shoe, involving a loading time. The NAMFO will facilitate normal locomotion.

THE ARCHES

The normal foot is basically directly loaded on the plantar surface of the calcaneous and the metatarsal heads. By accentuating both the longitudinal and transverse arches in the orthosis a number of objectives are achieved:

1. Abnormal weight distribution over the metatarsal heads can be redistributed.
2. Loading the longitudinal arch reduces the forces exerted on the metatarsal heads.
3. Loading the longitudinal arch, in eversion deformity allows larger force distribution area, therefore greater correction.
4. In loading the shafts of the metatarsals by utilizing a transverse metatarsal dome, pressures are lowered on the metatarsal heads (see Figure 1).

If you press behind the metatarsal heads you will find a point where pressure will cause the digits to extend. This is due to the attachment of the deep fibres of the plantar aponeurosis, the Sagittal Septa, into the sides of the flexor sheaths and the plantar ligaments. As the plantar ligaments are firmly attached to the bases of the proximal phalanges, pulling of the basically inextensible plantar aponeurosis up over the shafts of the metatarsals will produce digital extension. This is in part a reversal of the so called "Windlass action" that occurs on dorsiflexion of the toes (Figure 2).

The superficial fibres of the plantar aponeurosis insert into the skin of the anterior part of the ball of the foot, and as Bojsen-

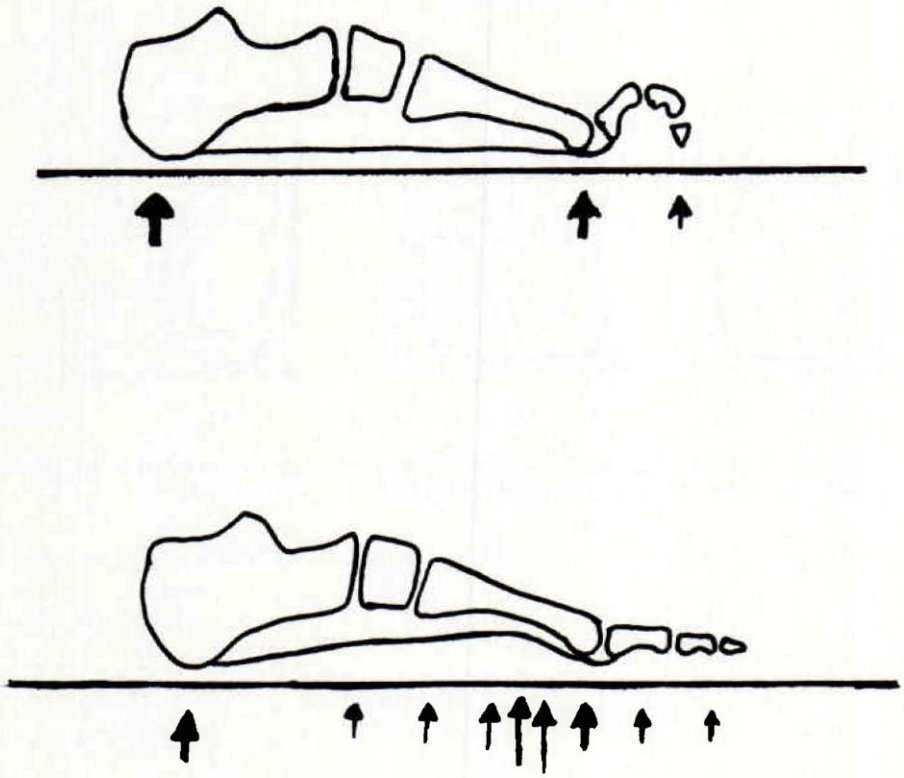

Figure 2. In toe clawing, forces are borne on the metatarsal heals and tips of the digits. The dome leads the metatarsal shafts and pulls on the plantar aponeurosis causing digital extension. For long standing deformity, therapy to elongate the intrinsic musculature would be recommended.

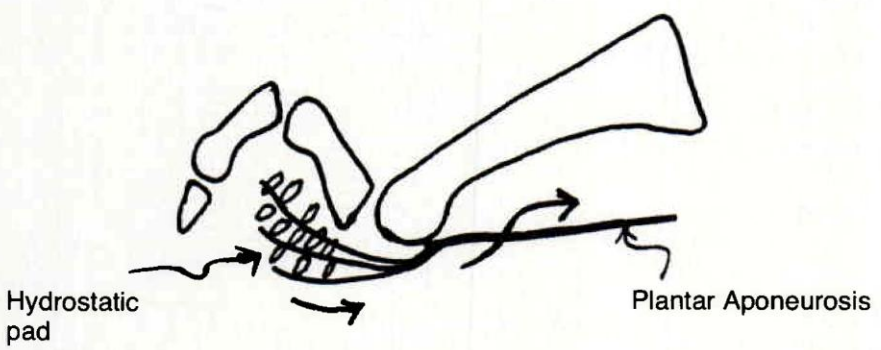

Figure 3. The hydrostatic pad, incorporated into the vertical fibres of the plantar aponeurosis, is pulled anteriorly in toe clawing. The metatarsal dome will pull this protective pad back under the metatarsal heads.

Møller (1978) points out, restrain the skin from sliding anteriorly during the pre-swing phase of gait. In toe-clawing or hammertoe deformity, the vertical fibres of the plantar aponeurosis—including its cushioning fat—that lie superficial to the metatarsal heads are drawn anteriorly, leaving the heads exposed to the trauma of locomotion. The exaggerated metatarsal dome we advocate will re-draw this protective cushion back under the metatarsal heads, take excessive pressure off the tips of the toes (frequently the site of pressure necrosis) by extending the digits, and will load the metatarsal shafts (Figure 3).

Soft commercial domes have long been available. Because they are compressible they serve predominantly to pad the foot and achieve limited correction. The hard plastic metatarsal dome incorporated into the NAMFO is markedly superior.

POSITION FOR TAKING THE IMPRESSION

Probably the easiest position is that with the patient prone on an examination table. Ready visual and manual contact can be made with the plantar and dorsal surfaces of the foot, and accurate alignment of the forefoot to the hindfoot, and the foot to the crura, can be achieved. The knee should be in some flexion to ensure the gastrocnemus is relaxed. If heel height is of concern, the position of the hindfoot to forefoot can be easily manipulated. In our practice we made no allowance for the normal range of heel heights.

THE METHOD

Boney prominences are marked. The joint spaces of the first and fifth metatarsal heads may be marked to confirm the location of the metatarsal heads. The foot is manipulated to ascertain the degree of correctability desired in the cast.

A 75 to 100mm plaster of paris bandage is wrapped around the foot.* There is no need to encapsulate the entire dorsum of the foot or the complete malleoli. It only makes it difficult to remove the negative impression. A measure above the trim is sufficient.

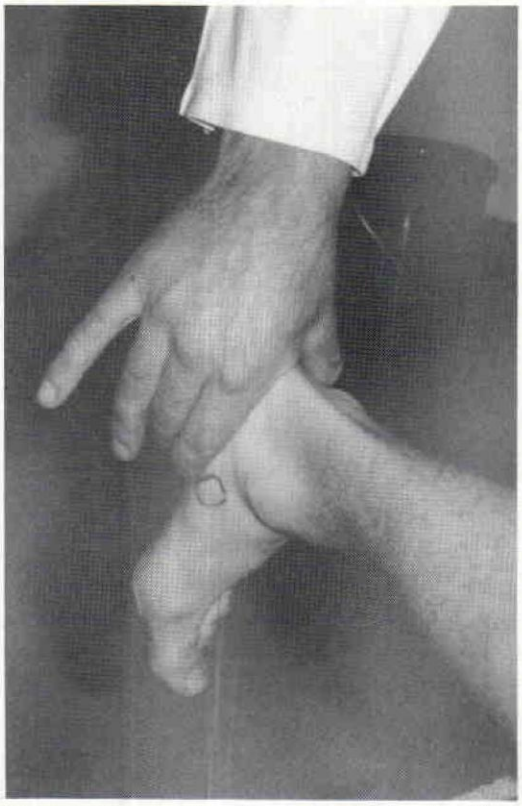

Figure 4. Gripping the calcaneous to achieve hindfoot control and position. The talus is outlined.

Moulding is commenced under the longitudinal arch. The calcaneous is grasped between thumb and forefinger, the second finger passing down under the sustentaculum tali. With a drawing motion the pressure-tolerant soft tissue under the sustentaculum tali and other medial and lateral soft tissue are compressed to stabilize the calcaneous. Calcaneo-talar joint control is sought and the amount of inversion/eversion is determined by manipulating the gripped calcaneous. This is the primary control for the entire foot (Figure 4).

Moulding is done in such a fashion as to draw the medial and lateral soft tissue

*No casting stocking is used, but a little lubricant over hairy areas may be applied.

down under the calcaneous. The rubbing is done in a downwards direction.

To locate the position of the apex of the metatarsal dome, pressure is applied with the pad of the thumb behind the metatarsal heads. Correct location is indicated when the digits extend. There is usually some breeching of the plastic during vacuum-moulding, so do not be afraid of over-emphasizing the dome.

With the calcaneous stabilized in the above manner, pressure is applied with the thumb pad to fashion the dome. The fingers curl up over to the dorsum of the forefoot and it is manipulated relative to the (stabilized) hindfoot to provide pronation/supination twist of the forefoot. The amount will depend on the degree of correctability and the desire to align the forefoot parallel to the hindfoot (Figure 5).

When the plaster of paris is cured, the impression is removed from the patient by sliding it off the heel. Distortion is minimal, even though the wrap is still slightly malleable.

Figure 5. Manipulating the forefoot relative to the (stabilized) hindfoot to achieve pronation/supination twist.

BALANCING THE ORTHOSIS

With a rounded heel and metatarsal heads, the orthosis will be stable within the shoe so long as the calcaneous and the first and fifth heads form a stable tripod. The still-green impression is placed on a flat surface. The second and third fingers of one hand are put inside the impression over the first and fifth heads and the index finger of the opposite hand is applied to the site of the calcaneous, gently adding pressure to achieve the stable tripod. The ma-

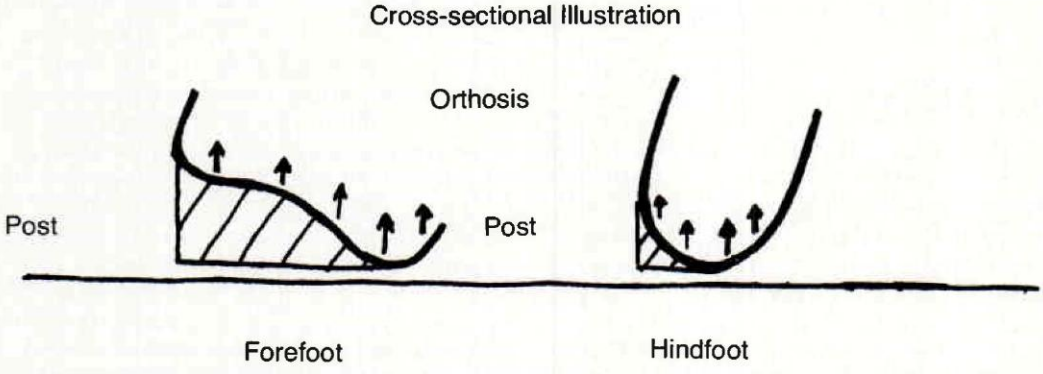

Figure 6. Posting the orthosis so as to distribute weight-bearing forces more evenly over the entire plantar surface of the foot in cases of non-correctible deformity. This reduces pressure on the borders of the forefoot and calcaneous.

nuever may correct error in taking the impression or it may introduce a greater than desired element of correction (this would be changing the amount of forefoot pronation twist). Judgment has to be exercised. It has been our experience that the great majority of patients can be balanced in this manner.

If deformity, fixed or functional, prohibits full correction to allow the calcaneous, first, and fifth metatarsal heads to be in contact with the floor, one may elect to post the orthosis to establish the tripod. Remember the NAMFO is designed to fit the patient's foot. It is not merely a shoe insert (Figure 6).

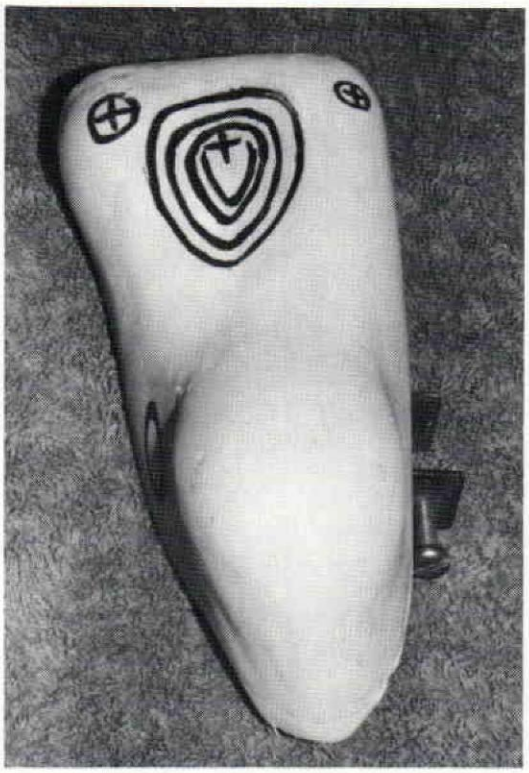

Figure 7. The completed positive impressions. The topographic lines indicate depth. The 'X' marks the highest point of the dome. Note the natural contours achieved and the definition around the calcaneous indicating the "grasping" effect that gives the control.

MODIFICATIONS TO THE POSITIVE IMPRESSION

As extensive modifications can be accurately achieved on the negative impression, few modifications are needed on a skillfully executed impression. Usually only a smoothing and the blending in of the "dome" into smooth profile is required. A vacuum hole may be drilled in the apex of the dome.

Occasionally, the dome needs to be widened and deepened (the apex is over the third metatarsal). Or, the area under the sustentaculum tali must be more heavily screened to enhance subtalar control (Figure 7).

Buildups are not normally required. If the patient has excessive pressure over boney prominences, it indicates insufficient skeletal stabilization allowing the boney framework to move excessively within the orthosis. This spells two possibilities:

1. Poor cast-taking
2. Over-optimistic expectations from the NAMFO. A NAMFO with extended leverage, that is an Ankle Foot Orthosis (a NAMAFO) may be indicated.

VACUUM FORMING

It is not necessary to wait for the impressions to dry. A "pantyhose" is put over the impression and the plastic is cooled rapidly. A quick spray of silicone ensures the hot plastic will not stick to the nylon (Figure 8).

THE FITTING

The NAMFO fits intimately over the plantar, medial, and lateral aspects of the foot. It redistributes forces and allows accurate correction of the skeletal structure working through a soft tissue interface. Forces will be applied to unaccustomed areas and there will be a variance in individual tolerances. Some accept the orthosis immediately while others need to build up their tolerance by wearing the orthosis, for example, three hours the first day, four the second, and so on. It may require breaking

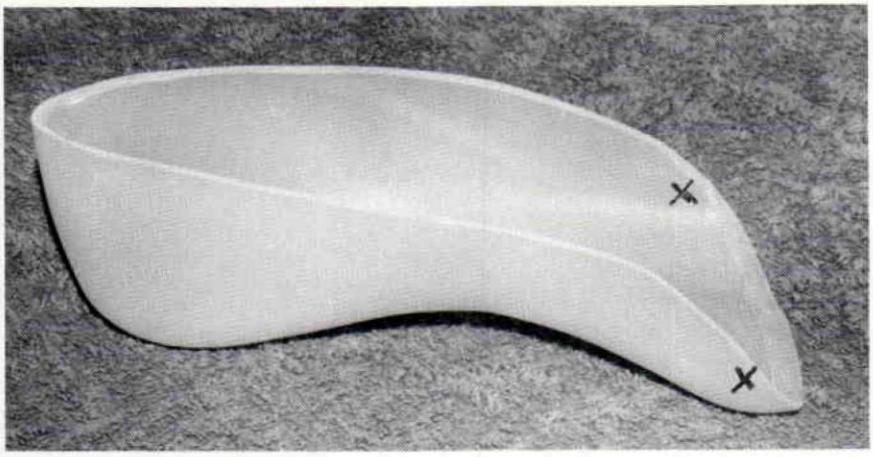

Figure 8.

the wearing into two periods during the day, with increasing increments. If the patient has not found the NAMFO comfortable within ten days, then the impression was incorrect.

Some reddening may be initially present, however, so long as you are confident of the impression, this is no cause for concern. Superficial reddening may occur until skin tolerance is achieved, just as a Patella Tendon Bearing Prosthesis (PTB) may initially cause reddening over the patellar tendon.

Patients should be instructed as to the variance in establishing tolerance. Most patients will describe a firm pressure from their new orthosis and will express frank or relative comfort. Occasionally you may not be able to achieve all the correction you want because the patient would not initially tolerate it. A later cast can be taken introducing the final correction.

The shoe is not part of the orthotic management as such. We often recommend inexpensive runners as the soft material holds the foot intimately within the orthosis, not allowing relative movement of the foot to the orthosis. The softer shock absorptive type heel is also advantageous.

Patients with diabetes and peripheral vascular disease require the usual extra care and attention to detail. Some restraint and slower introduction may be required until orthotic expertise is attained and the patient can provide reliable feedback. Otherwise, management is as described.

TIME

If accurate positive modifications are achieved, the impressions can be made, poured, screened, and vacuum-formed under the conventional time for producing UCBL shoe inserts.

APPLICATION

We have had outstanding success with a wide variety of patients whose feet are exposed to abnormal stresses due to imbalance or abnormal functional demands.

Rheumatoid feet with subtalar instability, exposed pressure-sensitive metatarsal heads and toe-clawing respond well to subtalar control, loading on the metatarsal shafts, the metatarsal cushioning redrawn posteriorly, toe extension, and the natural calcaneal pad enhanced.

Similarly, upper motor neuron lesion patients have responded well. The typical picture is of inversion/plantar flexion of the foot, toe-clawing and plantar thrust reflex. The calcaneal "gripping" provides greater subtalar control. The exaggerated dome will encourage digital extension, thereby reducing abnormal tone, as this is a distal "key point of control" used in physiotherapy technique.

Two particular kinetic reflexes, the plantar thrust reflex and the positive supporting reaction, are initiated by pressure on the ball of the foot. The dome will dampen these reflexes**. Thus, greater distal control may be achieved, which in turn facilitates proximal control. A significant number of patients who formerly would have been treated with an Ankle Foot Orthosis (AFO) respond with a NAMFO. This is psychologically more acceptable and suggests that this system has a definite role in early rehabilitation to facilitate voluntary control.

Impressive results have so far been achieved in the treatment of distance runners. Greater all-over plantar surface loading, natural soft tissue cushioning and the balance of forces suggest the NAMFO would have a vital place in the prophylactic as well as the sports-injury orthotic management. The marathon runner's foot requires all the assistance it can master to mitigate the enormous insults to which it is subjected. The system is compatible with the addition of a shock absorptive insole between the orthosis and shoe.

Plantar surface callosities, signs of abnormal forces, will resolve with the correct application of the NAMFO as the abnormal forces are resolved by anatomical correction. It is common experience for patients who have had years of podiatry treatment involving the continual removal of callosities, to return some months after initial fitting with soft smooth plantar skin, having had no subsequent podiatric attention. The pathological forces have been corrected, so the callosities disappear.

Thermoplastic A.F.O.'s, particularly for the rheumatoid and the neurological patient with abnormal reflexology and increased tone, should be cast in two stages—the first, the NAMFO, and the second part up the leg—to achieve the NAMAFO. Accommodation for heel height is made by manipulating the forefoot relative to the hindfoot. Similarly, the use of serial plaster for neurological patients with very marked, uncontrolled lower limb extensor tone and plantar thrust reflex should be conducted with attention to the principles raised in this article, and with similar techniques.

