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Number 1

Orthotics and Prosthetics

Journal of the American Orthotic and Prosthetic Association

The A.C. Knee Orthosis

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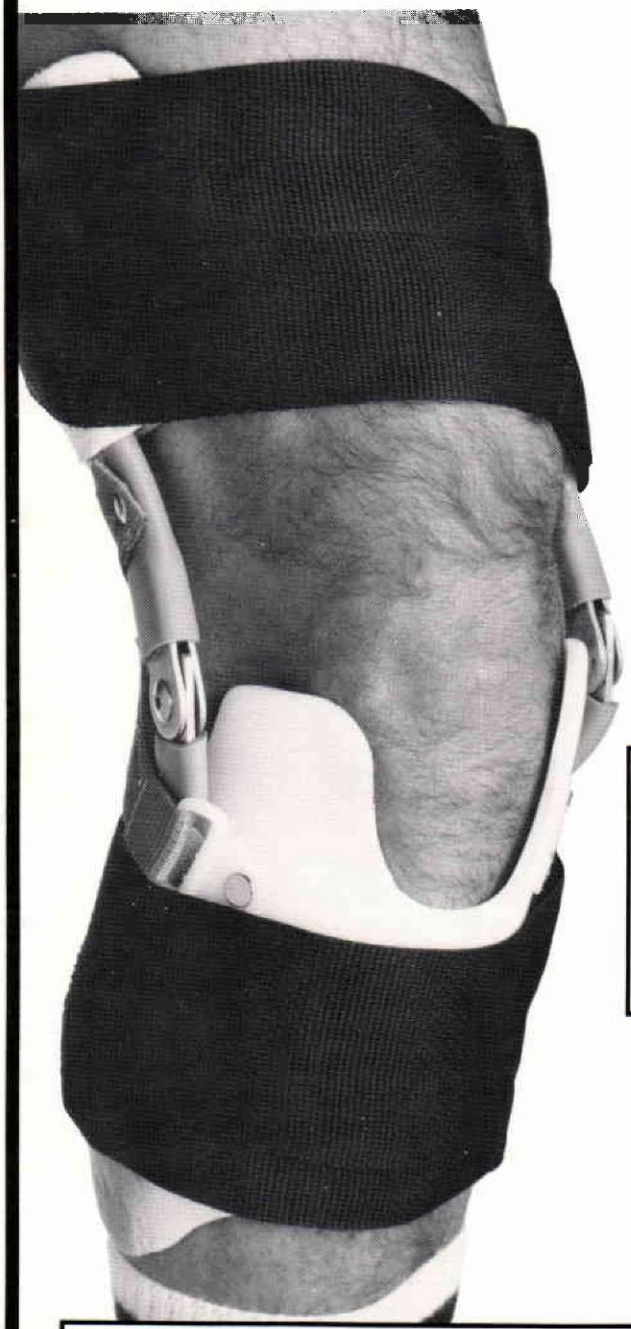

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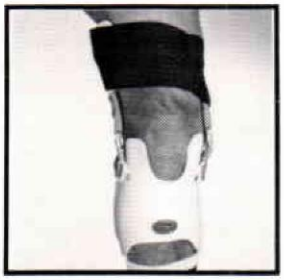

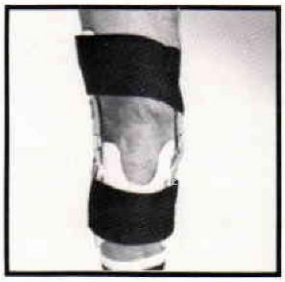

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Orthotics and Prosthetics

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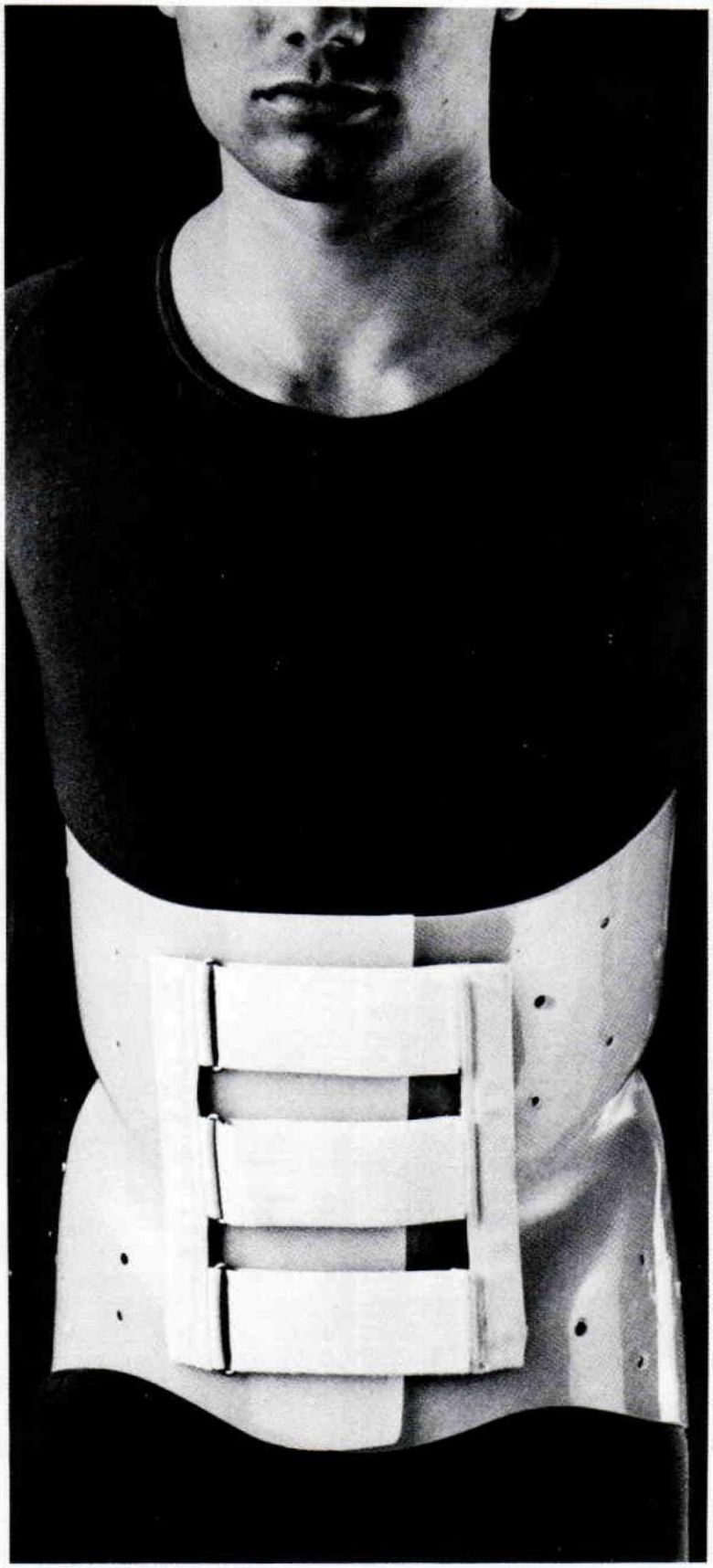

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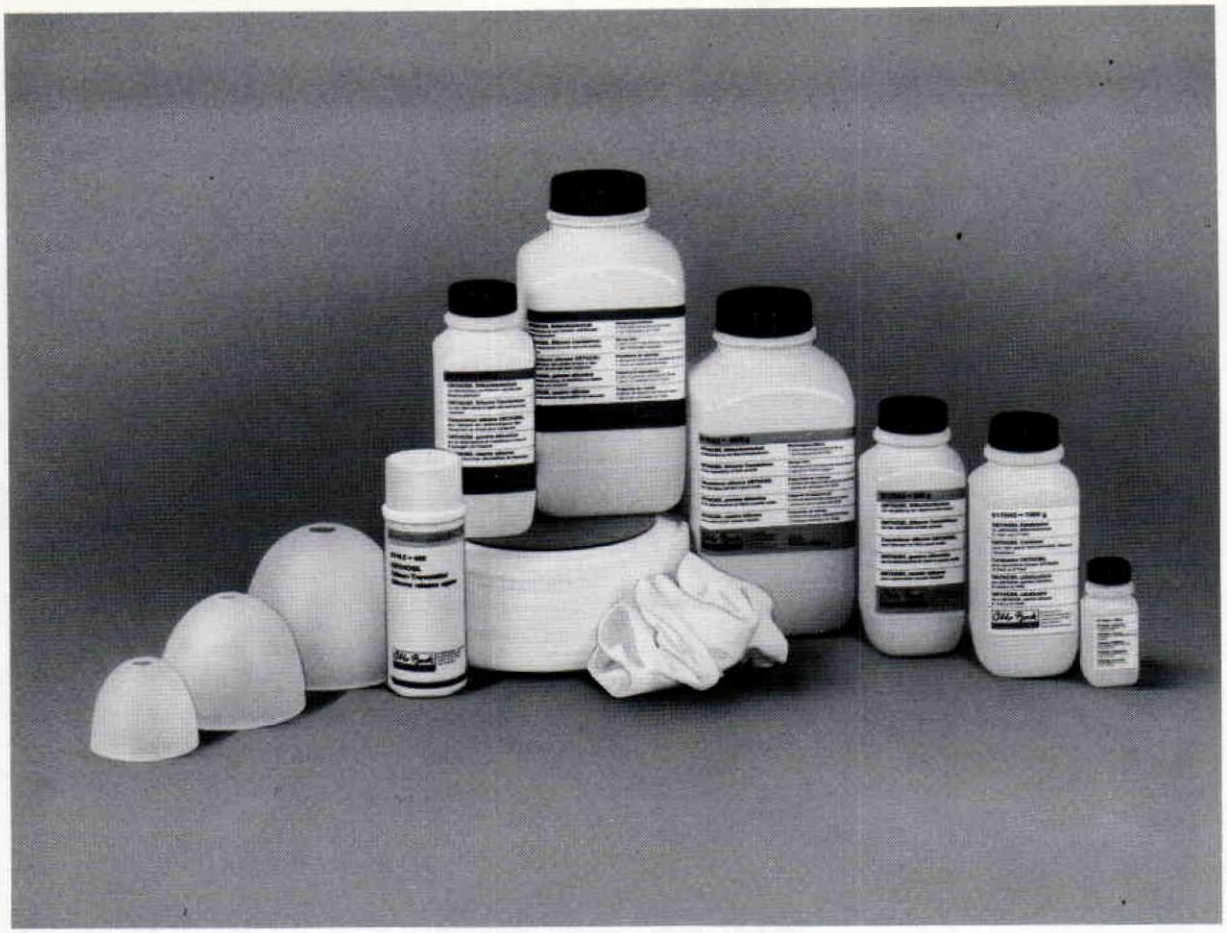