We would challenge many of the traditional treatments of the pediatric foot that involve the use of orthopaedic shoes with external modifications because of the lack of specific skeletal control. Preliminary work has shown encouraging results in a variety of conditions.

Once again, the improved control offered by this orthosis frequently enables a NAMFO to be used instead of an AFO. Advantages are all too obvious.

CONCLUSION

The thermoplastic NAMFO and the NAMAFO, taken in non-weight bearing, incorporates vastly improved subtalar control, and greater correction of abnormal forces on the forefoot by employing a metatarsal dome and increased shock absorption.

It is the authors' belief that with skill and understanding, possibilities not previously considered or achieved in the treatment of both the orthopaedic and neurological foot can be realized using this system.

**As the stimuli for these reflexes are considered to be stretch of the intrinsic musculature, and, to a lesser extent, cutaneous stimulation, we do not yet fully understand the mechanism behind this phenomenon. Certainly part of the answer would lie in the nature of the correction that is achieved, the total contact, and the resultant reduction of sudden stretch stimulating a clonus response and general extensor tone.

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AUTHORS

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Syntactic End Seal Technique

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

There are a variety of alignment couplings and prosthetic components that attach to wood or premade plastic end seals (Figure 1). The method of attachment is usually via wood screws or machine screws. The attachment of alignment couplings to wood end seals with wood screws is time consuming and prone to error. Premade end seals with threaded inserts offer the convenience of using machine screws for attachment, but require a separate step to attach the socket to the end seal with resin, foam or other adhesive material. The variety of hole patterns in the allignment couplings rarely allow interchangeability between different units and premade end seal hole patterns (Figure 2).

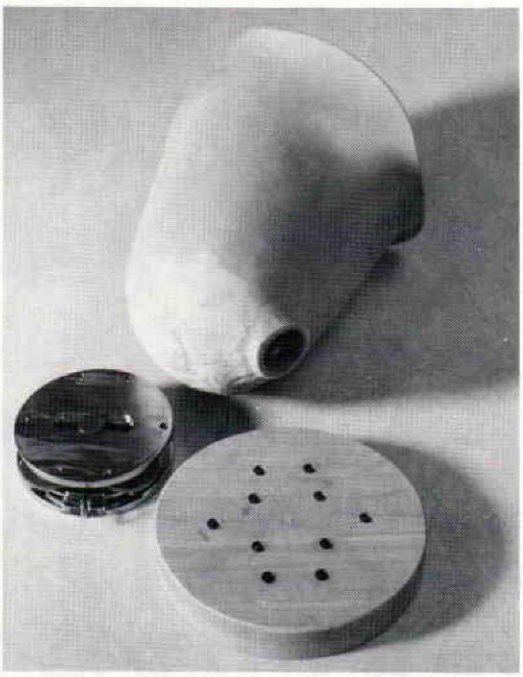

Figure 1. Recently developed universal end seal.

Figure 2. Hole patterns in alignment couplings vary greatly.

Figure 3. The top ring from the adjustable leg is aligned to the cup and its hole pattern is marked.

The Syntactic end seal technique creates an attachment end seal with imbedded threaded inserts while simultaneously attaching the socket to the end seal. The following procedures describe the technique in detail for use with the U.S.M.C.-V.A.P.C. below-knee adjustable pylon. But, many other prosthetic components require affixation for which the Syntactic end seal technique may also be useful. The plastic used in this technique was carefully

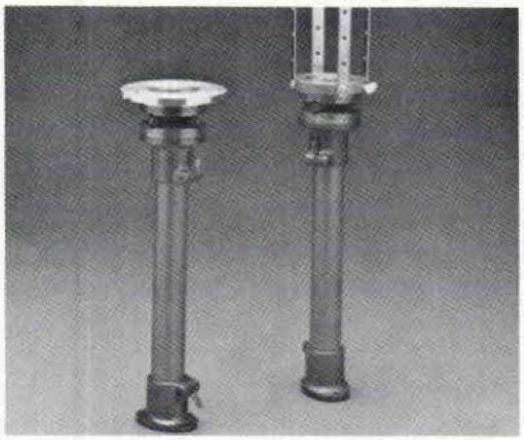

Figure 4. USMC below knee adjustable leg.

selected for its strength and durability. While other plastic materials may also be suitable for the Syntactic end seal technique, none were found to be as high in strength nor as fast curing as the new plastic called Syntactic resin.

The U.S.M.C. below-knee adjustable pylon (Figure 3) is the component we will use to demonstrate the Syntactic end seal technique. The attachment ring (Figure 4) at the top of the unit is available with six spaced holes. Remove the ring from the unit and place it on the bottom of a paper cup, noting the anterior position of the ring. The cup should have a large enough opening to permit the insertion of the dis-

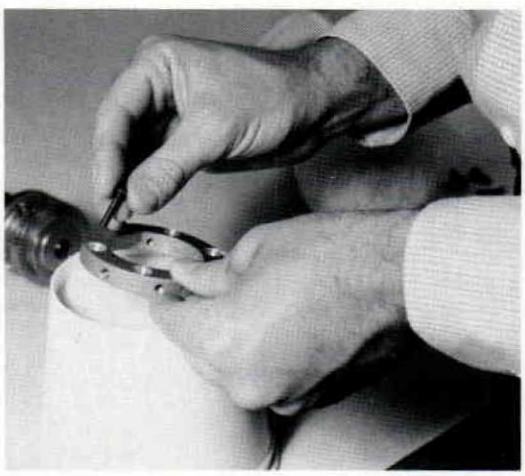

Figure 5. Machine screws are inserted through the ring and cup.

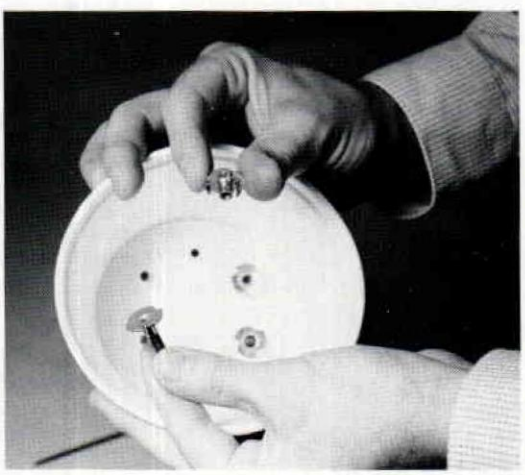

Figure 6. "T" nuts are fastened inside the cup to the machine screws.

tal end of a below-knee socket. Carefully mark the hole pattern using an awl or similar sharp instrument to pierce small holes through the bottom of the cup. Insert 10-32 flat head machine screws through the attachment ring and paper cup shown (Figure 5). Care must be taken to insure exact hole alignment. Inside the cup attach 10-32 "T" nuts to the 10-32 flat head machine screws and tighten snugly (Figure 6). Be sure the "T" nuts are inserted as shown with prongs facing upward toward the opening of the cup.

Noting the anterior position of the alignment ring, set the socket into the cup in standard bench alignment. The vertical duplication machine can be used to hold the socket in place, or alignment lines can be inscribed on the socket and the socket can be hand-held as shown in Figure 7. The socket should be generously roughened, particularly when thermoplastic sockets are used and a mechanical bond will be the primary adherent mechanism.

Syntactic resin is now used as a bonding agent to create the end seal with "T" nuts imbedded in it and at the same time to attach the socket to the end seal. A mixing ratio of 50/50 is suggested for maximum strength with Syntactin resin. The Syntactin resin will set in less than two minutes from the time the two components are mixed together. It is ready for grinding in less than ten minutes, or when the plastic has cooled. The strength of the resin increases for about eight to ten hours.

While patients have been walked within an hour after pouring the resin, precautions should be taken with any curing plastic before walking trials are started.

Syntactic resin may be used by itself or mixed with micro-spheres. The micro-spheres will, however, weaken the material. In a separate cup, mix 100 grams of the Syntactin resin "A" component. Carefully

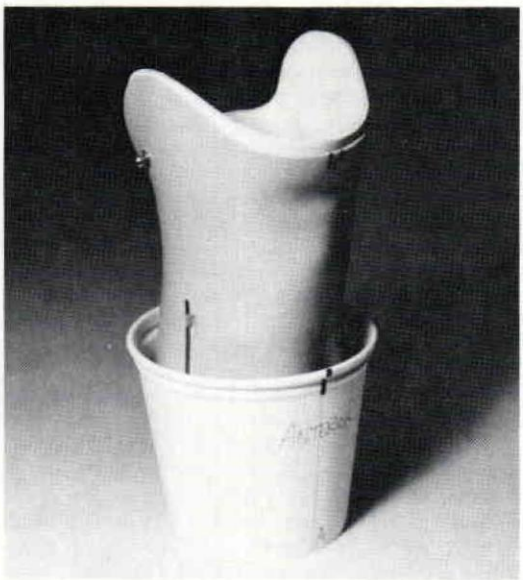

Figure 7. The below knee socket is balanced in proper bench alignment with "T" nuts in place.

Figure 8. Syntactic resin is mixed in a 50/50 ratio by weight.

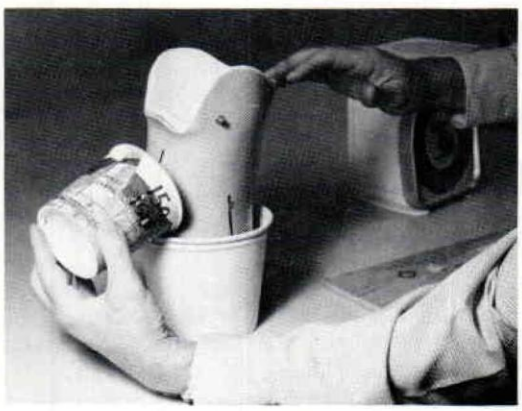

Figure 9. After a thorough and rapid mixing, the syntactic resin is poured into the cup.

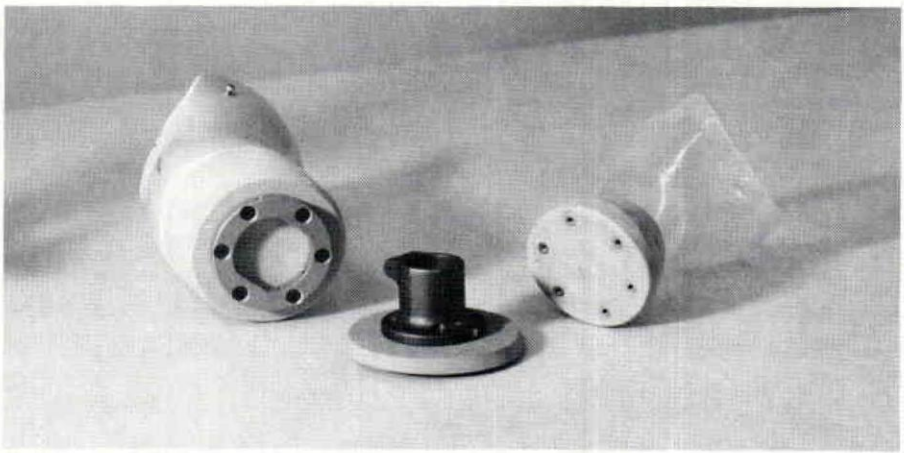

Figure 10. Syntactic end seal technique used with polyester below knee socket, Thermovac below knee socket, and with USMC below knee module clamping component.

measure the same amount of the "B" component into the cup and begin stirring immediately (Figure 8). Thorough mixing for 30 seconds is essential. Pour the contents of the mixing cup into the cup alignment and insert the socket in its proper alignment (Figure 9). Do not use silicone release agents on the interior of the cup as it seems to affect the surface cure of the Syntactic resin. Total organization of the work project is essential for good results.

When the Syntactic end seal has cooled, remove the cup by peeling or grinding (Figure 10). Care should be taken when grinding the attachment surface to remove material at exactly 90 degrees to the alignment of the "T" nut orientation (Figure 11). Syntactic resin may then be shaped as desired. Laminations with polyester or acrylic resin over Syntactic resin should be prefaced by roughing the surface of the Syntactic resin. Pure Syntactic resin without micro-spheres appears to adhere to or accept acrylic resin better than it does polyester resin. When Syntactic resin is mixed with micro-spheres, polyester or acrylic resin seem to adhere equally well.

In testing the strength of the Syntactic end seal technique in various prosthetic applications, the results in Figure 12 were compiled as pertinent to the prosthetic applications of the technique.

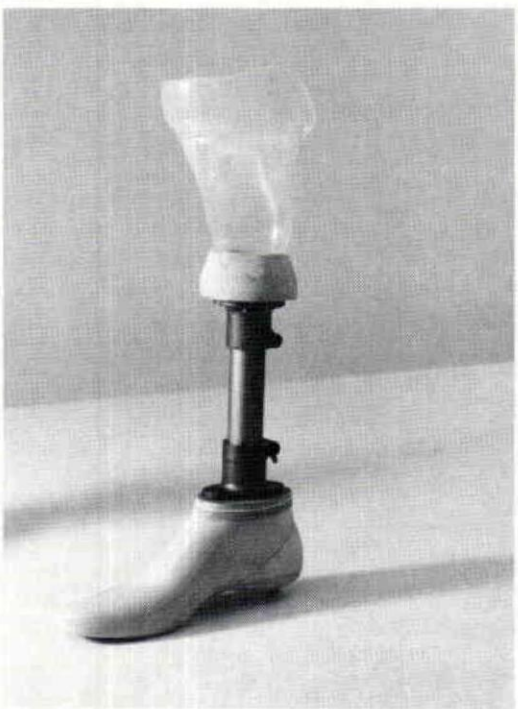

Figure 11. A Thermovac socket mounted on a USMC below knee pylon using syntactic end seal technique.

While further testing will be done on applications of Syntactic resin, experiences thus far have shown the material, when

TEST	DESCRIPTION OF TEST	BREAK POINT	COMMENTS
1	U.S.M.C. wood end seal with "T" nuts	950 lbs.	Pull to break, wood broke, "T" nuts intact
2	Syntactic Resin—Mix No. 1 micro-spheres	850 lbs.	Pull to break, Syntactic resin broke, "T" nuts intact
3	Syntactic Resin—Mix No. 2 micro-spheres	875 lbs.	Pull to break, Syntactic resin broke, "T" nuts intact
4	Syntactic Resin—unfilled	1000+ lbs.	Could not break
5	Polyester B/K socket U.S.M.C. wood end seal (polyester-solka floc)	580 lbs.	Wood Split in half at "T" nut locations, four "T" nuts used
6	Polyester B/K socket Syntactic end seal technique	650 lbs.	One "T" nut used, two three or four "T" nuts could not be broken on the test equipment
7	Thermo-Vac socket— Syntactic resin end seal	340 lbs.	Syntactic resin was filled with micro-spheres "T" nuts pulled out
8	Polyester socket-wood end seal U.S.M.C. below-knee adjustable pylon wood screws	130 lbs.	Wood screws pulled out, this socket had been walked on
9	Polyester socket-Syntactic resin V.A.P.C. below-knee adjustable pylon	450 lbs.	Coupling snapped in half and pylon bent. Syntactic end seal intact

Figure 12.

properly used, to be extremely high in strength. This may be possibly as high as 60,000 P.S.I. tensile strength.

CONCLUSION

The Syntactic end seal technique is an efficient method of creating an end seal and setting up a socket in bench alignment simultaneously. Research into the possibility of forming the socket at the same time as the end seal would further speed up the fabrication process, particularly in light of the high speed cure the Syntactic resin exhibits.

ACKNOWLEDGMENTS

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A Revised A/K Adjustable Socket

Paul Burnette, C.P.
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The Adjustable Above Knee Prosthetic Socket, originally developed at Rancho Los Amigos Hospital, is used both as an interim socket during the maturity process of the residual limb and as a lightweight adjustable socket for the marginal ambulator.[1] However, due to the construction at the distal attachment point, only the proximal four inches of the socket could actually be adjusted. This original design did not allow for distal atrophy of the residual limb, which resulted in the loss of total contact at the distal end of the residual limb, and patient discomfort. There also existed the possibility of proximal constriction from over-aggressive tightening. Since the distal dimensions could not be altered, the only solution we found to this problem was to change the socket at some point during the maturation process of the residual limb.

Our goal was to develop a socket which would be adjustable throughout the full length of the socket. This would eliminate the problem of changing the adjustable socket before the patient's limb had matured to the point where they could be fitted with a definitive socket. To determine the amount of adjustment necessary to fulfill this requirement, we measured 34 patients at the time of their initial preparatory prosthetic fitting and measured them again at the time of their first definitive prosthetic fitting (Figure 1). This time ranged from 3½ months to 14 months. Of the 34 patients (varying in age from 28 to 72 years old) six were eliminated from the study because of excessive weight change. The lengths of their residual limbs ranged from 8¼" to 10¾". The AP and circumference measurements were taken beginning at the ischial level and at 2" intervals increasingly distal on the residual limb (Figure 2). The results of these measurements were then used to determine the atrophy of the residual limb at each level (Figure 3).

This study documented that the residual limb usually atrophies in circumference uniformly throughout its length, and that some modification of the socket's adjustability was therefore desirable. Sanding the distal part of the shells does allow more flexibility, but it tends to weaken the structure, and increases the risk of socket fatigue. The solution was to modify the socket by adding slots at the socket pylon attachment point, and reducing the AP of the anterior shell (Figure 4).

The socket attachment plate was also modified to a rectangular shape to allow for the AP reduction. These modifications increased the proximal circumference adjustment range to 1½", the distal circumference adjustment range to 1⅛", and the

A/K SHRINKAGE REPORT

This study includes 28 sample measurements of residual A/K limb circumferences and AP measurements. It will demonstrate the atrophy that occurs in the residual limb between the initial (IN) fitting and the definitive (DN) fitting.

Minimal/Maximal/Average

The initial 0" level circumference (the most proximal measurement) ranges from 18.00 to 22.25 inches with the average 20.53. The definitive 0" level circumference ranges from 17.00 to 21.50 inches with the average 19.57. This indicates an average shrinkage of .96 inches.

The initial 2" level circumference ranges from 17.25 to 21.50 inches with the average 19.40. The definitive 2" level circumference ranges from 15.88 to 20.50 inches with the average 18.44. This indicates an average shrinkage of .96 inches.

The initial 4" level circumference ranges from 16.25 to 19.75 inches with the average 17.88. The definitive 4" level circumference ranges from 14.50 to 18.50 inches with the average 16.97. This indicates an average shrinkage of .91 inches.

The initial 6" level circumference ranges from 13.88 to 17.75 inches with the average 16.06. The definitive 6" level circumference ranges from 13.13 to 16.63 inches with the average 15.09. This indicates an average shrinkage of .97 inches.

The initial 8" level circumference ranges from 11.75 to 16.63 inches with the average 14.89. The definitive 8" level circumference ranges from 11.00 to 15.50 inches with the average 14.11. This indicates an average shrinkage of .78 inches.

The initial AP measurements ranged from 2.75 to 4.00 inches with the average 3.57. The definitive AP measurements ranged from 2.38 to 3.75 inches with the average 3.28. This indicates an average shrinkage of .30 inches.

Figure 1. Study of the 28 patients, showing average shrinkage.