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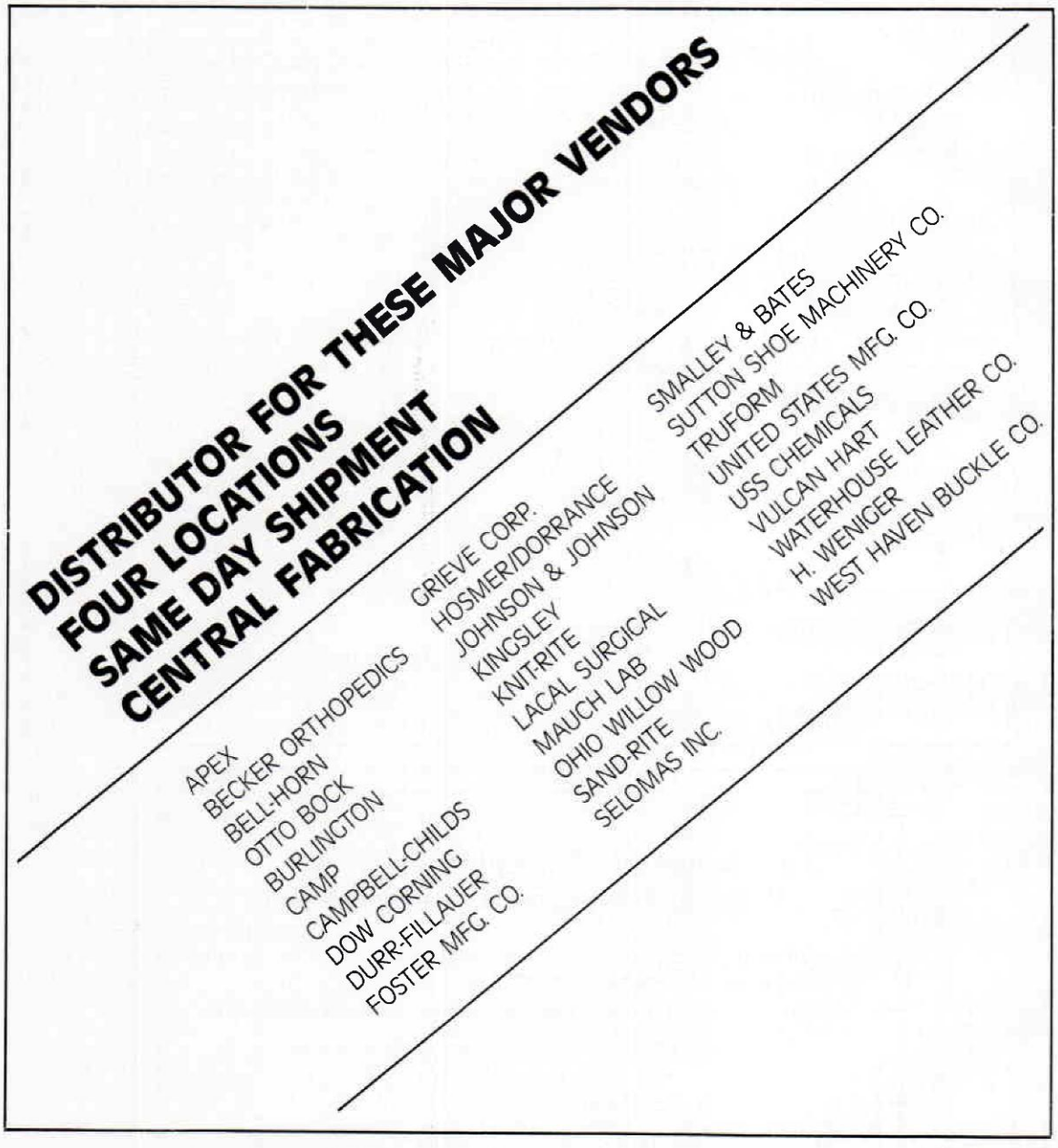

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Orthotics and Prosthetics, Volume 39, No. 1, pgs. 14–28.

The Enhancement of Prosthetics Through Xeroradiography®

by David Varnau, C.P.O.
Keith E. Vinnecour, C.P.O.
Monalee Luth
David F. Cooney, R.P.T., C.P.O.

INTRODUCTION

Today's prosthetist finds himself searching for new tools to enhance his fitting skills. With transparent test sockets, he is now able to visualize the residual limb inside the prosthetic socket. With Xeroradiography®, the contemporary prosthetist is able to identify his patient's unique bony anatomy before even commencing work on the prosthesis.

The concept of using x-ray images to improve prosthetic fit is by no means new. As early as 1963, King wrote of using x-rays as an adjunct to patellar tendon bearing (PTB) fittings.[6] Much more recently, Haslam, C.P. and Wilson briefly cited some merits of x-rays and Xeroradiographs® for prosthetics.[2] Credit for introducing Xeroradiography® into the field of prosthetics, however, must be given to Jan Stokosa, C.P.†

DESCRIPTION

Xeroradiography® is a dry, photoelectric process‡ for recording x-ray images on paper. Although its usefulness today is usually considered to be confined to the examination of the breast, Xeroradiography® is well-suited for any peripheral part of the body.[14]

Advantages of Xeroradiography®

The primary advantage that Xeroradiography® imaging offers the prosthetist over that of conventional film radiography (x-ray) is the clarity of the bone's boundary lines (Figure 1). This fact is due to the character of the Xeroradiographic® imaging process itself.[15]

Previously, when consulting x-rays of a residual limb, prosthetists either had to accept the blurred contours of the patient's bony anatomy, or were deprived of a lucid image of the soft tissue edges. Instead, each Xeroradiograph® can replace two x-ray film pictures (a bone picture and a soft tissue picture) and thus provide the prosthetist with more accurate and easily observable information at a glance.[11]

The Xeroradiograph® is developed on opaque paper, usually on a blue format. Unlike x-rays, the Xeroradiograph® can be easily stored as a part of the patient's chart since there is no need for a viewing box. The rich blue color of the properly exposed negative mode Xeroradiograph® serves to enhance the clarity of the image. Further,

†Jan Stokosa, C.P. is director of the Institute for the Advancement of Prosthetics, Lansing, Michigan.

‡‡Whereas a photo chemical process is used in conventional film radiography.[1]

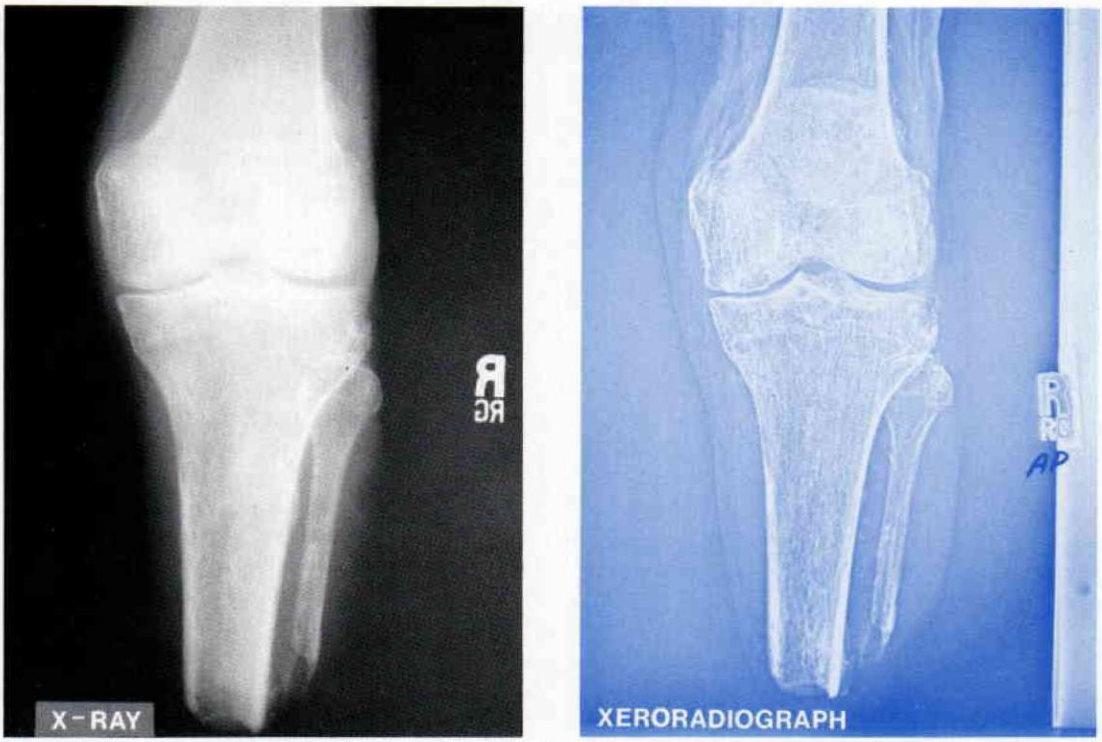


Figure 1. Comparison of bone detail and clarity of soft tissue margins on a conventional film radiograph versus a Xeroradiograph® of the same residual limb. Note magnification of the x-ray image.

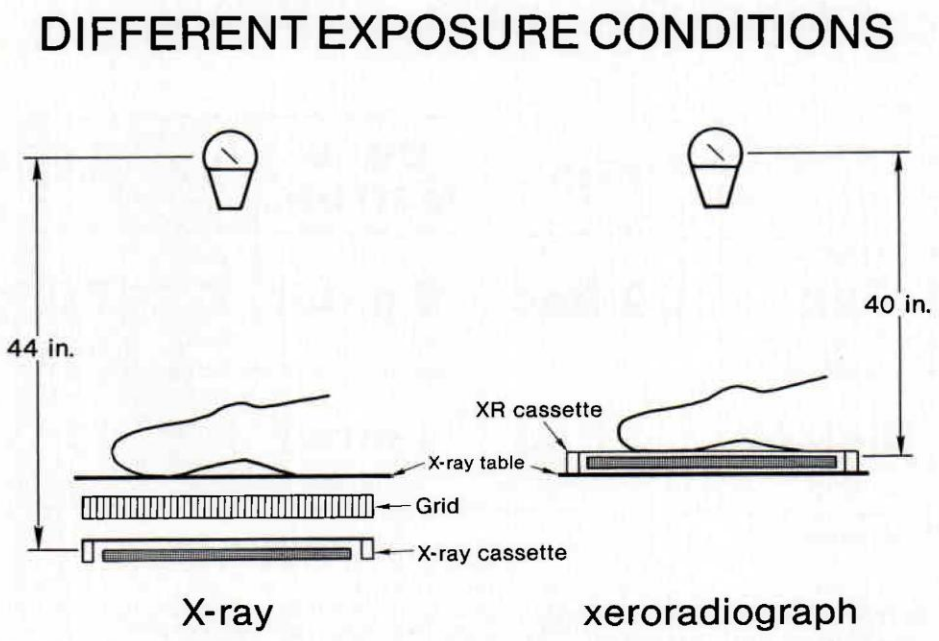


Figure 2. The x-ray cassette is approximately four inches (10 cm.) from the patient's residual limb, whereas the Xeroradiograph® cassette is in contact with the residual limb.

the usefulness of Xeroradiography® for prosthetics becomes even more obvious when it is pointed out that less magnification takes place in the procedure.[11] More magnification typically occurs on conventional film x-ray because the x-ray cassette is positioned further from the residual limb (Figure 2).

Disadvantages of Xeroradiography®

The Xeroradiographic plate is 9½" × 13⅝". As a result, it is not possible to photograph a long residual limb in its entirety. Symes level as well as long above knee residual limbs require two pictures merely to complete the image for one projection. To rectify this problem, the radiology technician must tape a radiographically opaque reference marker onto the midsection of the residual limb prior to imaging. The marker aids the prosthetist in piecing the two pictures together correctly. An alternative to this mosaic approach, of course, is to obtain conventional radiographs of the longer residual limbs.

A second disadvantage of Xeroradiography® is that the image is backwards. As a result, when consulting the Xeroradiograph,® the prosthetist must recognize that the Xeroradiograph® is a mirror image of the object.