IN AP		DE AP	
2.75	3.75	2.38	3.38
2.88	3.75	2.75	3.25
2.88	3.75	2.50	3.38
3.25	3.75	3.00	3.25
3.25	3.75	3.00	3.50
3.25	3.75	3.00	3.50
3.50	3.88	3.38	3.75
3.50	3.88	3.38	3.50
3.50	3.88	3.13	3.65
3.50	3.88	3.13	3.50
3.50	3.88	3.25	3.50
3.50	4.00	3.50	3.75
3.50	4.00	3.13	3.50
3.63	100.04	3.38	91.70
3.75		3.38	
AVERAGES		SHRINKAGE	
3.573	3.275	0.298	

Figure 2. Breakdown of AP shrinkage from initial to definitive fittings.

IN 0	DE 0	IN 2	DE 2	IN 4	DE 4	IN 6	DE 6	IN 8	DE 8
18.00	17.00	17.25	15.88	16.50	14.50	15.38	13.50	14.13	12.88
18.50	17.25	17.75	16.38	17.00	15.25	15.75	13.88	14.25	13.50
18.75	17.88	18.13	16.88	16.75	16.00	15.25	14.75	14.25	13.75
19.13	18.88	18.00	17.88	16.25	16.38	14.38	14.38	13.25	12.75
19.25	18.38	18.13	17.25	17.25	16.50	15.75	14.50	15.00	13.88
19.75	18.50	19.13	18.00	17.25	16.75	14.38	13.50	13.13	12.75
20.25	19.13	19.38	18.25	18.00	17.13	17.25	16.50	16.63	15.50
20.25	19.38	19.00	18.50	18.25	17.63	17.25	16.25	16.00	15.25
20.25	19.13	19.00	18.25	17.88	17.00	17.25	16.50	16.00	15.13
20.38	19.50	19.63	18.88	18.50	17.75	17.25	16.63	16.38	15.50
20.38	19.50	19.00	18.25	17.88	17.13	17.25	16.50	15.25	14.50
20.50	19.75	19.38	18.63	16.88	16.13	13.88	13.13	11.75	11.00
20.50	19.62	19.25	18.38	17.13	16.25	14.13	13.13	13.50	12.75
20.50	19.63	19.25	18.38	18.00	17.13	15.75	14.75	15.00	14.25
20.50	19.75	19.75	18.88	18.50	17.75	16.75	15.88	15.38	14.50
20.75	19.50	20.13	19.00	18.25	17.75	15.38	14.50	14.75	14.00
20.75	19.50	20.00	19.00	18.75	18.25	17.00	16.50	15.50	15.50
20.75	19.88	19.50	18.50	16.13	15.13	14.25	13.13	14.00	13.75
20.75	19.75	20.25	18.75	18.50	16.88	16.75	15.50	14.75	14.00
21.00	20.21	19.13	18.25	18.75	18.00	17.13	16.25	16.25	15.50
21.00	19.75	19.88	18.75	18.50	17.38	16.75	15.50	16.50	15.00
21.25	20.35	19.75	18.75	18.38	17.50	15.25	14.25	14.13	13.38
21.50	20.25	20.25	19.50	18.00	17.25	15.75	15.00	14.50	13.75
21.50	20.25	19.75	18.50	18.75	16.88	16.50	15.25	15.13	14.25
22.00	21.50	21.50	20.50	19.75	18.50	17.75	16.25	16.25	15.13
22.25	21.25	20.13	19.00	18.25	17.25	16.13	15.00	14.75	13.88
22.25	21.38	20.25	19.38	18.38	17.50	16.25	15.25	14.50	13.75
22.25	21.13	20.50	19.75	18.13	17.50	17.25	16.38	16.00	15.38
574.89	547.98	543.05	516.30	500.54	475.05	449.79	422.54	416.91	395.16
AVERAGES									
20.532	19.571	19.395	18.439	17.876	16.966	16.064	15.091	14.890	14.113
SHRINKAGE									
0.961		0.956		0.910		0.973		0.777	

Figure 3. Breakdown of the shrinkage at each level from initial to definitive fitting.

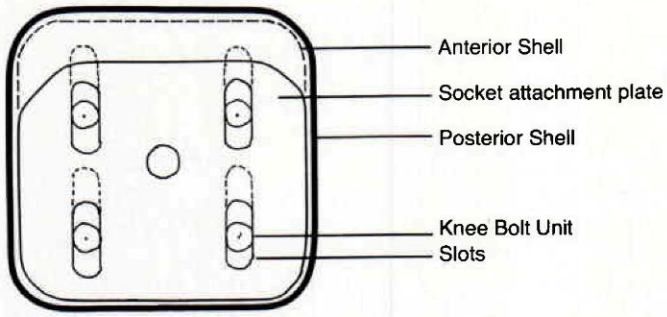

Figure 4. Diagram of distal attachment point.

AP dimension to ½" of adjustment. This allowed for a reduction of the socket's dimension throughout its length in direct correlation with atrophy of the residual limb, thereby maintaining total contact.

DISCUSSION

It must be pointed out that there are times when a prefabricated A/K socket will not provide an adequate fit, despite its greater adjustability. The need for a custom socket then becomes apparent. However, where indicated, the simple modifications described in this article allow the prosthetist a means for early fitting of the above knee amputee with a lightwight socket, which can easily be adjusted proximally and distally to accommodate for atrophy throughout the maturation of the residual limb.

NOTES

[1]Monsen D., Schmitter E., and Quigley M.: *Innovations in Rehabilitation of Amputees Associated with Malignancies*, 1981.

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Fabrication of the Water-Resistant Recreational B/K Prosthesis

Kenneth P. LaBlanc, B.S., C.P.O.

INTRODUCTION

The Veterans Administration Research Engineering Center (VAREC) has developed a method to provide a water-resistant prosthesis using commercially available components. This method allows a reduction in fabrication time as compared with others, such as the "Ultra Light" or Otto Bock methods. This is made possible by the use of the commercially available Beachcomber foot. The following article describes the fabrication technique for a below knee prosthesis only. However, with the use of the Otto Bock plastic knee set-up and the elimination of the plastic tubes, this method may also be used for above knee prostheses.

CASTING AND FITTING PROCEDURES

Using standard prosthetic procedures, a negative impression is taken, a positive model made and modified, and a socket laminated. The socket's distal end is foamed to form an extension for attachment of an alignment coupling.[1] The proper size foot is selected and standard bench alignment is used to assemble the component parts. The Staros/Gardner alignment fixture is ideal for this set-up. Figure 1 illustrates the prosthesis with the alignment

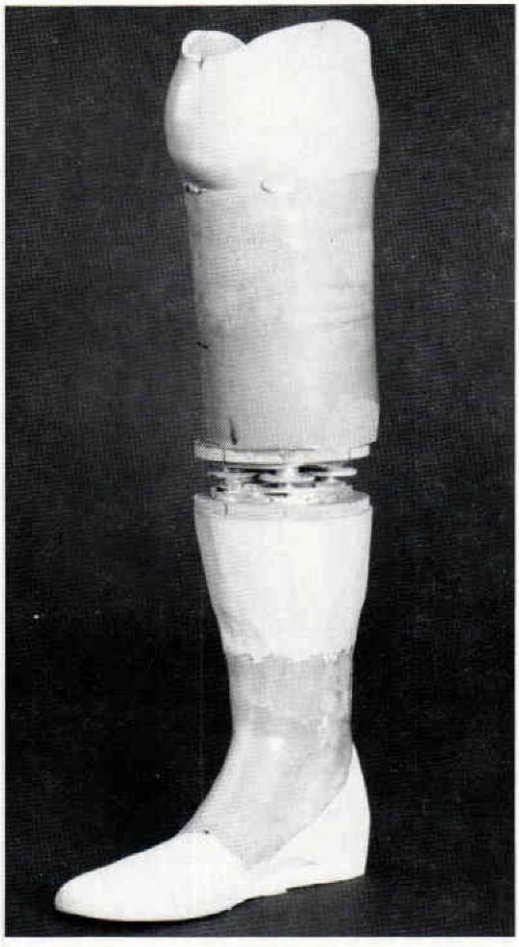

Figure 1. Prosthesis ready for fitting (Old-style foot).

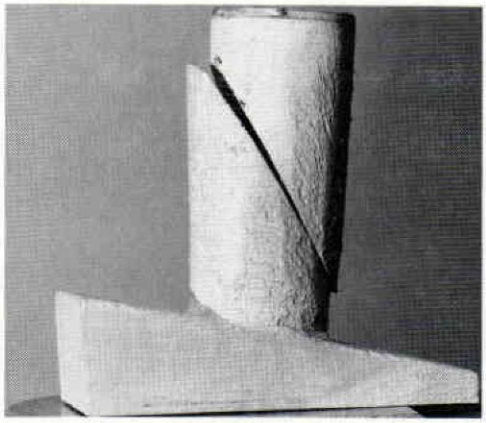

Figure 2. Wooden holding device for transfer fixture.

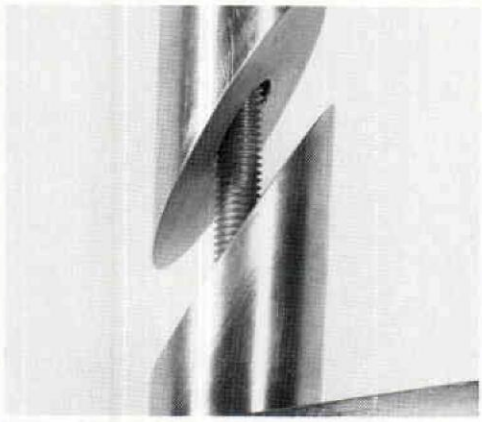

Figure 3. New aluminum holding device.

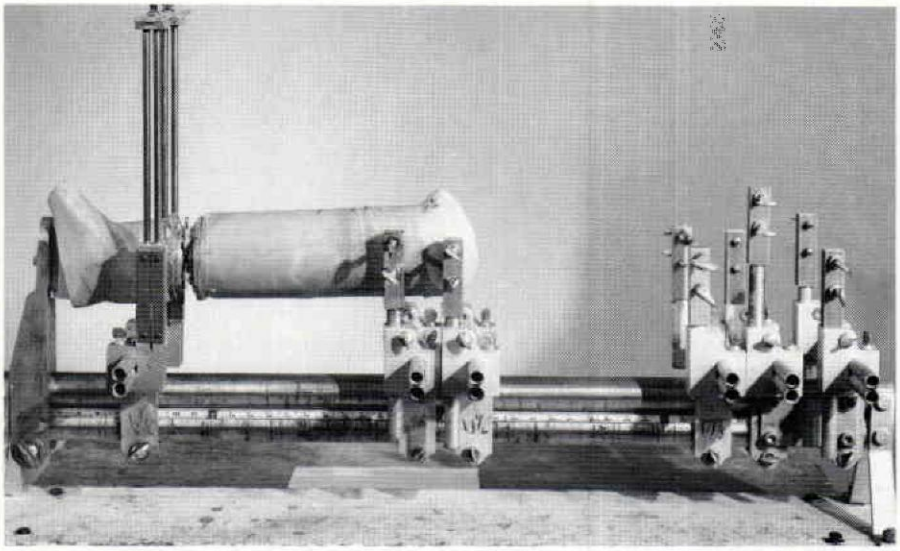

Figure 4. Prosthesis in transfer fixture.

fixture in place, ready for fitting and dynamic alignment, with the rubber sole cemented to the foam ankle block.

With the fitting and dynamic alignment procedures completed, the prosthesis is now ready to be transferred and finished.

TRANSFERRING PROCEDURE

The rubber sole should be removed at this time. A simple holding device is used to hold the foot during the transfer procedures (Figure 2). By tightening the ankle bolt, the top portion within the tube is offset, similar to the way most footrests on wheelchairs are held in place. Figure 3 illustrates the new holding device presently being used. This device may be used in either the horizontal or vertical transfer fixture. We at VAREC prefer to use the horizontal fixture.

The prosthesis is then secured in the transfer fixture with a saw guide in place (Figure 4). Two saw cuts are made through the foam sections, one below the alignment fixture, one above it. The first cut should be through the ankle block as far proximal as

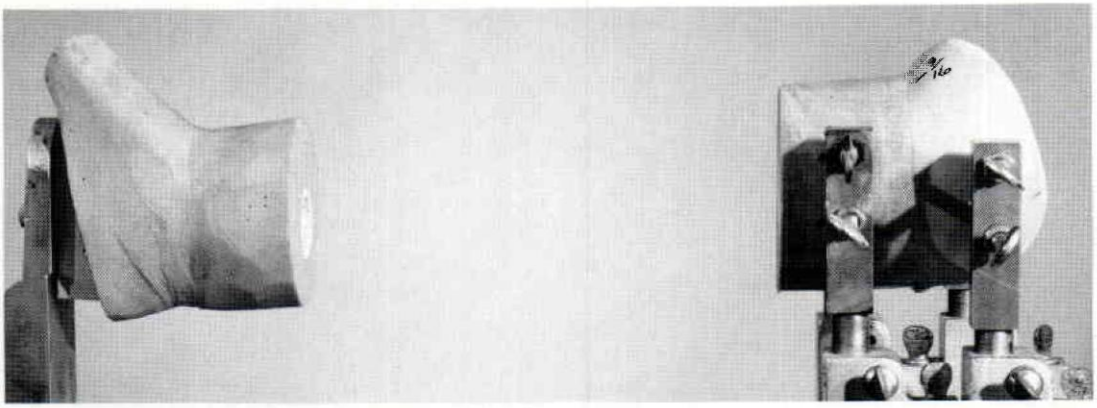

Figure 5. Prosthesis after alignment fixture is removed.

possible. The second cut is made at the very distal end of the socket, and should expose the lamination. Figure 5 illustrates the prosthesis after the two saw cuts have been made and all materials in-between have been removed.

A piece of 1¼" O.D. Poly Vinyl Chloride (PVC) tubing—available in most hardware stores—is measured and placed in the void between the ankle block and the socket. This tube is then centered on a similar tube already in the ankle block and the very distal end of the socket. Bond it in place (at VAREC we use Devcon 5 minute epoxy for bonding) and let the epoxy harden. Be sure to place paper over the fixture, to protect it from the epoxy. Figure 6 illustrates the tubing bonded in place. Once the epoxy has hardened, the prosthesis may be removed from the transfer fixture.

FINISHING THE PROSTHESIS

A ¼" hole is drilled at the posterior distal end of the socket in the PVC tubing, and a ¼" O.D. PVC flexible tube is installed. This tubing allows the air to escape as water enters the larger tube. Trim the foam from the posterior part of the socket to allow the tube to lay against the socket wall. The PVC tubing should be long enough to reach from the hole to at least 2" above the proximal posterior (center) trim line of the socket. This step is important, and will

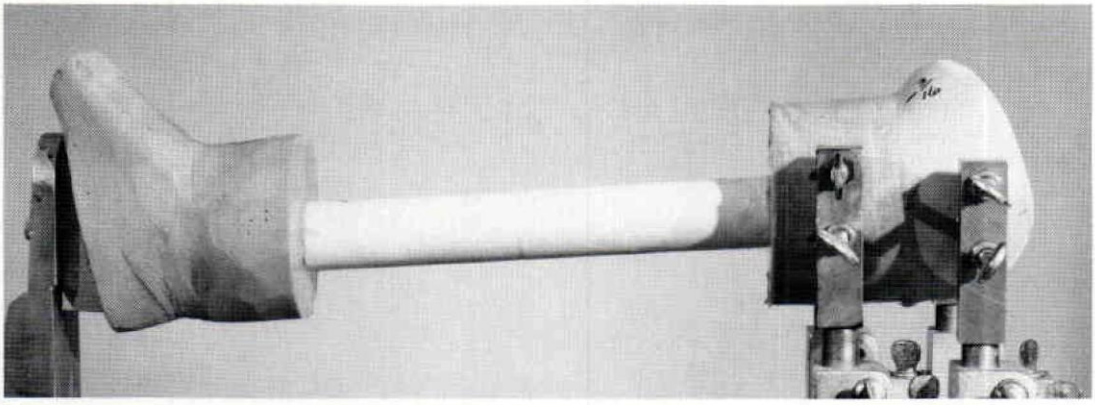

Figure 6. PVC (1¼") tubing bonded in place.

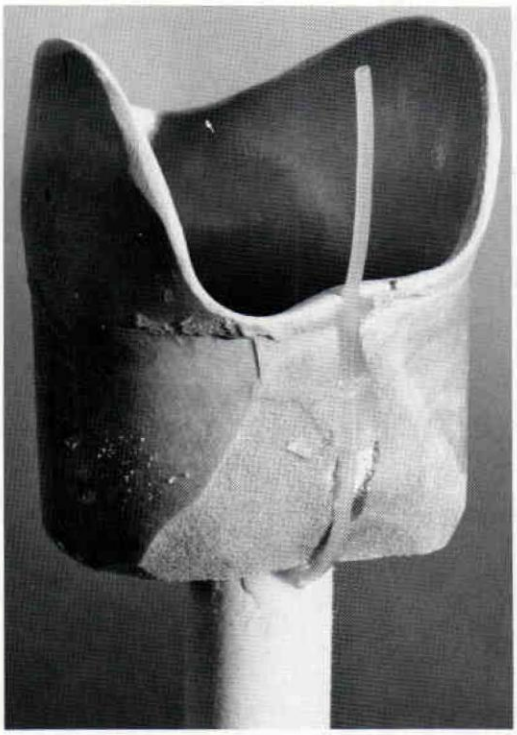

Figure 7. Air tube bonded in place.

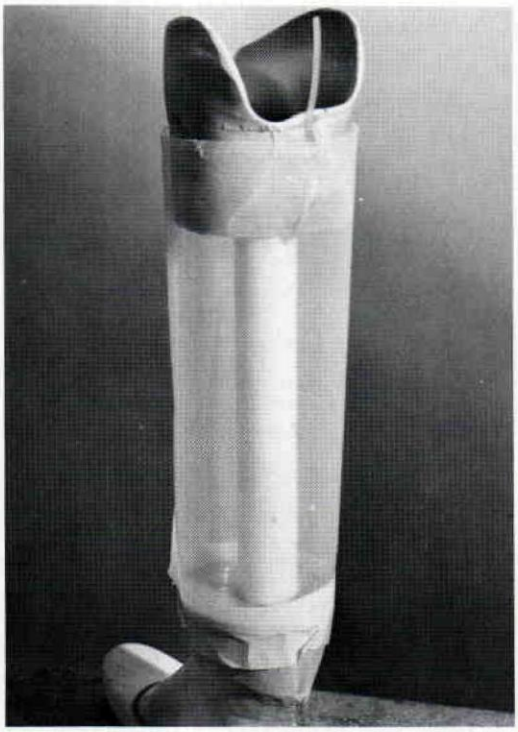

Figure 8. Plastic sleeve taped in place ready for pouring foam to obtain proper shaping.

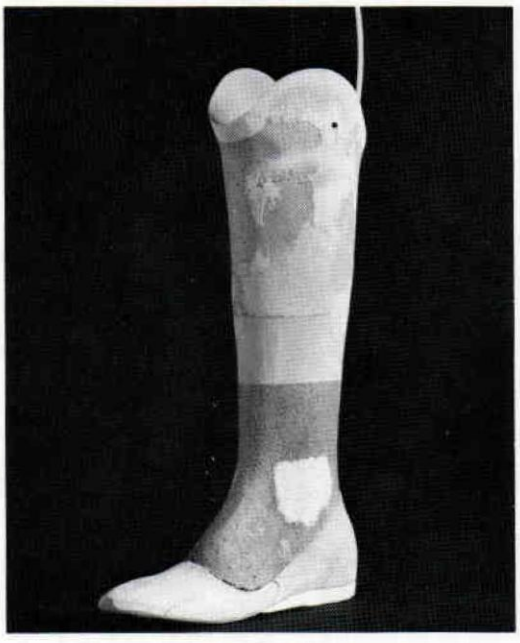

Figure 9. Prosthesis ready for lamination.

prevent resin from blocking the tube during final lamination. Bond the small tube in place with epoxy. Figure 7 shows the small tube in place.

Place a thin piece of polyethylene or X-ray film over the prosthesis, forming a sleeve in which to pour the foam (Figure 8). Tape it in place so the foam may be poured into the sleeve. Mix the necessary amount of foam to fill the cavity. The amount of foam used varies with the size and length of each prosthesis. Pour the mixture and let it harden.

After the foam has hardened, shape the prosthesis as desired to agree with measurements, filling all voids. The foam ankle block must be reduced to accommodate the thickness of the final lamination, thus providing a smooth transition to the rubber sole. The prosthesis is now ready for lamination (Figure 9).

LAMINATING PROCEDURES

The conventional lamination procedure is used. Although vacuum is not necessary however, it does help hold the PVC in place around the ankle. Two layers of nylon stockinette are used for final lamination. The air tube is taped closed and a piece of Kemblo rubber is glued over the PVC tubing at the distal end.

Measure a piece of nylon stockinette, wide enough to fit over the prosthesis, and twice the length of the prosthesis plus three or four inches. Locate the middle of this piece and sew a semi-circular shape at that point. Then pull the stockinette over the prosthesis. Reflect the remainder over the first part of the stockinette (Figure 10). Make sure the proper size of stockinette is used, so that there are no wrinkles left. Tie the stockinette off to the mandrel at the proximal end of the socket.

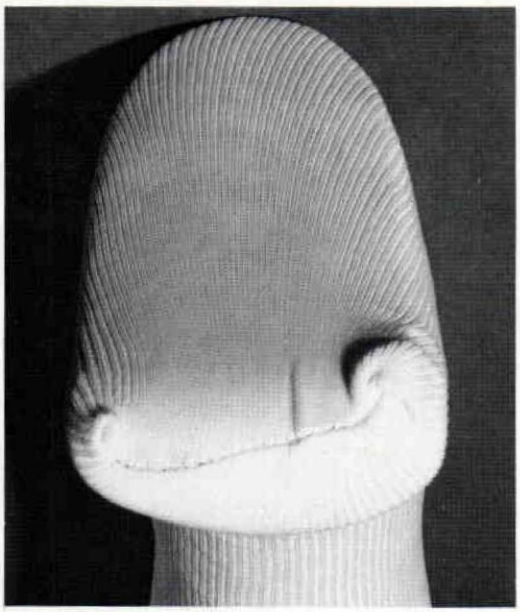

Figure 10. Two layers of stockinette pulled over prosthesis. Seam over keel area.

Pull a snugly fitting PVA sleeve over the entire prosthesis. The sleeve should be pulled over the prosthesis, in order that the small opening ends at the most distal part of the foot (keel area). Tie the PVA sleeve to the mandrel. If vacuum is used, connect it at this time.

Mix the proper amount of resin and the appropriate color for the prosthesis. Pour the mixture into the PVA sleeve. Work the resin into the stockinette. String out the resin, as excess resin adds weight, not strength. Once the resin is in place, pull the small end of the sleeve back and tape it off with pressure sensitive tape. This will give you a smooth line at the keel area. Remove excess resin in the small part of the sleeve. Let the resin cure properly.

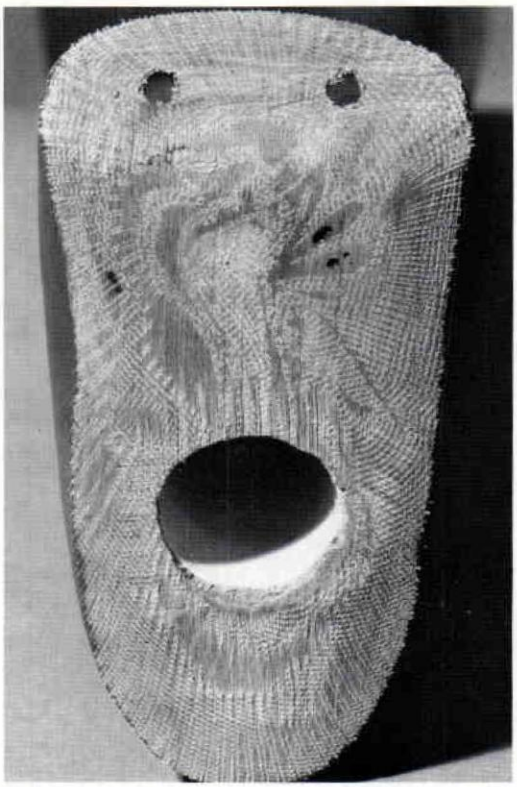

Figure 11. KEEL area sanded and ¼" holes drilled for bonding sole to KEEL.

Trim all areas to finish the prosthesis. Remove the Kemblo patch, exposing the PVC tubing. Trim the air tube at the proximal edge of the posterior wall. Sand the distal part of the keel[2] so the rubber sole may be bonded in place. Drill two ¼" holes in the keel (Figure 11). Tape should be placed around the borders of the keel in order that the cement does not spread.

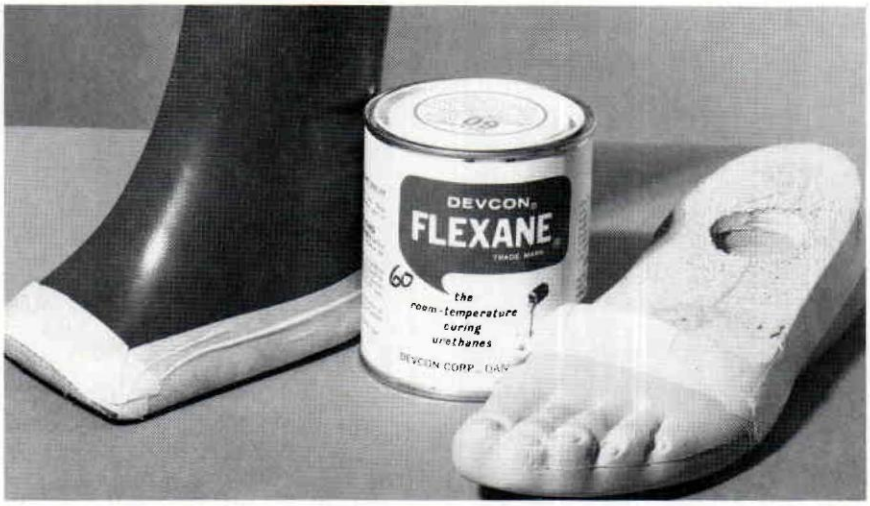

Figure 12. Tape placed around edge of KEEL and rubber sole.

Tape should be placed around the rubber sole edges for the same reason (Figure 12).

To cement the rubber sole in place, use Devcon Flexane Putty #60 or #80 (#60 is more flexible). Mix an amount according to directions provided with the cement. Bond the sole in place, matching the hole in the rubber sole to the PVC tubing opening. Pressure-sensitive tape may be used to hold the sole in place until the cement cures. It should cure for twenty-four hours before the prosthesis is worn. Be sure that the flexane is placed into the two ¼" holes drilled in the keel. The cement line may be painted with the proper color to provide a better appearance (Figure 13).

To allow water to drain out of the socket area, three or four holes ⅛" to 3/16" are drilled at the distal end of the socket. Their location must be within the PVC tubing. If a liner is used, a hole should be drilled in the same area. The first prosthesis fabricated at VAREC had plugs with holes (Figure 14); however, it was found that drilling a few holes worked better.

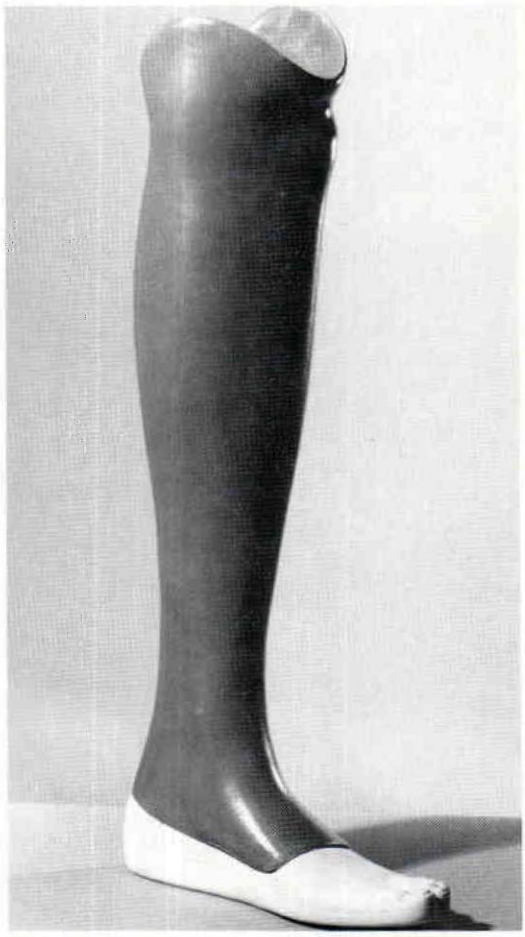

Figure 13. Rubber sole bonded to prosthesis.

DELIVERY

With a PTB design, add a suspension strap, fabricated from waterproof materials; the prosthesis is now ready for delivery. Figure 15 illustrates a posterior view of the air hole. Figure 16 illustrates the com-

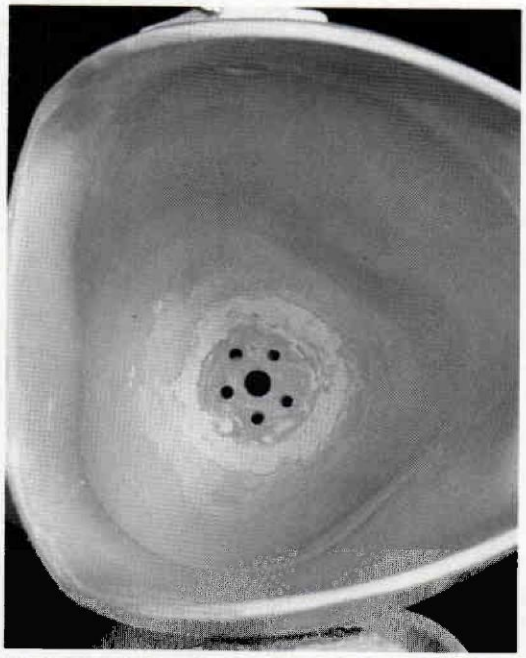

Figure 14. Distal end of socket (interim) with holes to allow water to drain from socket.

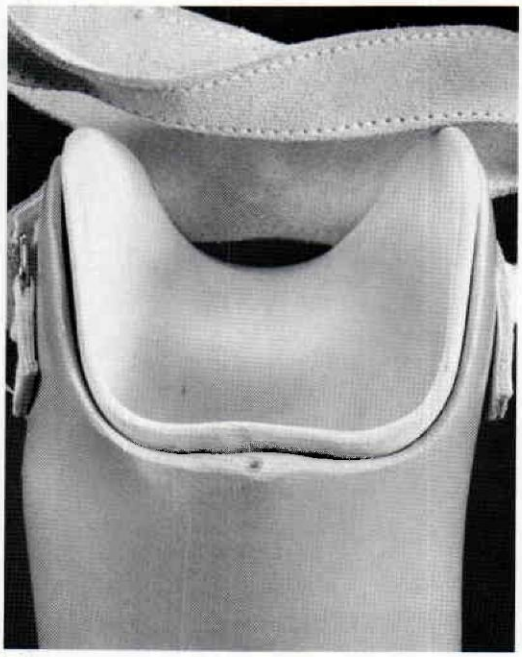

Figure 15. Posterior view showing air vent.

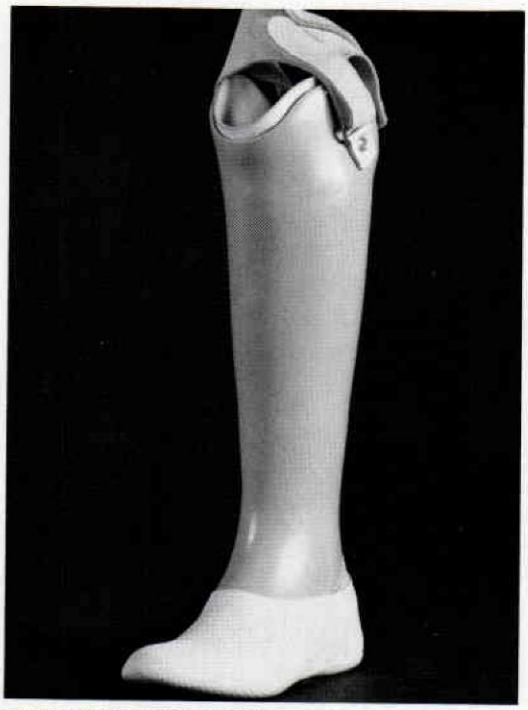

Figure 16. Completed P.T.B. prosthesis.

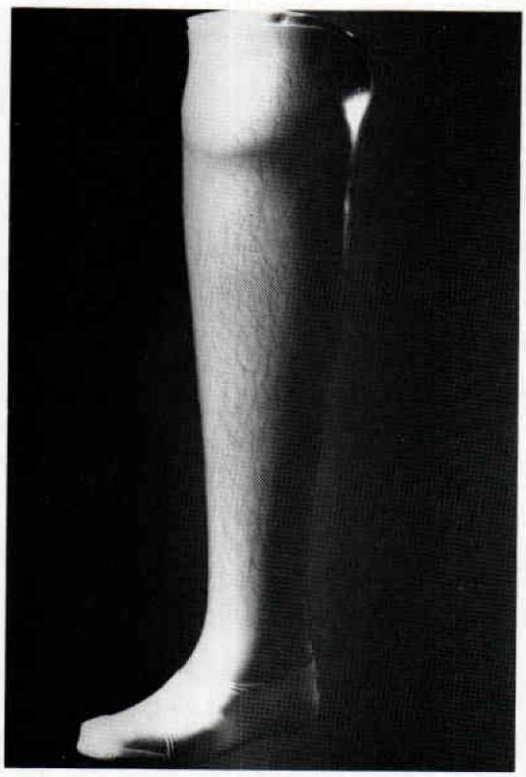

Figure 17. Completed P.T.S. with a cosmetic touch.

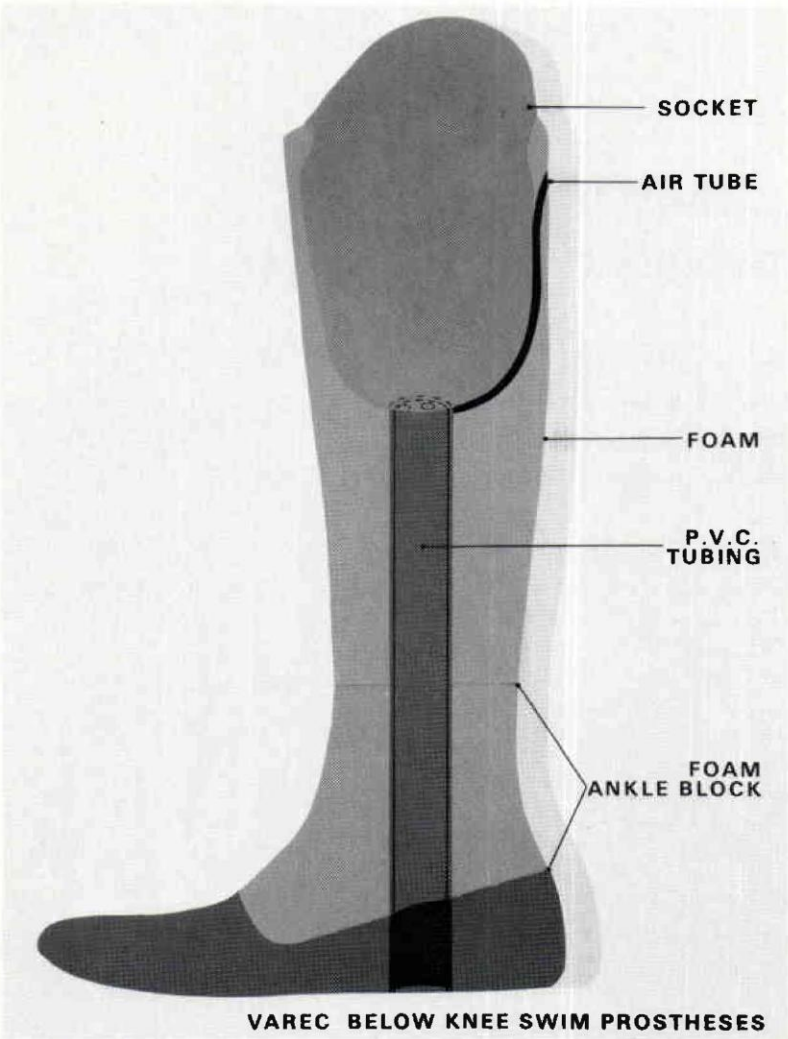

Figure 18. Diagram identifying various components of VAREC's swim prosthesis.

pleted prosthesis, anterior view. Figure 17 illustrates a completed P.T.S. with a cosmetic finish. Figure 18 illustrates a cutaway of the entire prosthesis and identifies the different components.

The PVC tubing allows water to enter the prosthesis as the amputee walks into the water, making it less buoyant. The air escapes via the air tube. As the amputee exits the water, it drains out at the bottom of the foot. Swim sneakers may be used, but holes should be made in the sole to allow water to enter and exit the tube.

CONCLUSION

This paper has outlined the fabrication techniques for a waterproof recreational Below-Knee prosthesis. By the use of tubing and air outlet lines, buoyancy may be controlled.

NOTES

[1]Otto Bock foam is used at VAREC for this procedure.

[2]Note that the center portion of the distal part of the heel will be slightly higher. This must be sanded flush to the edges of the keel. Do not expose the foam beneath.

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Hip Disarticulation: A Prosthetic Follow-Up

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Hip disarticulations and hemipelvectomies represent radical forms of surgery which are done rarely and only when other alternatives aren't available. Such radical surgery is often done secondarily to a malignancy, although other diseases or conditions may ultimately lead to hip disarticulation. Although there have been several articles dealing with follow-up treatment of tumors or biomechanical modifications of prosthetic devices, few reports have been done regarding either the success of prosthetic fitting, or the problems faced by patients who wear a hip disarticulation prosthesis.

Table 2 cites the literature reporting the results of prosthetic fittings of patients with hemipelvectomies done due to a tumor. User percentages vary from six to 80 percent in groups ranging in size from ten to 60 patients. In most cases, the primary focus of the articles was not prosthetics and, therefore, the data were not well developed.

In a report by Sneppen, et. al.,[1] on 41 consecutive cases done for malignant tumors, prosthetic fitting occurred in 30 of the 41 cases. Six patients were primarily supplied with prostheses utilizing leather bucket-type sockets (Figure 1) and 24 with

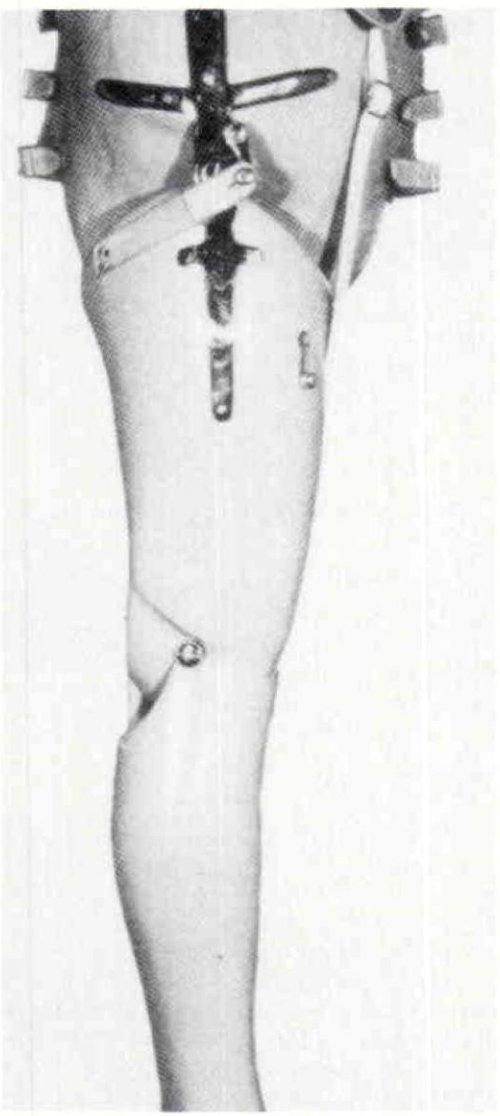

Figure 1. Leather Bucket Type, Tilting-Table Prosthesis. (Reprinted from *Orthopaedic Appliances Atlas*, J. W. Edwards, 1960).