Finally, with Xeroradiography,® the patient is usually exposed to a greater radiation dose. The exact difference in radiation exposure between Xeroradiography® and x-ray varies, depending on the type of x-ray screen, film, filters, and resulting technique that is used for a comparison. Generally, using the Xeroradiography® technique that we suggest (see technical information in Figure 20), the local bone radiation dose appears to be as much as nine times that of conventional x-ray film technique† (Figure 3). Although this is undesirable, the amount of radiation both in terms of skin dose, as well as estimated bone marrow dose, is neither alarming nor

RADIATION DOSE COMPARISON

	Skin	Bone Marrow*	kV	mAs
XR	.09 Rad	.9 mrad	120	50
X-RAY	.01 Rad	.1 mrad	55	5

* estimated

Figure 3. Comparison of the radiation dose from Xeroradiograph® and x-ray. Typical entrance exposure (skin dose) and estimated local absorbed dose are listed for each process. Based on data from University of Wisconsin Medical Physics Lab. Thermo lumenescent detectors (TLD's) were taped on a bilateral BK and exposed separately for Xeroradiographs® as well as conventional bone detail x-rays.

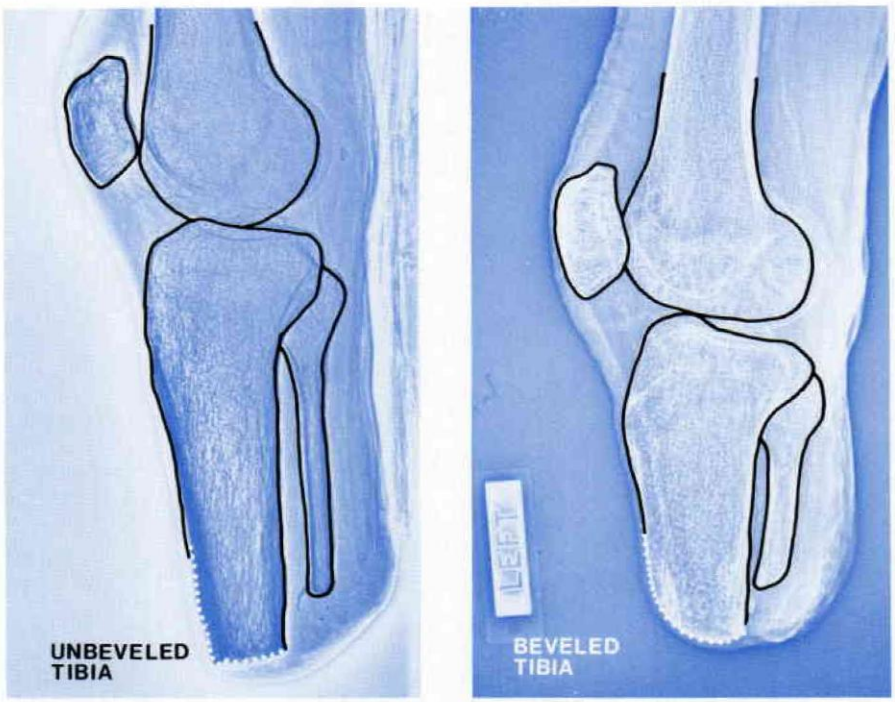


Figure 4. Lateral views of two Xeroradiographs® demonstrating the variety in below knee anterior distal tibial margins. Note: Development method of Xeroradiograph® on left was a positive mode and that on right was a negative mode.

considered dangerous to the patient, mainly because usually only one Xeroradiograph® series is necessary for the adult (see Method Section). Even so, for the juvenile patient, the benefits of Xeroradiography® must be weighed against the greater radiation dose.

USES OF THE XERORADIOGRAPH®

Because contours are intensified on Xeroradiographs,® the boundary lines between bone and soft tissue are pronounced .[1, 11, 13] Thus, the Xeroradiograph® is well-suited for the prosthetist's interest in bony contours. Further, the Xeroradiograph® provides valuable and sometimes surprising information that is not readily apparent through clinical examination. Since the Xeroradiograph® is only slightly

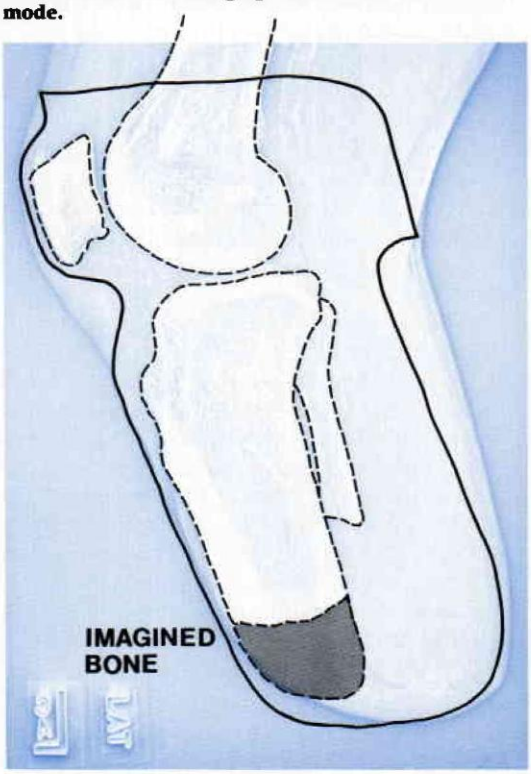


Figure 5. Lateral view illustrating the usefulness of the Xeroradiograph® in assessing the thickness of the distal soft tissue, especially in cases of hard-packed edema.