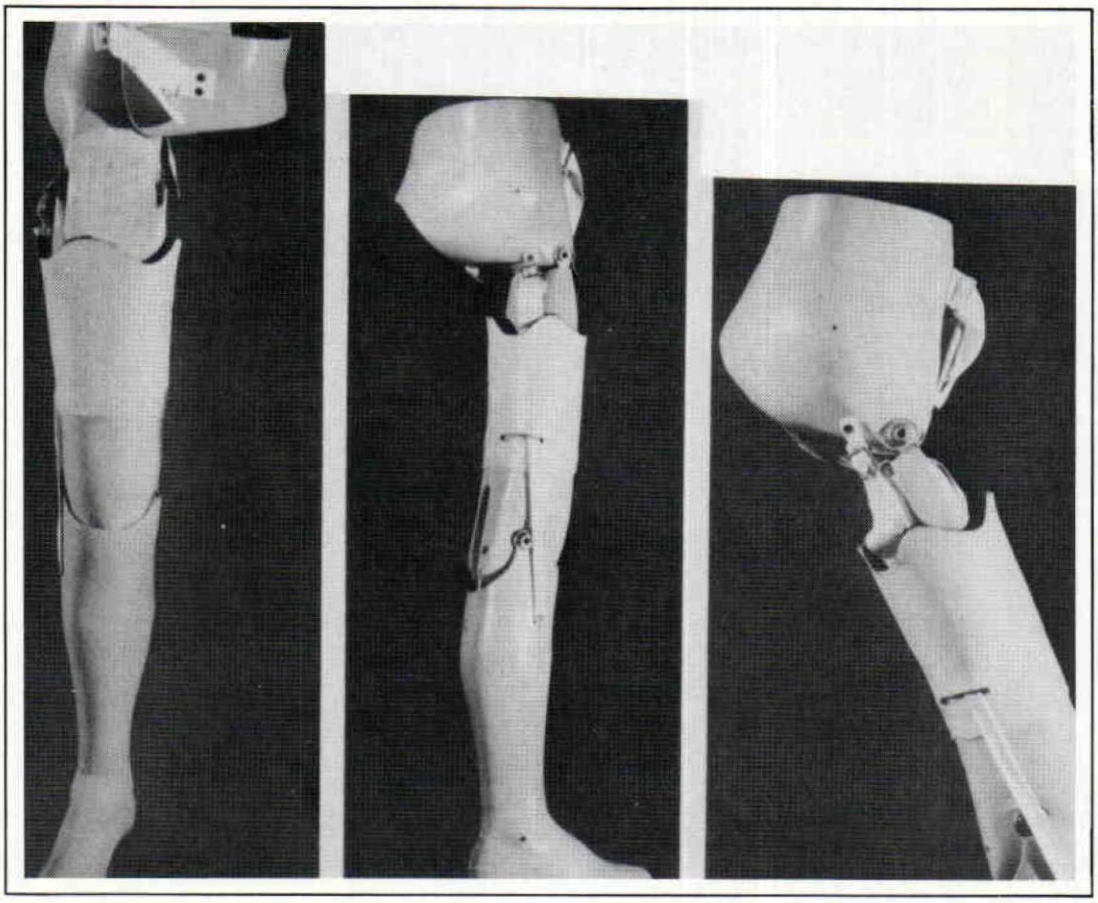

Figure 2. Canadian Hip Disarticulation Prosthesis. (Reprinted from *Orthopaedic Appliances Atlas*, J. W. Edwards, 1960).

Canadian style Hip Disarticulation (CHD) prostheses (Figure 2).

There has been some discussion about the philosophical problems faced by surgeons regarding the prosthetic fitting of children having amputations done for tumors. In 1972, Lambert[2] studied a group of 85 children with primary bone tumors at the University of Illinois and concluded that, since the average wear time was 15.5 months per case, the cost of prosthetic fitting was justified in all cases. Unfortunately, he made no record of whether the children began with a prosthesis and then discountinued use prior to death, or surgery, or were alive, well and not using a prosthesis at follow-up. This group included 11 upper limb prostheses, and does not deal with any problems encountered in lower limb prosthetic fitting or wearing at follow-up.

Most authors agree that hip disarticulations are performed almost exclusively for the treatment of tumors. For example, the 1975 revised edition of New York University's Limb Prosthetic Manual states, "In the rare instances in which amputation is required by trauma or nonmalignant disease, . . .". Such a statement leaves the reader with the impression that virtually all such surgery is done for reason of malignancy.

The most commonly used hip disarticulation prosthesis is the so-called Canadian hip disarticulation (CHD) version, introduced by McClaurin in 1957. More re-

cently, the Otto Bock Modular (OBM), endoskeletal version has been employed, due to lighter overall weight, improved cosmesis, and the opportunity to utilize interchangeable and adjustable components.

Since the operation is rare, and follow-up studies dealing with patients' utilization of the hip disarticulation prostheses are sparse, this study was conducted to determine: 1) the incidence and reasons for amputation at the hip disarticulation and hemipelvectomy level; 2) the incidence of prosthetic fitting in these patients; 3) the factors affecting it; 4) the incidence of prosthetic use among those patients fitted with a device; and 5) the factors which contribute to or detract from prosthetic use.

METHOD

We obtained the records of all University of Iowa patients having had either a hip disarticulation or hemipelvectomy since 1962, and reviewed these records to determine the diagnosis, surgical procedure, prosthetic fitting, and follow-up information. Following the categorization of all cases by cause (Table 1), we attempted to contact patients fitted with prostheses to determine fit and use of the prosthesis, problems relative to the amputation level, and problems encountered which specifically relate to the parts or design of the prostheses. We derived the above information from patient follow-up, or by telephone call.

Etiology of Hip Disarticulation or Hemipelvectomy

Etiology	# Pt. (%)	# Fitted	# Users at Follow-up
Tumor	24 (48%)	9	8*
Infection	10 (20%)	1	0
Trauma	5 (10%)	4	3
Congenital	1 (2%)	1	1
Vascular	20 (20%)	0	0
TOTAL	60	15	12

*3 died following fitting and documented wearing history prior to death

Table 1. Etiology of Hip Disarticulation or Hemipelvectomy

Fitted/Users of Hip Disarticulation Prostheses

Author(s)	Date	# of Patients Fitted	# of Patients Using at F/U
Lewis & Bickel[4]	1957	25	2 (8%)
Miller[6]	1959	32	22 (69%)
Watkins [3]	1962	10	8 (80%)
Higinbothom[7]	1966	60	24 (40%)
Douglas[8]	1975	50	3 (6%)
Sneppen[1]	1978	30	15 (50%)
Shurr	1983	15	12 (80%)

Table 2. Fitted/Users of Hip Disarticulation Prostheses

RESULTS

Incidence and Cause of Amputation

As listed in Table 1, tumor led to amputation most frequently (24 of 60 cases [40 percent]). Ten amputations (17 percent) were the result of secondary infection, usually related to another problem such as paraplegia, multiple sclerosis, or osteomyelitis. In five patients (8 percent), hip disarticulation resulted from trauma, most frequently caused by farm equipment. One patient had a congenital hip disarticulation. Ten procedures (17 percent) were done for vascular insufficiency.

Incidence of, and Factors Affecting, Prosthetics Fitting

Criteria for HD level prosthetic fitting include: patients who 1) have a healed wound; 2) can expend the energy needed; 3) desire to learn to walk with a prosthesis; and 4) have no illness at the time of fitting which would negate learning how to use a prosthesis. In tumor cases such a condition might ultimately occur.

Table 1 shows that 15 (or 25 percent) of the patients were fitted with a prosthesis. Most of these patients had an amputation for either tumor (nine cases) or trauma (four cases). In only one of the ten cases of amputation done for infection did the patient's overall medical condition allow for a realistic expectation of prosthetic fitting. The one congenital hip disarticulation patient was fitted with a prosthesis at age 16 months, without difficulty. None of the ten patients who had amputations for vascular reasons were fitted. One trauma patient was never fitted because of severe depression. In the tumor-caused amputation group, nine were fitted with prostheses. Patients who had demonstrable metastatic chest lesions were not considered prosthetics candidates. For this last group, the time of death after surgery ranged from three to 60 months.

Incidence of Prosthetics Use

The initial fitting time of the four patients with trauma-induced amputations ranged from one to three months after injury. Three learned to use the prosthesis readily and continued to use it at follow-up, ranging from 15 to 24 months. The fourth patient also had a shoulder disarticulation and an above-knee amputation on the other lower extremity. His gait training was understandably difficult, and at follow-up, he reported that the energy costs were too great for the benefit derived.

The one fitted patient whose amputation had been caused by infection discontinued wear of his prosthesis after two months because of discomfort in the socket and around the waist.

All nine of the fitted patients, whose cause of amputation was a tumor, learned to use the prosthesis without difficulty. Three of these patients died secondary to their disease. Time of prosthesis use prior to death ranged from 11 to 60 months. The remaining six patients were alive and well at follow-up, with five of them still using their prosthetic devices.

Factors Affecting Use of a Prosthesis

The factors which effect the use or lack of use of a hip disarticulation prosthesis can be illustrated by examining the cases of six tumor patients and three trauma patients who became regular prosthesis users. Follow-up information about many facets of prosthetic use and fitting demonstrates these factors.

Patient TU-1 was 29 years old when the hip disarticulation was done for a metastatic lesion in the proximal femur. An OBM prosthesis was fitted three months after surgery. Twelve sessions of physical therapy for gait training allowed TU-1 to be discharged with a walker. At his nine-year follow-up visit, the patient reported that he had completely given up using his device, stating that it was easier to use a wheelchair at his home. He does not work outside of the home and stated that he believed fitting of the socket should be done following the patient's return home when the patient's weight has stablized. Since this patient also required a walker, he was unable to use his hands in the upright position. The cosmetic loss of the limb and its

appearance was not worth the discomfort he sustained while wearing the socket, remaining in a wheelchair nearly all day.

TU-2 had an osteogenic sarcoma of the femur which resulted in a hip disarticulation at age 15. She was fitted two years postoperatively with a CHD prosthesis and discharged from physical therapy following 15 visits, using one cane. At three years post-op, she was fitted with an OBM system. At last follow-up, nine years after fitting, she was wearing her prosthesis every day, all day, in her job as a desk clerk at a motel. She compared the two prostheses, saying that she prefers the lighter weight and more cosmetic OBM system. Tearing of the cosmetic foam cover and breaks in the rubber bands of the hip joint have been recurrent problems. The foam covering the knee tears, leaving a separation line visible when she sits in a short skirt. She carries rubber bands in her purse, to replace those in the hip joint when they wear out.

TU-3 underwent hip disarticulation for a femoral chondrosarcoma at age 14. She was fitted with an OBM one month post-operatively. She was discharged from physical therapy after 15 visits, walking well and using one cane. While in high school, she became a cheerleader and broke numerous hip joint attachment plates (Figure 3). Following graduation from college, she became an elementary education teacher. She uses her prosthesis full-time. This case demonstrated the prosthetic adjustability needed for longitudinal growth.

TU-4 is a 20-year follow-up of a hip disarticulation done for a metastatic fibrosarcoma. She was fitted four months post-operatively with a CHD prosthesis, which she described as adequate, yet heavy, and one in which she could never control the knee. Following 20 physical therapy visits for gait training she was discharged, using crutches. Twenty years later, she was converted to an OBM, which she much preferred due to its lighter weight and safety knee, which she can more easily control. She only uses the prosthesis indoors, and uses crutches when she is outdoors. The conversion to the OBM system has not altered this habit. Sitting in her prosthesis is still quite uncomfortable.

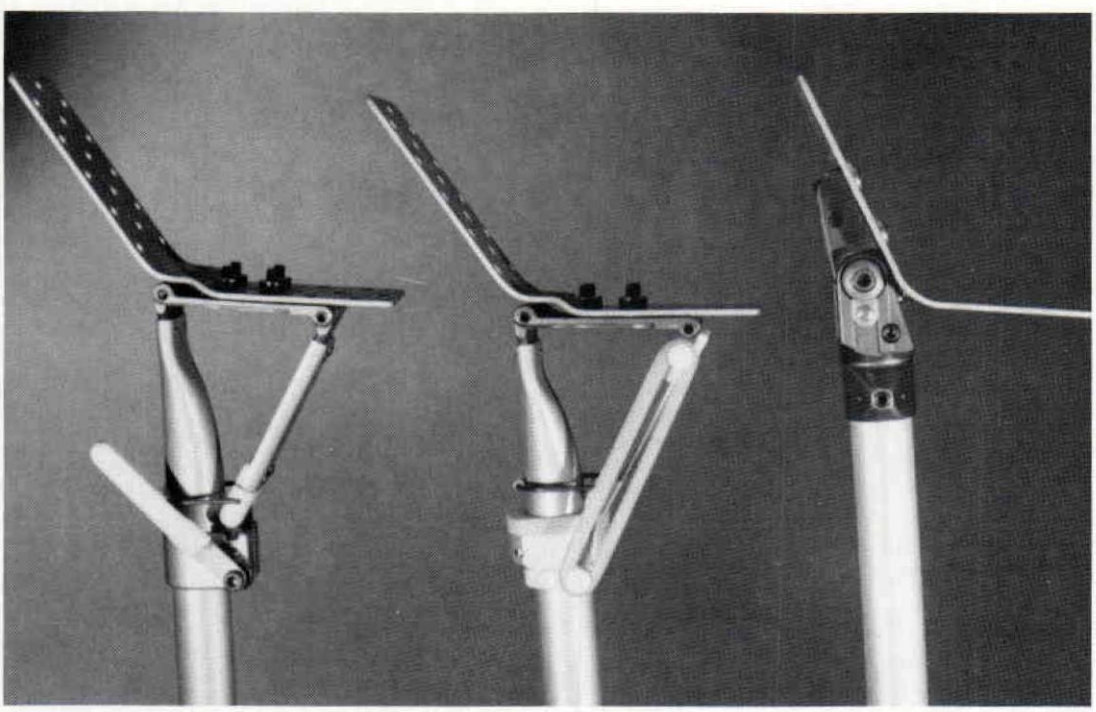

Figure 3. The chronological progression of the Otto Bock Modular Prosthetic Hip Joints.

TU-5 had a hip disarticulation for a mixed sarcoma of the femur. This 49 year-old patient was fitted five months post-operatively with a CHD prosthesis. He was discharged from physical therapy following 24 visits for gait training, walking well and using a cane only part time. One year later he was using the prosthesis occasionally, but was more pleased using crutches. The prosthesis proved to be too heavy for this patient.

TU-6 was amputated at age two weeks for a rapidly enlarging femoral sarcoma present at birth. He was fitted with a CHD prosthesis at age two years. Twelve years later he continued to use a CHD device with a minimum of complaints, other than those related to skeletal growth. He has completely mastered functional ambulation, and while he walks slower than normal, this does not concern him. He uses no canes or crutches.

Three of the five patients fitted after disarticulation because of trauma reported daily use of their prostheses at an average follow-up time of two years. Their case information obtained from follow-up visits identifies specific individual situations.

TR-1 was fitted with an OBM system six months post-operatively, at age 23. Following seven visits in physical therapy, he was able to walk 100 meters and climb stairs easily, using no assistive devices. At three-year follow-up he had changed occupations from farming to light industry work, wore his prosthesis all day, every day, using no cane. He had fractured the hip joint pylon attachment on two occasions. He also had complained about the discomfort associated with long periods of sitting.

TR-2 was fitted at four months post-injury with an OBM system. He required 14 visits to physical therapy and was discharged walking independently with two canes. He was age 46 at the time of injury, and at 28 months post-fitting he remained an independent, all-day wearer with no complaints about prosthesis failure.

TR-3 was fitted at 15 months post-amputation with a CHD prosthesis. His medical records were not specific, except to note that he was discharged home walking well with one cane. He returned to farming 120 acres, and ten years later still walked well, using his device daily. He has been subsequently lost to follow-up.

DISCUSSION

Although most hip disarticulations and hemipelvectomies are due to tumor, other etiologies occur. Tumor accounted for 24 of 50 amputations in our series. The etiologies of vascular insufficiency and infection are often lumped together in classic studies. However, in this series the records were sufficiently clear to warrant separation, with equal numbers of cases together accounting for 20 (40 percent) of the cases. Trauma accounted for five cases and congenital for one. Other reports have not grouped cases similarly.

If only the patients fitted with prostheses are considered, our percentage of patients still wearing prostheses equals that reported by Watkins[3] (80 percent). Compared to Watkins, however, our series includes more than tumors. Authors have alluded to the possible decreasing interest in prosthetic usage associated with age, despite etiology or functional level. However, no author has clearly identified this trend. Much more information is necessary to elucidate the issue.

Questions concerning type of prosthesis and the subjective evaluation of the devices allowed for interesting comparisons in those four patients fitted with CHD prostheses. Two of the four were subsequently fitted with the OBM system and, without exception, the patient's responses were positive. The improved cosmesis and soft-cover accounted for the positive response. The apparent lighter weight was also a positive factor. One patient prefers the safety knee in her OBM system, since the chronic buckling of her CHD prosthesis was a problem. Both patients, however, have complaints about hip joint rubber-band breakage, a problem which the manufacturer has addressed. Likewise, the location of the hip joint and the uncomfortable sitting it produces deserves consideration and redesign. Otto Bock has recently developed the 7E7 hip joint, which addresses this problem (Figure 4).

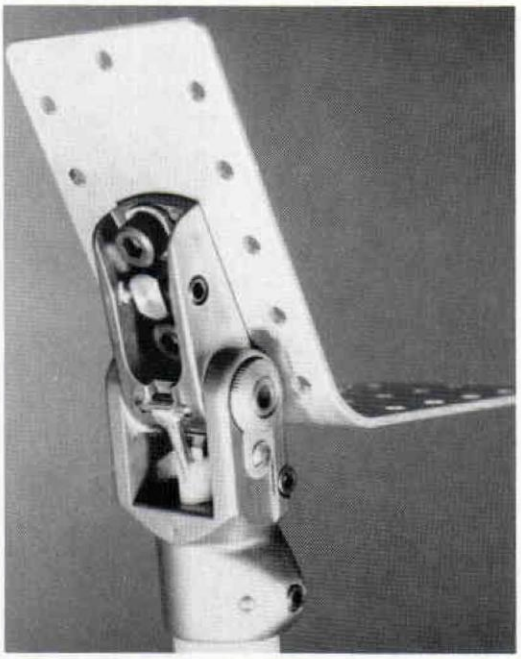

Figure 4. The Otto Bock 7E7 Hip Joint, positioned more anterior than distal.