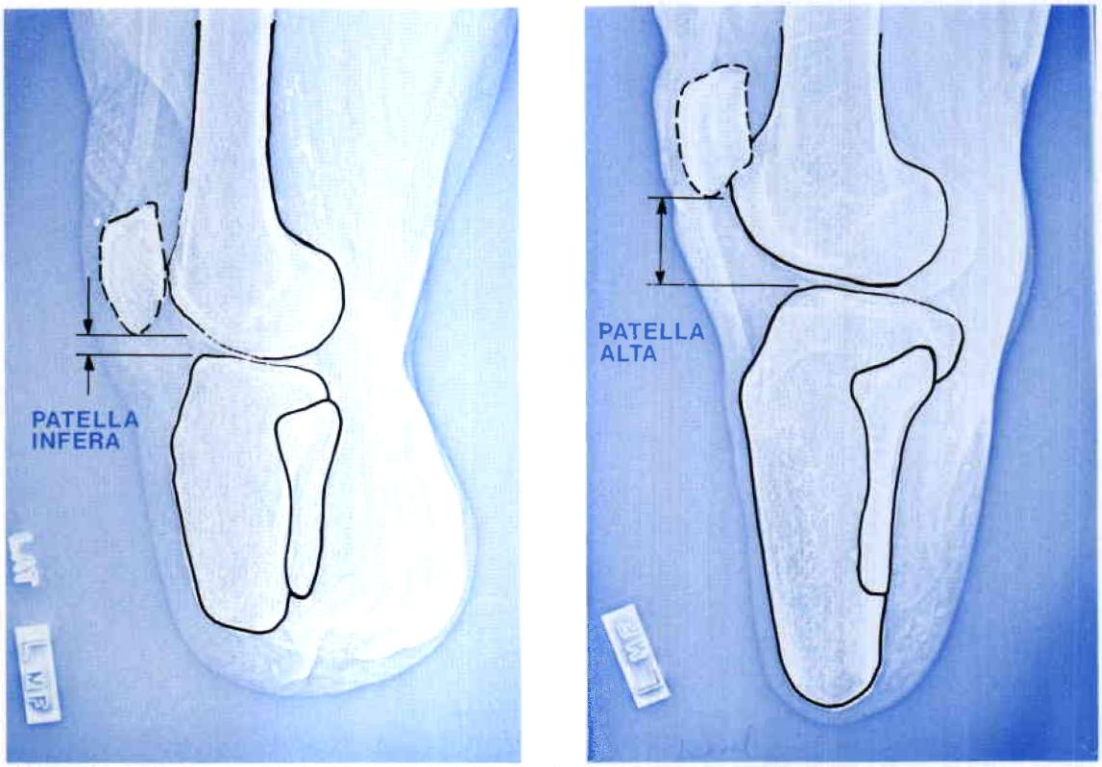


Figure 6. Lateral views which demonstrate the difference between patella alta and patella infera.

magnified,[11] numerous measurements can be obtained directly from it.

Although Xeroradiography® is valuable when fitting prostheses for all amputation levels, this paper will deal only with its use in the treatment of below knee amputations.

By inspecting the Xeroradiograph® of a given patient, the prosthetist can better appreciate the actual length of the tibia,† the contour of the anterior distal tibial margin (Figure 4), as well as the thickness of the distal soft tissue. Much of the guesswork is eliminated from this important aspect of the casting and cast modification procedures. Frequently, in cases of hard-packed distal edema, the prosthetist imagines that the length of the patient's tibia extends further distally than it actually does (Figure 5). The Xeroradiograph® then enables the prosthetist to correctly locate the anterior distal tibial relief during cast modification.

The relative position of the inferior border of the patella to the tibial plateau also varies significantly from one individual to the next. Customarily, the so-called "patellar bar" is placed just below the inferior border of the patellar. Yet many patients have a condition termed patellar alta or a high-riding patella, while still others have patella infera[4] or a low-riding patella (Figure 6).

The existence of one condition versus the other has important ramifications for the prosthetist when he is identifying the proper position for the patellar bar. It is evident, then, that the placement of the patellar bar "midway between the lower edge of the patella and the tubercle of the tibia" as advocated by Radcliff and Foort[10] is in fact incorrect for certain patients (Figure 7). The Xeroradiograph,® thus, aids the

† In order to determine actual dimensions from the Xeroradiograph,® the prosthetist must first account for the exact magnification of the image.

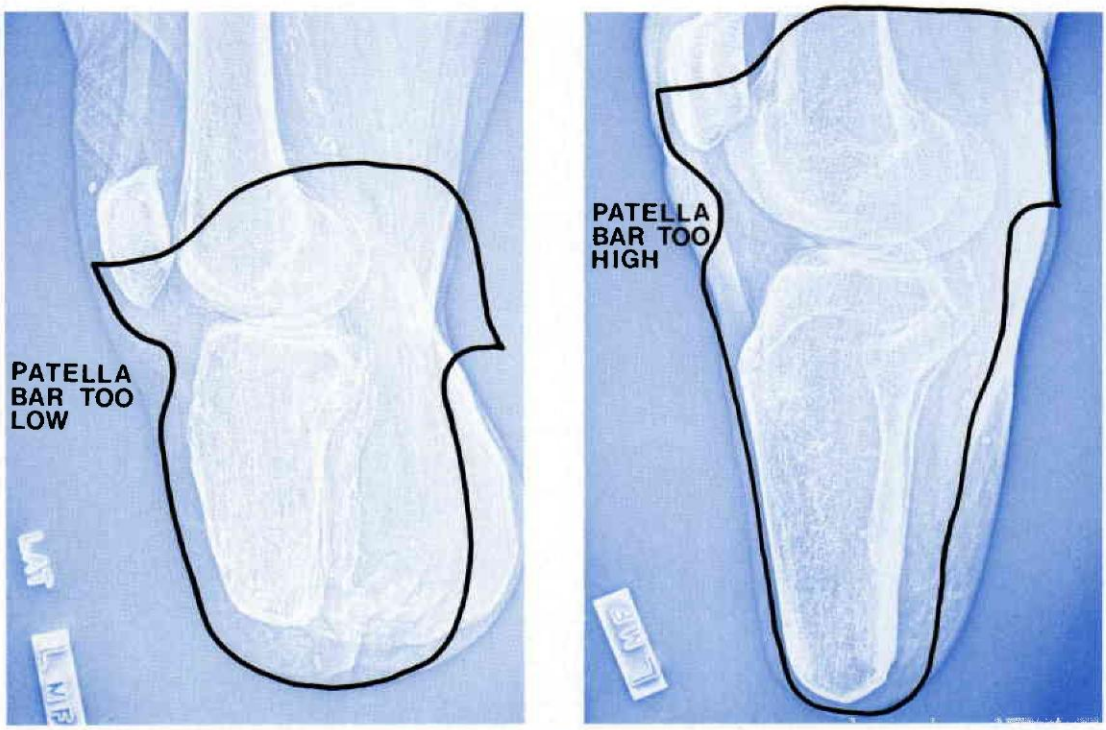


Figure 7. Lateral views with an overlay of the socket outlines. With patella alta, the prosthetist is mistakenly inclined to locate the patellar bar too high. The reverse is true with patella infera.

prosthetist in correctly positioning the patellar bar at the femorotibial joint space.

Prosthetists who routinely use transparent test sockets have noted the presence of an airspace just proximal to the tibial tubercle. This appears to be caused by the patellar bar forcing the patient's tissues posteriorly. Another contributing factor may be that the positive model does not reflect the patient's anatomical contours just proximal to the tibial tubercle. Contrary to popular notion, plaster may be removed and flared from the level of the tubercle into the patellar bar. The angle of the flare is dictated by the contour of the patient's proximal tibia as seen on the lateral Xeroradiograph.® The contour of the proximal tibias in Figure 4 are examples where the flare above the tubercle would be less dramatic than that shown in Figure 5.

The length of the fibula, like that of the tibia, is readily apparent on a Xeroradiograph.® Briefly consulting the anteroposterior (AP) projection will provide a quick reference for the terminus of the fibular shaft. Guessing as to the shape, position, and size of the fibular head is unnecessary with the Xeroradiograph® (Figure 8). Also, cases of absence of the fibula are obvious on a Xeroradiograph.® Problems of pressure on the cut end of the fibula and fibular head are diminished while medio-lateral (ML) stabilization on the fibular shaft can be maximized. The lateral projection, on the other hand, is useful for identifying whether the patient's fibula is positioned posterior to, or on, the midline.

The shape of the medial tibial metaphysis varies from one patient to the next (Figure 9). With an AP projection of a given patient's Xeroradiograph,® the prosthetist can anticipate the amount of flare possible in the tibial metaphyseal region. This information aids the prosthetist in creating an anatomically-shaped, weight-bearing area.

After reviewing the Xeroradiographs® of nearly 100 adult below knee residual limbs, we found in our practice that fully 13 per-

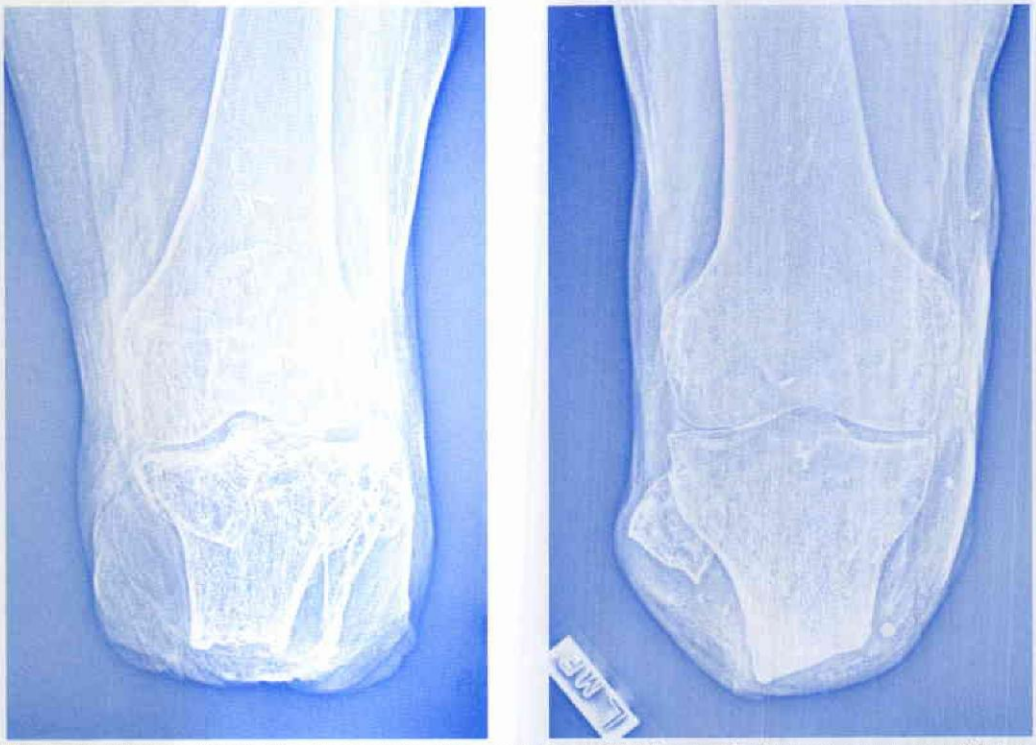


Figure 8. AP views illustrating the variety of bony anatomy that the prosthetist may encounter with two short below knee amputations.