Fracture at the hip joint of the OBM system appeared to be related to intense use of the prosthesis. However, the second generation of hip joint has apparently corrected that problem.

The foam cover also produced problems. Additionally, the prosthetic skin soiled easily. None of these problems were severe enough to coerce any patient to desire to change to an exoskeletal system.

The issue of residual limb/socket problems remains. One patient was advised that fitting would be withheld until preoperative weight was regained. This comment assumed no weight gain past pre-operative status, which, in our experience, does occur. It also ran counter to our early fitting concepts. All patients tolerated the pressures generated at the residual limb/socket interface. However, relatively minor local irritation or volume fluctuation was common. These were usually dealt with by socket modification and were not chronic in any patient.

Only the article by Watkins (1962)[3] speaks to the number of visits necessary to teach the patient to walk at an acceptable level. His comparisons were between leather "Tilt Table" sockets and the then-new CHD prosthesis. An average of 20 visits for physical therapy was necessary to achieve independent gait with the "Tilt-Table" type. An average of 17 visits was necessary to achieve independent gait with the CHD, with or without a cane. An average of nine sessions was required to achieve independent use of the OBM, with or without a cane. These figures do not include the triple amputee who failed to learn, or any cases who subsequently gave up. Age appears to affect the number of sessions necessary for gait training. However, because of the small size of the group, no conclusions can be drawn.

Only one patient was dependent on crutches. Gait using crutches and prosthesis is less than acceptable because the prosthesis normally can afford independent use of both upper limbs. The inability to use the upper limbs was a contributing factor in the prosthesis rejection by TU-1.

One trauma patient who was fitted at age 35 with the CHD later gave up his prosthesis use because he believed crutch walking was easier. He also farmed 120 acres. This should not be related necessarily to the CHD or any prosthesis. Further case evaluation is needed to answer the question of why prosthesis use was discontinued.

CONCLUSIONS

Hip disarticulation/hemipelvectomy are rather rare procedures made necessary by tumor, trauma, infection, vascular insufficiency and congenital abnormality. Prosthetic devices may be fitted to suitable candidates, with success in usage dependent upon 1) prosthetic socket fit; 2) the patient's ability to walk independently enough to free hands from assistive devices; 3) the limited need for sitting for long periods; and 4) the lack of relative changes in body weight and size.

Patients appear to prefer the modular endoskeletal system. Improvements in the biomechanics of the devices have made learning to walk easier and quicker. More research is needed to better define this patient group and to identify further pros-

thetics and ambulatory problems experienced with long term utilization of hip disarticulation prostheses.

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The Thigh Corset: Its Effects on the Quadriceps Muscle and its Role in Prosthetic Suspension

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The present study aims at evaluating the etiology of the frequently observed atrophy of the thigh in patients who use thigh corsets.[1,2] This was done on the basis of femoral nerve conduction studies and electro-myographic findings in the quadriceps muscle. Measurements of thigh circumference were used to quantitate volume changes in the thigh.

The purpose of the thigh corset is to distribute the weight-bearing surface area of the stump while suspending the below knee prosthesis. It also adds increased sensory feedback and additional mediolateral stability. A commonly observed clinical finding among users of the corset is a decrease in the soft tissue bulge of the thigh. Whether this is the result of neuropathic or myopathic changes due to either the corset, the underlying disease process, or the result of disuse, has not been clearly defined.

MATERIALS AND METHODS

Five patients using thigh corsets were included in this study. Four were males, one was female; all were in the age group between 61–78 years. One patient had bilateral amputations (case #5) but only used the thigh corset unilaterally. The age, date of amputation, date of prosthetics and corset fitting and past medical history are shown in Table 1.

The circumference of the thigh was measured bilaterally at the junctional level between the middle and lower third of the thigh. The length of the thigh was defined as the distance between the anterior superior iliac spine and the medial tibial plateau. Bilateral femoral nerve conduction studies were performed stimulating just below the inguinal ligament as described by Gassel (1963).[9] Measurement of the distance was made from the cathode of the bipolar stimulating electrode to the active recording electrode. The temperature of the patient's extremity was controlled to 90–92°F. The latencies were measured and plotted against the distance to the recording surface electrodes (TECA #6030). The response was recorded with a DISA electromyograph system. Needle EMG studies were carried out in the vastus lateralis and medialis of both sides; first at rest, then with increasing effort and maximal effort—using a method described by Buchtal[7] (1957, in his study of normal subjects).

Similar to Buchtal's study, the measurements of duration and number of phases were taken in at least 20 action potentials in

Patient	Age	Amput.	Age Corset	PMH
C. R.	67	R 1/80	8/80	DM PVD
T. McD.	62	R 1974	1976	DM PVD
M. L.	78	L 1976	1976	DM PVD
T. C.	76	L 1955	1955	
A. L.	61	Bil. 1979	1979	DM

Table 1. Patients using the corset.

each muscle site. Three sample sites were used in each muscle studied. The values were compared to the normal values of the same age group using needle electrodes (Buchtal 1957) and also compared to the contralateral side. A deviation of + 25 percent of the mean value was considered normal.

Patient	Total Thigh Length	Circumference R	Circumference L
#1 R. C.	43 cm.	52 cm. amp.	60
#2 M. T.	55 cm.	50 cm. amp.	56
#3 L. M.	46 cm.	51	45 amp.
#4 C. T.	48 cm.	46	34 amp.
#5 L. A.	45 cm.	40	39 amp.

Table 2.

RESULTS

Reduction of the circumference of the thigh as compared to the contralateral side was present in four cases (Table 2). Case #5 with bilateral amputation had almost symmetrical wasting. Femoral nerve conduction latencies were normal in three cases. Patient #4 (the eldest of the group) had bilateral increased latencies and patient #3 had a mild increase in the contralateral side (Figure 1).

Needle EMG findings were characterized by a reduction of motor unit potentials and of either poor recruitment or occasional spontaneous activity at rest. Measurements of the mean duration of at least 20 action potentials in each sampled site is represented in Table 3. They were found to be within normal limits in three patients and increased in two. Patient #5 (bilateral amputation with thigh corset on one side) had increased duration in the vastus medialis of both sides and Case #1 had symmetrically increased duration in both of the vastus muscles. All patients showed mild increases in the percentage of polyphasic potentials.

DISCUSSION

Atrophy of the quadriceps muscle may arise from a variety of disorders; neurogenic causes include peripheral neuropathy or compression of the nerves supplying the muscle, e.g., pneumatic tourniquette compression of the thigh (Weingarden 1977).[16] Myopathic processes include intrinsic muscle disease or myofibrotic changes following intramuscular injections (Alvarez 1980),[1] (Hollaert 1975).[11] Disuse atrophy of the thigh resulting from prolonged immobilization has been studied with CAT scanning techniques. These studies have described the wasting to be primarily restricted to the quadriceps muscle. The electromyographic and histological aspects of this disorder are well documented both in humans (Wolf 1971)[17], (Brooks 1970),[2] and animals (Patel 1969).[14]

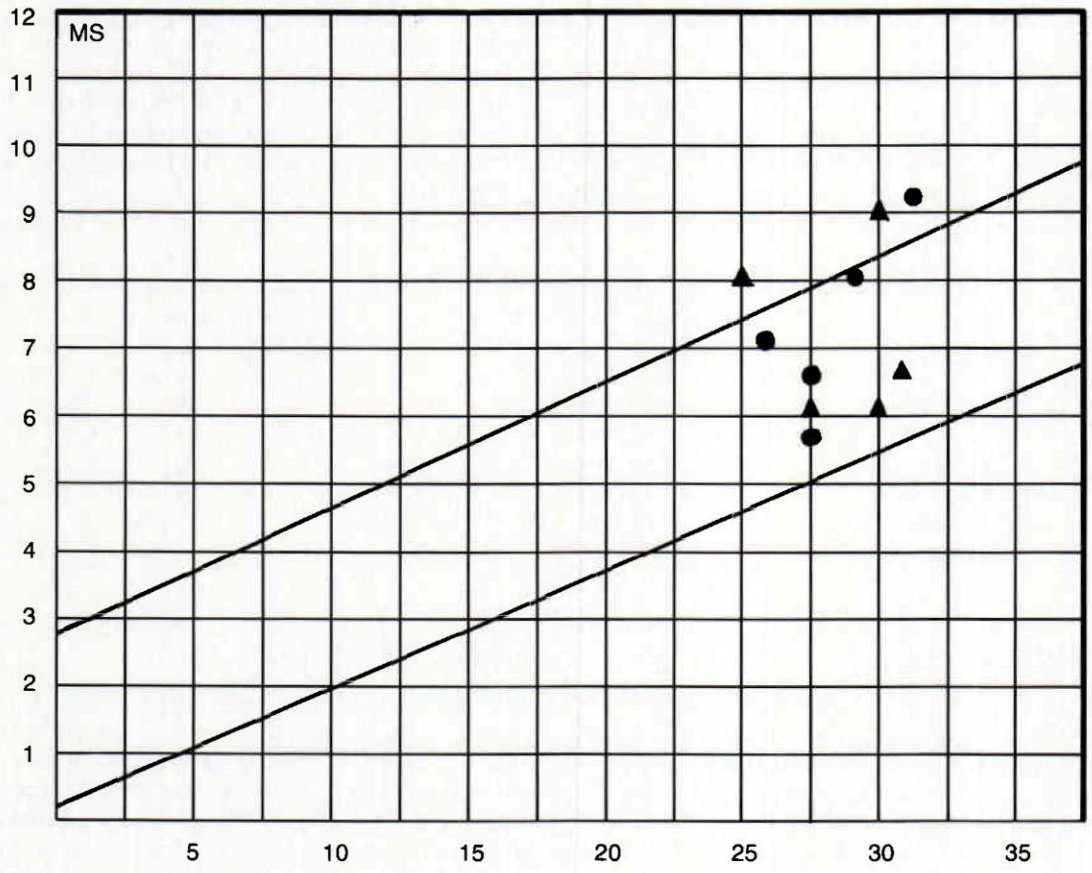

Figure 1. Femoral nerve latencies against the distance. Lines indicate mornal usage (Gassell 1963).

A brief review of the electrodiagnostic findings of old age is helpful before commenting on our findings. Changes in conduction velocity were reported first by Norris, Shock, and Wagman in 1953[13], and were later confirmed by others (Campbell 1973)[6]. Buchtal was the first to report changes in duration and shape of action potentials in the elderly (Buchtal 1954)[3] with an increase in both mean value and standard deviation in subjects over 70. A significant reduction in the number of motor unit potentials was found by Campbell, et. al. to be the major EMG findings in the muscles of the older population. Awad in 1977, using the Willison method for automatic analysis, found evidence of increasing mild chronic partial denervation. Therefore, the electrophysiologic data of the present study indicated in Figure 1 and Table 3 excludes the diagnosis of myopathy as the cause of the muscle wasting, both in terms of quantitative and qualitative electromyography. The differential diagnosis should therefore consider neurogenic or disuse atrophy. Considering the age group of the patients studied, the only criteria is the duration of the action potentials. In neurogenic atrophy, the duration is found to be increased (Buchtal and Pinelli 1953)[5] while in disuse atrophy, the mean duration remains within normal limits (Quidin 1980),[12] (Wolf 1971).[17]

In the present series of patients, duration remains within normal limits in three out of five patients. In two cases, an increase in duration was found but this involved both legs; hence, the increase in duration may be unrelated to the corset. Furthermore, in Case #5, the patient had bilateral amputation and used a thigh corset on one side only. He was found to have identical circumference of thigh in both legs and bilateral increase in motor unit action potential duration. Therefore, with the limited sample of patients included in this study, it can be suggested that:

A. The atrophy of the thigh observed in amputees using the thigh corset does not seem to be the result of either neuropathic or myopathic injury from the corset itself.
B. In our series, the quadriceps atrophy correlates with the electromyographic characteristics of disuse. This probably relates to the fact that in our patients, the corset suspension was selected because these were marginal ambulators.
C. The corset itself may be uncomfortable to wear, which may further discourage activity of the amputated extremity and manifest as quadriceps atrophy.
D. In our series, the electrical abnormalities also may be related to the underlying disease (e.g., diabetes or PVD).

Further studies, perhaps in a younger or more active age group, could further define the presence of degree of atrophy. In an extremity that has more than the marginal function of our geriatric age group, perhaps the findings should not be as significant.

Nevertheless, the data from our work and related studies indicate that the thigh corset offers no direct harmful effects to those who wear it. The energy cost of the corset suspension has been shown to be equivalent to the supracondylar cuff (Cummings).[8] It has been employed with success in pediatric settings where physiologic knee instability or genu valgum

	Years of	VASTUS LATERALIS		VASTUS MEDIALIS	
Patient	Use	Corset	Noncorset	Corset	Noncorset
No. 1	1 year	20.4 (+31%)	17.1 (+9.6%)	19.4 (+97%)	16.4 (+30%)
No. 2	7 years	14.6 (−2.6%)	16.28 (+8.5%)	13.8 (+14%)	14.8 (+22%)
No. 3	5 years	15.5 (−1.8%)		13.8 (+6.1%)	
No. 4	26 years	16.8 (+9.3%)	21.3 (+32%)	13.5 (+3.8%)	20.6 (+5%)
No. 5	3 years	15.9 (+6.0%)	15.3 (+2%)	19.9 (23.1%)	15.1 (29%)

Table 3. Mean deviation of M.V.P. and deviation from mean normal.

exists. It has also been recognized for providing significant relief from excessive pressure on the patellar tendon and has therefore been popular among diabetics, and those who subject their residual limb to prolonged use. It has been effective in assisting greater mediolateral stability in those patients having a short residual limb.

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A Novel Concept in Fitting Bilateral Above-Knee Amputees: A Case History

William R. Svetz, C.P.O.

In March, 1982 we saw Mr. R.S.B., a twenty-three year old male with bilateral traumatic above knee amputations secondary to a railroad accident. These residual limbs were not ideal for prosthetic fitting.

The left limb was approximately seven inches in length and twenty-two inches in circumference at the ischial level. The entire anterior surface of the limb was covered with scar tissue and grafts from the inferior margin of the Scarpus Triangle to the distal end of the femur. There were also open areas permeating the graft area. The flexion angle was five to ten degrees and the abduction angle approximately fifteen to twenty degrees when relaxed, but this could be passively reduced to approximately five degrees of abduction. We had good extensor power to neutral, but some resistance to extension due to the anterior grafting.

The right limb was approximately three inches in length from the perineum and twenty-two inches in circumference. We had good viable tissue on this limb with minimal scarring. The problem would be to keep this limb in the socket and to stabilize the patient on this side during ambulation.

The usual prescription in a situation like this is a lock knee on the right side, safety knee on the left, and single axis feet to enhance the stability of the safety knee. In addition, quadrilateral sockets, hip joints, pelvic bands and split pelvic belt would be prescribed.

I personally have never been impressed with the majority of bilateral above knee prosthetic wearers. In most cases, the patient complains of a sensation of falling backwards. To compensate for this, they attempt to establish the center of gravity as far forward as possible. This is accomplished by an excessive amount of lumbar lordosis and hip flexion. The stance is similar to that of a parapalegic who has been treated orthotically. With this posture, an excessive amount of energy is required to maintain balance. Many times the patient must use both upper extremities to stabilize himself. This limits the ability of the patient to function bimanually in a standing position.

When walking, the bilateral above knee patient demonstrates an excessive amount of shifting and hip elevation to clear the floor during swing phase. This again is quite energy-consuming, and limits the distance the patient can travel. Also, pinching and discomfort can occur in the perineal region. These are some of the problems we want to eliminate, or at least decrease, in managing the problems of a bilateral above knee amputee.

Quite by coincidence, at the same time we were evaluating R.S.B., we were also fitting a Spina Bifida case with the L.S.U.

Reciprocating Gait Orthoses, which incorporated reciprocating hip joints.* In managing this paraplegic, I was impressed with the way the cable and solid pelvic belt kept the pelvis from rotating anteriorly, but allowed a reciprocating gait.

Fundamentally, the coupling of the hip joints with a cable permits one hip to extend when the other flexes, but prohibits bilateral hip flexion. Unlocking or uncoupling the cable permits free flexion for sitting. It is possible, therefore, to permit flexion and extension for walking, but at the same time provide adequate stability for standing. This lessens the energy required to maintain standing balance and allows the patient more freedom with his or her hands in standing activities. The pelvic band is fit low posteriorly, pressing on the sacrum, for increased control of pelvic rotation.

It was felt that these same features would be beneficial in meeting the needs of R.S.B. and, in addition, that the solid pelvic band would also enhance the medial and lateral stability that we would need, especially with his short residual limbs.

Therefore, bilateral above knee prostheses with endoskeletal construction and a solid pelvic band and reciprocating hip joints were prescribed. We chose Otto Bock # 3R20 polycentric type knees because of the stability characteristics, ease of motion, and mechanical elevation provided to increase floor clearance during swing phase. We also elected to use SACH feet. We decided to align the sockets in abduction as described by Goralnik and Scheinhaus.[1]

At the time of initial fitting, the scar tissue on the left lower limb had open areas and was draining. Wearing of the prostheses did not seem to traumatize these areas. I feel that increased stability and the action of the reciprocating units in controlled pelvic rotation were the reason. Balance and stability were easy to establish. However, excess reduction of the lumbar lordosis increased the patient's feeling of falling posteriorly. Rotation of the pelvic band on the proximal section of the reciprocating hip joints quickly eliminated this problem.

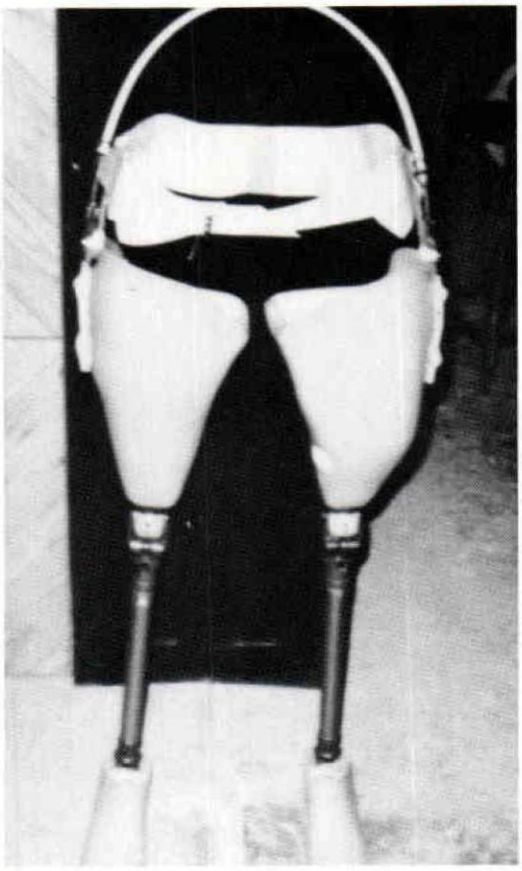

Figure 1. The completed prostheses.

The abducted alignment of the sockets along the solid pelvic band seemed to eliminate the problem of pinching and pain at the proximal medial areas of the sockets. The use of a solid pelvic band and hip joints gave superb medial and lateral stability with minimal limitation to function. The use of the reciprocating hip joint system and abducted socket alignment was greatly enhanced by the use of the 3R20 polycentric knee joints. The ability to fine tune the stability of the knees with the ease of knee flexion during gait and the extension assist made it much easier to dynamically align the prostheses.

After two weeks of therapy, R.S.B. was able to traverse six lengths of the parallel bars unassisted. There was still no complaint of pubic pinching or pressure, and

*Parts manufactured by Durr-Fillauer Medical, Inc., Orthopedic Division, Chattanooga, Tennessee.

Figure 2. After two weeks of therapy, R.S.B. could traverse six lengths of the parallel bars unassisted.

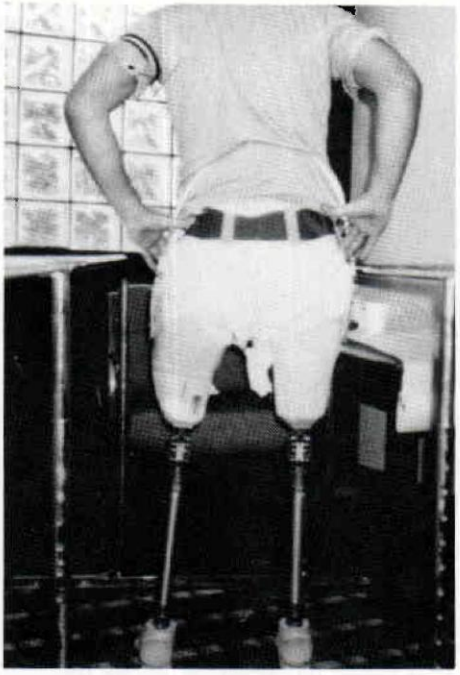

Figure 3. The solid band enhanced medial and lateral stability.

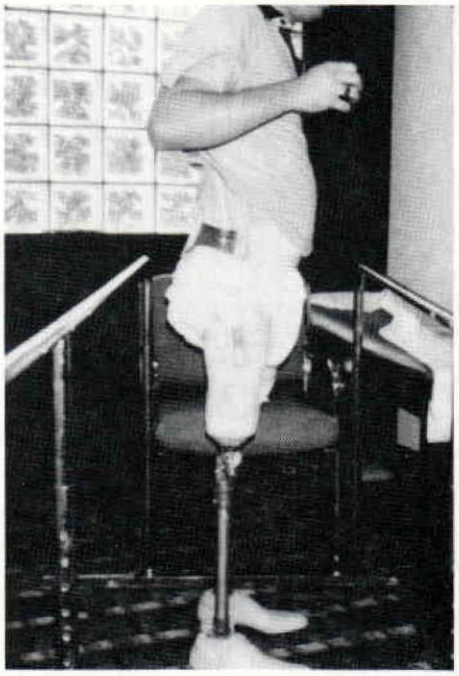

Figure 4. R.S.B. experienced much less medial lateral shifting of the trunk.

no problems whatsoever with knee stability. There was much less medial lateral shifting of the trunk than I have observed with other bilateral above the knee patients at this point in their training. I feel this is due to the solid band which enhanced the medial and lateral stability, especially on the three-inch side, and the polycentric knees which increased floor clearance during knee flexion.

By using the cable, it was possible to use the extensor power of the stronger left side to augment the force necessary to flex the socket and initiate knee flexion on the right side. With the larger pelvic band and proper placement of the hip joints, displacement in the sockets was never a problem. From a sitting to a standing position, and during ambulation, the sockets stayed closely oriented to the patient with almost no pistoning. The prostheses were completed and delivered, and R.S.B. was discharged from the rehabilitation unit in May.

Subsequent follow up revealed that R.S.B. was not using the prostheses. In one

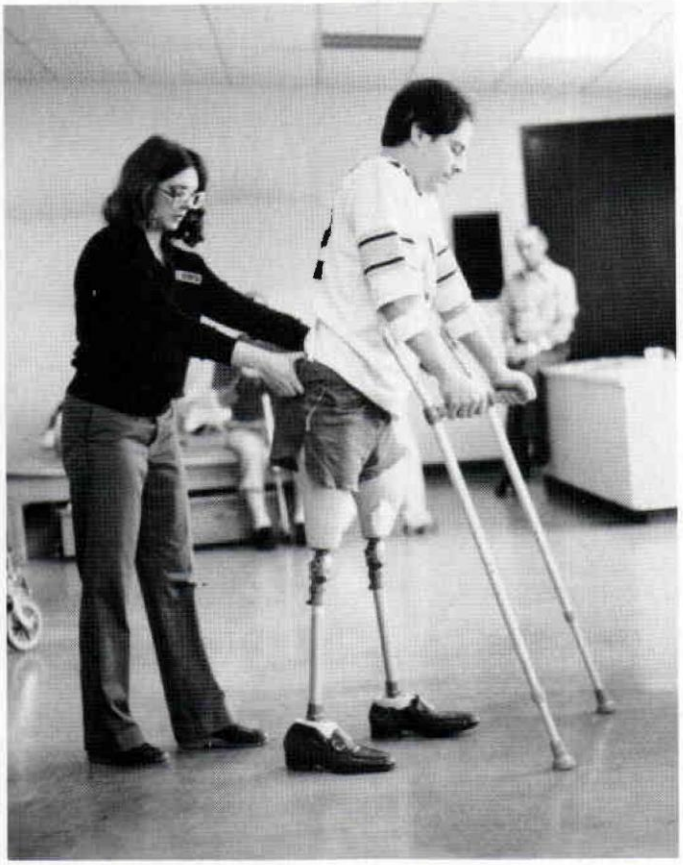

Figure 5. From a sitting to a standing position, and during ambulation, the socket stayed closely oriented to the patient with almost no pistoning.

instance, the sockets had to be modified because of a gain in weight. The patient also complained of the weight of the prostheses, due primarily, we feel, to the modular construction and polycentric knees. Later on, R.S.B. underwent grafting procedures for revision of the scar tissue. A few months after the operation, R.S.B. was scheduled for follow up and possible prescription of new sockets.

In this instance, prescription of bilateral above knee prostheses incorporating reciprocating hip joints cannot be called a total success. The presence of scar tissue and grafts has been a major complicating factor. Nonetheless, we feel the concept has considerable merit and we advance the concept for your consideration in meeting the need of these patients.

ACKNOWLEDGMENTS

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NOTES

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The Demand for Orthotics and Prosthetics Technicians: Preliminary Survey Results

Michael B. Duggan

INTRODUCTION

The Quincy Subgrantee of the Massachusetts Balance of State Comprehensive Employment and Training Act (CETA) Prime Sponsor has been operating orthotics and prosthetics (O&P) technician training programs.

Due to recent budgetary cutbacks in CETA monies, the Quincy CETA office faced a difficult dilemma in selecting which of its skills training programs to operate. It was felt by the Quincy CETA staff that graduates of earlier Quincy CETA technician courses had saturated the market in Massachusetts. In researching the demand for technicians in the country as a whole, we found that there were no "hard" data in existence. Estimates of demand for technicians were, in many cases, based on "off-the-cuff" guesses.

Therefore, as part of an overall strategy of determining which of its programs were most viable, Quincy CETA elected to perform a survey of the 530 certified orthotics and prosthetics facilities in the country to estimate the short-term future demand for trained technicians.

SURVEY METHODOLOGY

Exhibit 1 is a sample of the survey questionnaire which was sent to the O&P facilities. The first question asked about the number of technicians actually employed in 1981 and 1982. This question would give information about employment growth. The second question asked each facility to estimate the number of technicians that they would hire in 1983 and in 1984. Questions three and four requested salary information. Question number five asked for specific hiring requirements for technicians. The sixth question would give information on the supply side of the market—that is, where the O&P facilities found prospective technicians to hire. Finally, question number seven asked if the respondents would like more information on the Quincy CETA O&P program.

In order to facilitate responses from the O&P facilities, a self-addressed return envelope was included in the questionnaire package.

RESULTS

Of the 530 questionnaires mailed out, four were returned because the facilities were either no longer in existence or had relocated. 191 surveys were mailed back to the Quincy CETA office, which was a response rate of over 36 percent. Of these respondents, 184 were complete enough to be used in the tabulation of the replies. Therefore, the results discussed below are based on 184 respondents, or 35 percent of the total number of certified orthotics and prosthetics facilities in the country.

The details of the survey are shown for four separate categories: 1) all respondents,

Survey of Demand for Orthotic & Prosthetic Technicians

Respondent:

1. Number of Technicians Employed in Firm?

	1981	1982
Orthotics Technicians	____	____
Prosthetics Technicians	____	____

2. How many Technicians do you think you will hire in:

	1983	1984
Orthotics Technicians	____	____
Prosthetics Technicians	____	____

3. What is your starting hourly wage for technicians? (please check)

	$4–4.50	$4.50–5	$5–5.50	$5.50–6	$6–6.50	Other (Specify)
Orthotics	____	____	____	____	____	____
Prosthetics	____	____	____	____	____	____

4. What salary range could a technician expect after two years experience? (please check)

	$5.50–6	$6–6.50	$6.50–7	$7–7.50	$7.50–8	Other (Specify)
Orthotics	____	____	____	____	____	____
Prosthetics	____	____	____	____	____	____

5. Specific hiring requirements for technicians (please check)

	High School Diploma	College 2 yr	College 4 yr	Previous Experience 1 yr	Previous Experience 2 yr	Previous Experience 3 yr	Previous Experience none	Certification Yes	Certification No
Orthotics	____	____	____	____	____	____	____	____	____
Prosthetics	____	____	____	____	____	____	____	____	____

Other (please specify) _____

6. What are your sources for technicians? (please check)

	Technicians School	College	In-house Training
Orthotics	_____	_____	_____
Prosthetics	_____	_____	_____

Other (please specify) _____

7. Would you be interested in more information on the Quincy Skills Center School of Orthotics and Prosthetics? Yes _____ No _____

Exhibit 1.

2) orthotics and prosthetics facilities, 3) orthotics facilities, and 4) prosthetics facilities (See Tables 1–4 respectively).

Since the tables are straightforward, only certain responses need to be discussed here. First, the starting salary and the salary for a technician with two years experience is approximately ten percent less for a prosthetics technician than for an orthotics technician, for prosthetics and orthotics firms respectively. Secondly, the majority of respondents rely on in-house training as a source of technicians.

All Respondents Sample = 184

1. Number of Technicians Employed

	1981	1982
Orthotics	440	476
Prosthetics	323	354

2. Number of Technicians to be hired

	1983	1984
Orthotics	112	96
Prosthetics	94	84

3. Starting hourly wage for technicians:

Orthotics	$5.00 to $5.50
Prosthetics	$5.00 to $5.50

4. Salary after two years experience:

Orthotics	$7.00 to $7.50
Prosthetics	$7.00 to $7.50

5. Specific hiring requirements for technicians:

	High School Diploma	College 2 yr	Previous Experience 1 yr	2 yr	None	Certification
Orthotics	61%	8%	18%	14%	3%	11%
Prosthetics	52%	8%	15%	12%	4%	9%

6. Sources for technicians:

	Tech School	College	In-house Training
Orthotics	27%	4%	77%
Prosthetics	22%	3%	73%

7. Percent requesting more information about Quincy CETA's program:
   72%

Table 1.

O&P Facilities Sample = 123

1. Number of Technicians Employed

	1981	1982
Orthotics	360	388
Prosthetics	257	284

2. Number of Technicians to be hired

	1983	1984
Orthotics	85	72
Prosthetics	80	66

3. Starting hourly wage for technicians:

Orthotics	$5.00 to $5.50
Prosthetics	$5.00 to $5.50

4. Salary after two years experience:

Orthotics	$7.00 to $7.50
Prosthetics	$7.00 to $7.50

5. Specific hiring requirements for technicians:

	High School Diploma	College 2 yr	Previous Experience 1 yr	2 yr	None	Certification
Orthotics	67%	10%	20%	15%	5%	12%
Prosthetics	66%	10%	20%	15%	5%	13%

6. Sources for technicians:

	Tech School	College	In-house Training
Orthotics	32%	4%	89%
Prosthetics	29%	4%	87%

7. Percent requesting more information about Quincy CETA's program.
77%

Table 2.

Orthotics facilities Sample = 34

1. Number of Technicians Employed

	1981	1982
Orthotics	80	88

2. Number of Technicians to be hired

	1983	1984
Orthotics	27	24

3. Starting hourly wage for technicians:
   Orthotics $5.00 to $5.50

4. Salary after two years experience:
   Orthotics $7.00 to $7.50

5. Specific hiring requirements for technicians:

	High School Diploma	College 2 yr	Previous Experience 1 yr	2 yr	None	Certification
Orthotics	85%	6%	23%	21%		15%

6. Sources for technicians:

	Tech School	College	In-house Training
Orthotics	29%	9%	91%

7. Percent requesting more information about Quincy CETA's program:
   65%

Table 3.

Prosthetics Facilities Sample × 27

1. Number of Technicians Employed

	1981	1982
Prosthetics	61	66

2. Number of Technicians to be hired

	1983	1984
Prosthetics	12	16

3. Starting hourly wage for technicians:

Prosthetics $4.50 to $5.00

4. Salary after two years experience:

Prosthetics $6.50 to $7.00

5. Specific hiring requirements for technicians:

	High School Diploma	College 2 yr	Previous Experience 1 yr	2 yr	None	Certification
Prosthetics	74%	7%	7%	7%		7%

6. Sources for technicians:

	Tech School	College	In-house Training
Prosthetics	19%	4%	100%

7. Percent requesting more information about Quincy CETA's program: 59%

Table 4.

PROJECTIONS OF DEMAND

For this preliminary paper, the projections of demand will be simplistic. Demand will be calculated by relating the response rate to the total number of certified facilities. Table 5 shows the projected demand by facilities in 1983 and 1984.

As Table 5 indicates, in 1983 there will be a demand for over 580 technicians and in 1984, demand will be for 500 technicians.

A future study will include additional projections as well as a more in-depth discussion of the implications of this survey.

Projected Demand for Technicians

Facility		1983	1984
All	Orthotics Technician	320	275
	Prosthetics Technician	263	235
O&P Facilities	Orthotics Technician	243	206
	Prosthetics Technician	229	189
Orthotics Facilities	Orthotics Technician	77	69
Prosthetics Facilities	Prosthetics Technician	34	46

Table 5.

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Orthotists and Prosthetists: Issues in a Developing Profession

Ira S. Schoenwald, Ph.D.
Ruth K. Scott, Ph.D.
Larrie Lance, Ph.D.

INTRODUCTION

Orthotics and prosthetics as a profession is in the midst of a period of major professional change. Developments in six major areas are causing heated discussion and sometimes acrimonious debate amongst practitioners and facility owners. The six areas are: changes in professional status, certification, business management, patient management, mode of service delivery, and the use of prefabricated orthoses. These developments were felt to be most important by the leaders in the field of orthotics and prosthetics whom we recently surveyed. These leaders included officials of the American Board for Certification in Orthotics and Prosthetics Inc., the American Orthotic and Prosthetic Association, and the American Academy of Orthotists and Prosthetists, small facility owners, and directors of professional education programs. The purposes of this article are to present the results and to discuss the implications of some of our findings.

CHANGES IN PROFESSIONAL STATUS

Orthotics and prosthetics is changing from a profession dominated by small practices and skilled craftsmen to one that is increasingly centralized, and in which the force of technological change has produced a need for more analytical and scientifically oriented practitioners. A major characteristic of this change is the growing need for technical competence and the consequent need for standardized educational requirements. In the past, practitioners were either self-taught or learned their skills as an apprentice. They learned "by doing"—by observing and working long hours with a master craftsman. They seldom had formal post-secondary education. But with new technologies and practices, there developed a need for more depth and far more detailed knowledge of the sciences and allied health care. Training evolved in response to these needs, so that today it has a more "professional" character, requiring standardized educational programs and certification procedures.

Beginning this year, this standardization consists not only of specific topics outlined in the essentials, but the addition of other general educational requirements gained through earning the baccalaureate degree. This important development represents an acknowledgement that prosthetics and orthotics is equal with other allied health fields. That is, increased professional status for orthotists and prosthetists is achieved in part through increased educational accomplishment. It is not possible to participate as an equal of

other health professionals if one does not share common values, vocabularies, and knowledge. Further, if the field is to remain in charge of its own destiny and not be overtaken by other professions, it must standardize its education, skills, and practice.

CERTIFICATION

A second aspect of the change in professional status is the issue of practitioner control of who practices, and of what practitioners must know, through formal certification processes. The process of certification has been described by R.A. Chase[1], and will be examined in more detail in a later article.

In orthotics and prosthetics, the requirements for certification include, in addition to the bachelor's degree, a year of internship, written, practical, and oral examinations by the American Board for Certification in Orthotics and Prosthetics, Inc. Establishment of a formal licensing program affects both the numbers and types of practitioners in any professional field. The introduction of a certification process enhances the profession's image among its certified peers in the other allied health fields. With the expected consistency of higher level professional standards comes increased confidence and professional status.

But changes in certification requirements can produce feelings of animosity among those certified according to "older" criteria, and those certified according to the new. The rate of change in the field, reflected in the changes in the certification process, can create divisions in the field. Our study indicates that many already established practitioners feel that the newly certified professional does not respect the older professional, who is rich in experience, if short on formal degrees. Among the newly certified, there is a sense that the "old guard" is unable to accommodate rapidly changing technology.

These divisions are a natural consequence of the rapid changes that increased technology is bringing to many of the allied health professions. For example, nursing is still debating over the proper role of the baccalaureate degree while also fighting challenges to its professional identity from "newer" professions, such as physician's assistants. Even the widespread growth of medical specialties among M.D.s has caused much division and debate.

BUSINESS MANAGEMENT

It is not new to those of us who work in the medical fields that the costs of health care continue to grow at a rapid rate. Recent attempts to cut costs through government programs, increased competition from other "providers," and changes in the field itself have increased the pressure on small and large practices to become more efficient and more concerned with being good business managers. Our survey substantiates the concern by many practitioners for the need to improve managing skills, and to increase their knowledge of reimbursement options and other techniques to improve cost effectiveness. "If we are not business minded, we go broke" is a common theme from the field.

But along with the increased concern for business practice come other problems of patient management. Because the orthotist/prosthetist is likely to have more direct patient contact than in the past, it is often necessary to discuss billing with patients, a skill which few in the profession report comes easily. Professionals contend that part of the discomfort lies in the question of how to justify billing for professional services, the major component in the cost to the patient, when the patient expects to be billed for a device that is, in the end, constructed of relatively inexpensive materials.

An ironic twist in this issue is that other health care providers, who in large part bill patients solely on the basis of professional services, are often unsympathetic. They also view the device as the end-product, as the only legitimate element in a wide spectrum of services that include professional consultation, patient analysis, prescription, education and problem-solving, as

well as fabrication and fitting. In fact, manufacture of the physical device may require the least technical expertise in the entire process.

PATIENT MANAGEMENT SKILLS

The growing need for business skills is coupled with the need for patient management skills. The services provided by today's orthotist/prosthetist are largely patient-oriented in nature. Practitioners must deal directly with a wide variety of patients and an even wider variety of patient conditions. They may aid a patient who needs help in finding funds for their medical needs, engage in patient follow-up, grieve with a recent amputee, and deal with defensive patients who are unwilling to accept a permanent disability. Our survey respondents stated an urgent need for communication and patient management skills that go beyond the technical aspects of their expertise. There is an increasing recognition of the need for workable interpersonal techniques to better manage the day-to-day patient encounters that orthotists and prosthetists face.

CHANGES IN MODE OF SERVICE DELIVERY

Two trends are emerging in service delivery. At one level we can see the development of larger group practices with centralized fabrication facilities utilizing cost efficient manufacturing principles, while at the same time, small, solo practices are proliferating. Each has different implications.

Larger, centralized practices may be conducive to peer review at the expense of a loss of fabricating and technical skills, while the smaller solo practice may give the practitioner more direct "hands on" fabrication experience, but at the expense of valuable collegial interaction. This dual process is not without precedent. Witness the recent growth of large centralized group medical facilities and health maintenance organizations in many parts of the country, while smaller, more general practices develop as well.

PREFABRICATED ORTHOSES

A final development noted by those we surveyed is the increased production and utilization of prefabricated orthoses. Practitioners are now faced with competition from "drugstore orthotists," who dispense prefabricated devices that are far cheaper for the patient. Although the drawbacks of their use may seem apparent to the practitioner, there are no good data to tell us whether or not these devices meet patient needs, even though in an era of economic stress thay may be the only option for many.

Practitioners in our survey raise important questions. For what conditions are they, or should they be, used? Should they be controlled in the same way as prescription drugs? If so, who should dispense them? Is it possible to train pharmacists and others to fit them without damaging the status of certified professionals? Are dispensers of prefabricated orthoses "skimming off" patients who would otherwise consult a professional orthotist?

This trend toward "over-the-counter" orthoses, then, challenges all other developmental areas that we have discussed in this article, including quality of patient care and management, professional status of the practitioner, economic interests of the profession, type of service delivery, and the meaning of certification. These challenges were seen as major ones by those we surveyed.

SUMMARY

Leaders in orthotics and prosthetics have enumerated a number of professional concerns which are presented here as a series of developments in the field. We have attempted to present their concerns, and to discuss some of their professional implications. We hope that our efforts here will

lead to increased discussion and debate. Consensus may never be complete, but it certainly cannot begin until we have a clear understanding of the issues that confront the professional orthotist/prosthetist. As we continue to examine these developments, we invite the active participation and cooperation of all who work in orthotics and prosthetics. Your support is most welcome, and your active feedback is invaluable.

NOTES

[1]R. A. Chase, "Proliferation of Certification in Medical Specialties: Productive or Counterproductive, "*New England Journal of Medicine* 294, February 26, 1976: 498.

AUTHORS

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REVIEWS

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

Prevention and Treatment of Running Injuries, Robert D'Ambrosia, M.D. and David Drez, Jr., M.D., Book Division, Slack, Inc., 6900 Grove Road, Thorofare, New Jersey 08086, 204 pages, $39.50.

The last few years have seen a boom of public interest in physical fitness and running. This has led to an increase in running injuries presented for treatment. This book addresses the problem in a holistic manner, considering not only injuries of the musculoskeletal system, but also questions of nutrition, heat injury, and the particular problems of the female runner. As the title suggests, the goal of the book is not just to treat running injuries, but to prevent them. To this end then, separate chapters discuss the matters of neurophysiology of stretching and flexibility conditioning.

Of special interest to orthotists are the chapters on the biomechanics of running and the design of orthoses. These two chapters consider in detail the angular changes that take place in the foot during running, the problems that misalignment of these joints might pose, and how an orthosis might be used to address them. Therefore, an orthotist called upon to treat running injuries and wishing to understand not only the specific matter of designing orthoses but also the larger questions involved, will find this book of interest.

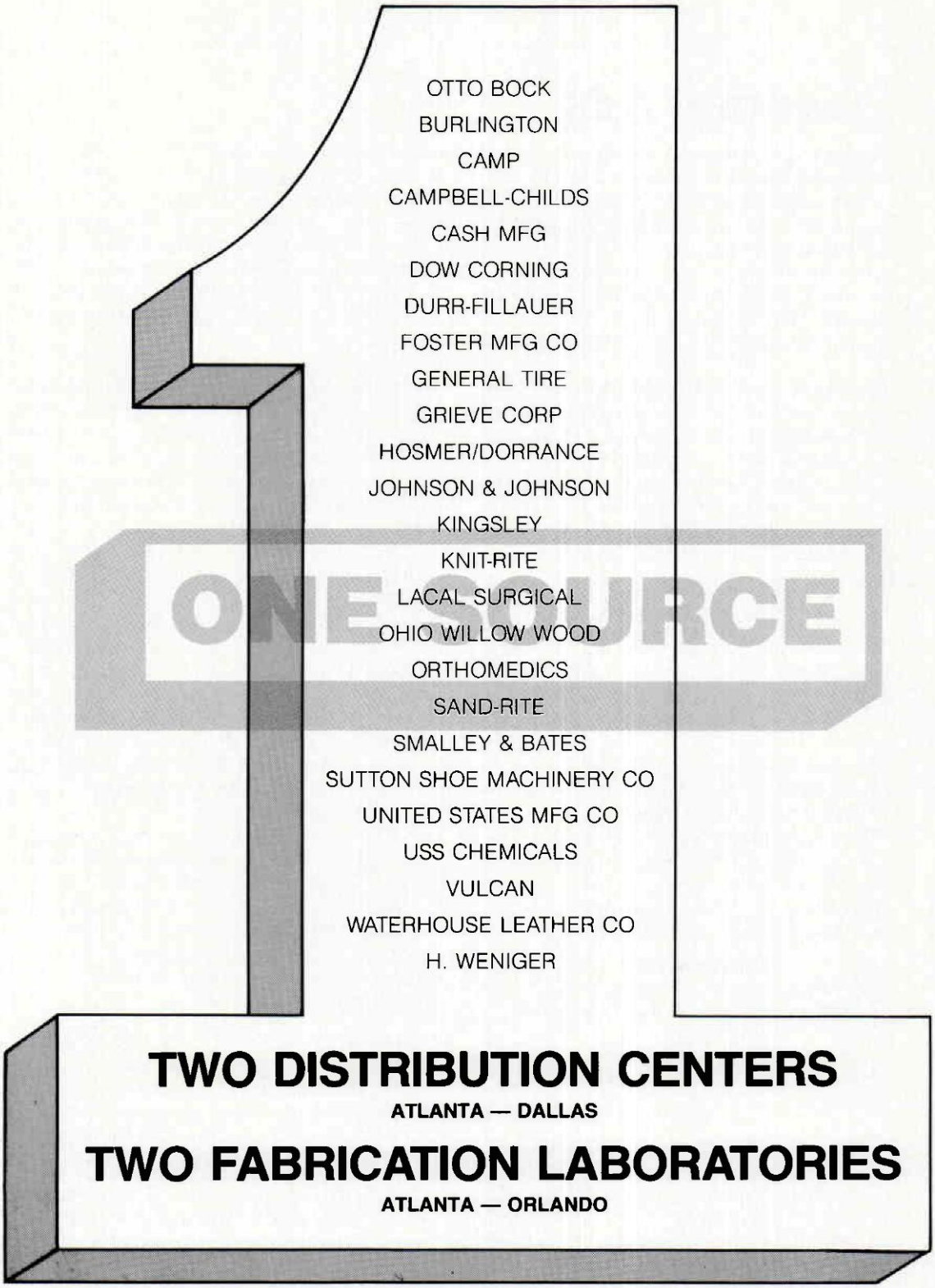
A number of reservations should be noted, however. The word orthotic is used throughout rather than the word orthosis. The matter of running surface is not specifically addressed, and, similarly, shoes are not discussed. This latter point is particularly puzzling, considering the vast attention it receives amongst runners. Shoe modifications are not mentioned and the chapter on orthoses devotes most of its attention to the problems of the pronated flexible foot and says very little about the cavus foot.

Skin Problems of the Amputee, by S. William Levy, M.D., Warren H. Green, Inc., 8356 Olive Boulevard, St. Louis, Missouri 63132. 320 pages, index, $49.95.

This book is an outgrowth of Dr. Levy's many years of experience with the Dermatology Study Group at the University of California at San Francisco. The result is distilled in this volume, and it should prove most useful to the prosthetist and other members of the clinic team not used to dealing firsthand with skin problems, and the dermatologist not used to working with amputees.

The initial portion of the book is a discussion of basic considerations with a description of the anatomy and physiology of the skin, and a similar description of the prosthesis and amputee's remaining limb. Throughout the book, emphasis is given to the concept of the clinic team and the necessity of close cooperation by all involved.

There are a multitude of color plates and many case histories are cited to illustrate treatment of skin problems. The book reproduces as appendices two pamphlets intended for the education of the amputee and are concerned with hygiene and edema. A third appendix discusses prosthetic socks and sheaths.



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FROM: SIEGFRIED PAUL, CPO (E), INTERNATIONAL SCIENTIFIC PROGRAM CO-CHAIRMAN
ROBERT E. FANNIN, CO, DOMESTIC SCIENTIFIC PROGRAM CO-CHAIRMAN

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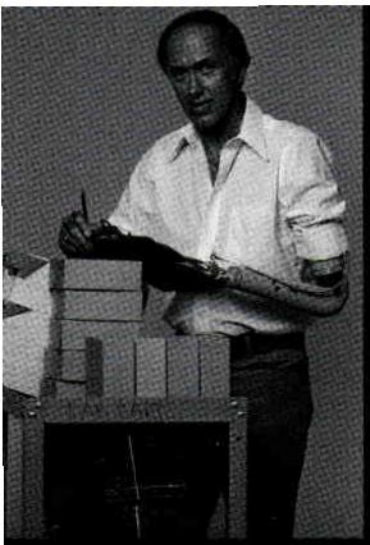

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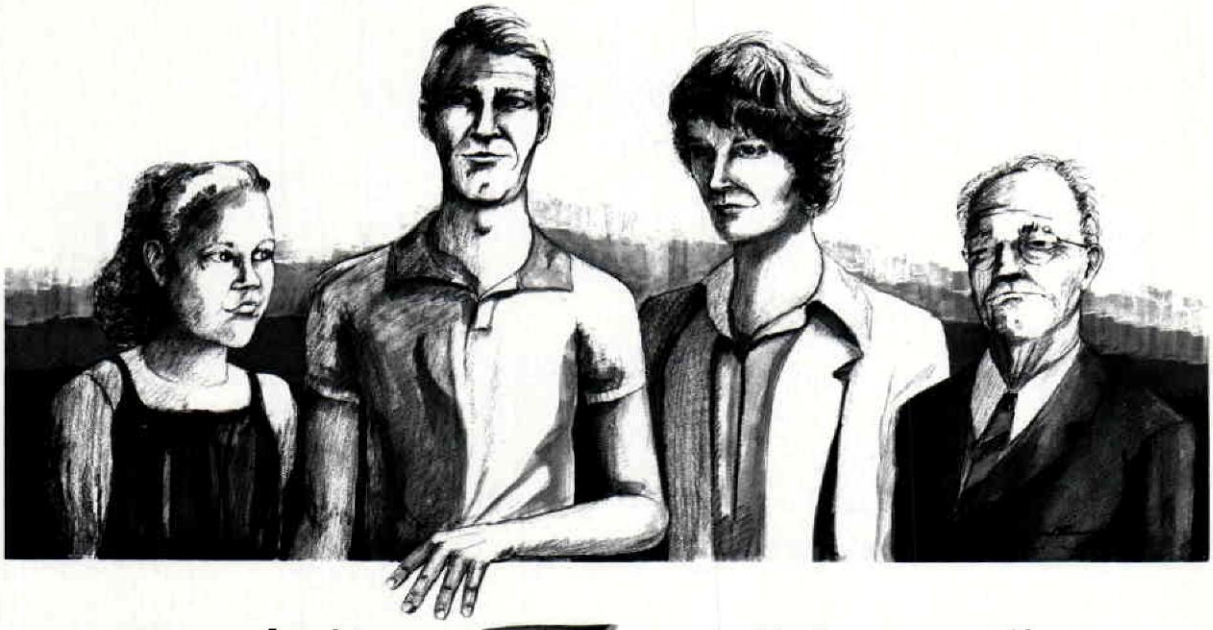

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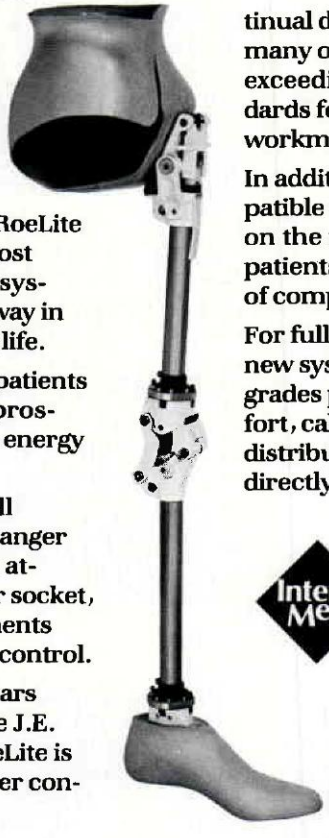

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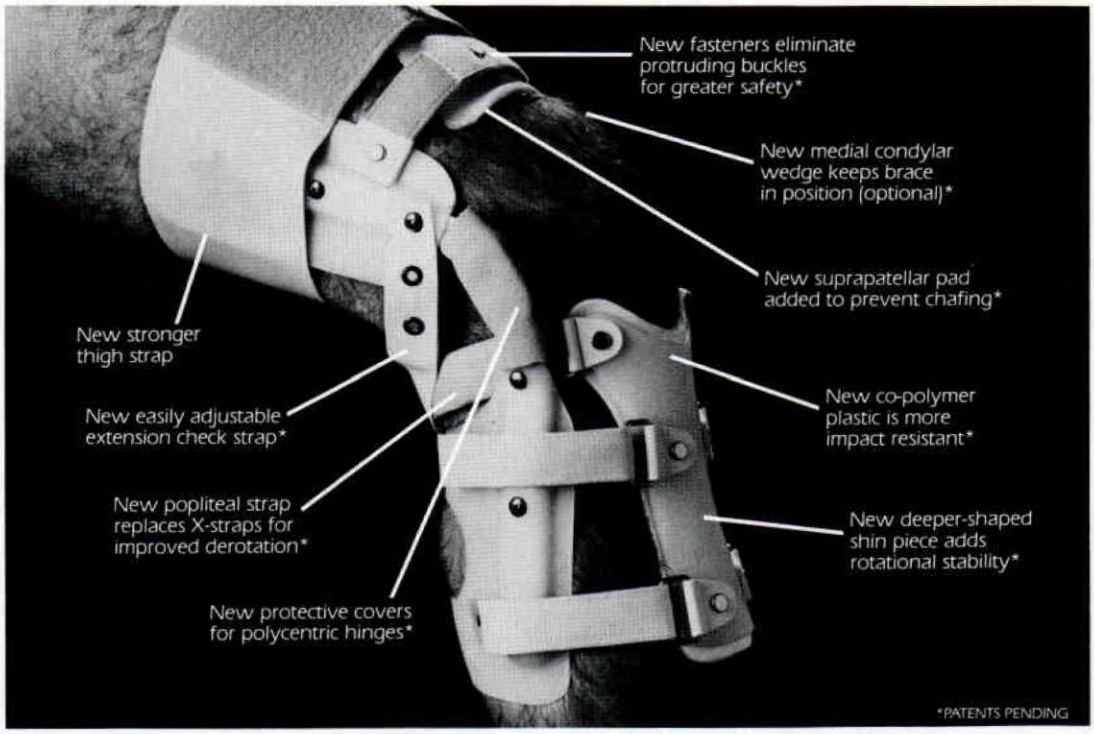

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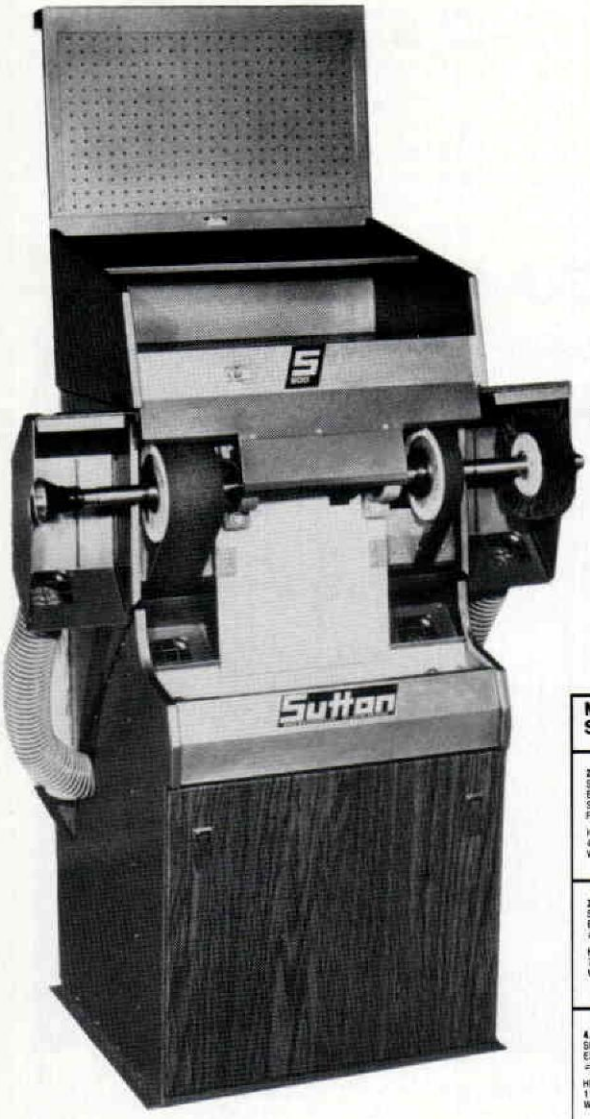

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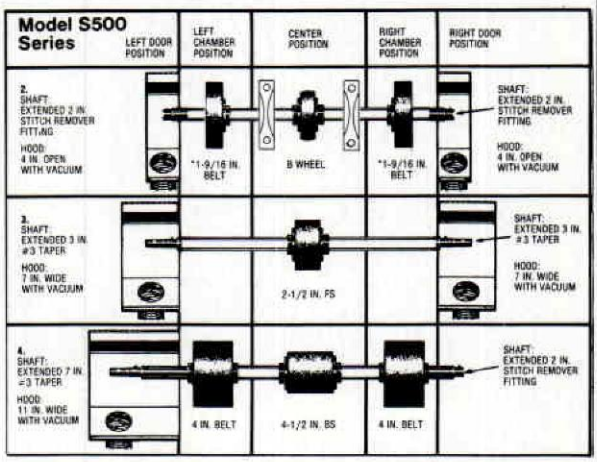

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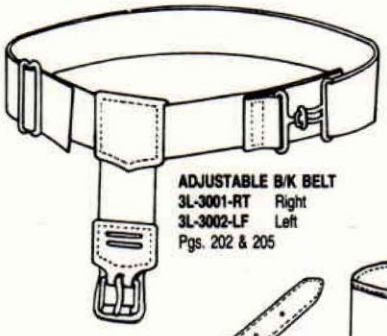

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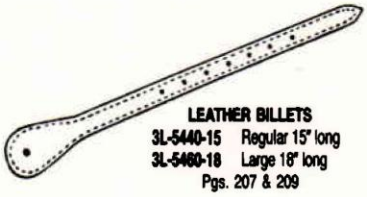

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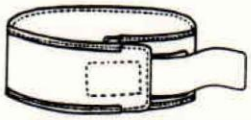

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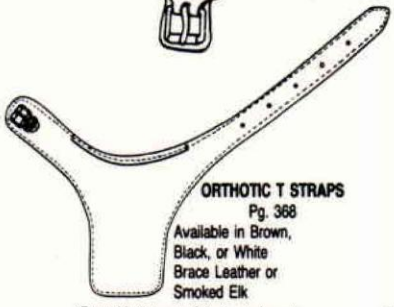

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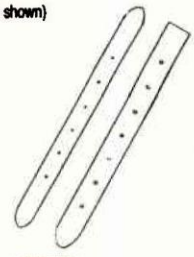

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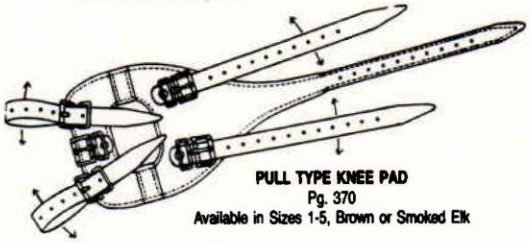

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