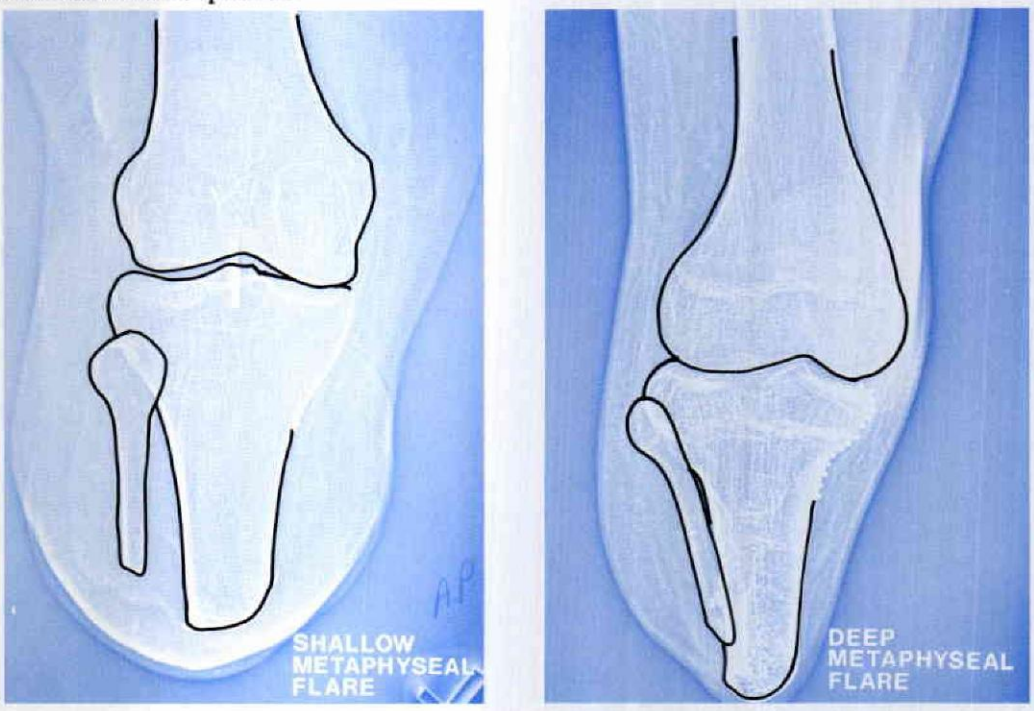


Figure 9. AP views exhibiting the variation in the contour of the medial tibial metaphyses.

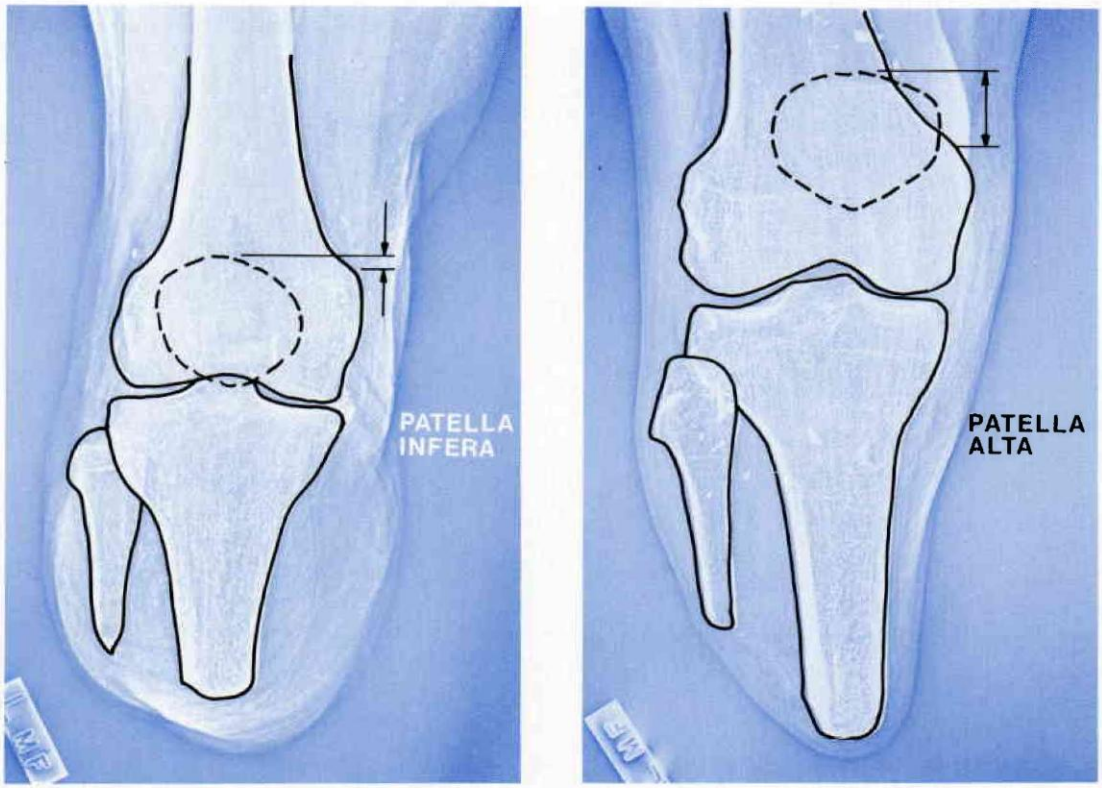


Figure 10. AP views demonstrating the relative distance between the proximal border of the patella and the adductor tubercle for cases of patellar alta and patella infera.

cent of our below knee amputees have tibias shorter than three inches and are PTS candidates. As pointed out by Marshall and Nitzchke, the patient with a four-inch length residual limb is a good candidate for the PTS socket.[8] However, as they also point out, the PTS prosthesis requires "more skill and knowhow" of the prosthetist for successful fitting.[7]

One important anatomical consideration for the PTS socket, particularly the supra-patellar PTS, is the relative position of the proximal patella to the adductor tubercle. Here again, the existence of patella alta or patella infera is crucial (Figure 10). This information aids the prosthetist both during casting and cast modification to ensure optimum suspension and correct proximal PTS socket contours.

CLINICAL VERSUS XERORADIOGRAPH® MEASUREMENTS: SURVEY RESULTS

The Xeroradiographs® of 92 adult below knee amputees were reviewed and the following observation was made. It is virtually impossible to conclusively correlate the AP and ML diameter measurements on the Xeroradiograph® to the clinical measurement taken on the patient. That is, no formula could be devised that would reliably allow the prosthetist to predict the patient's clinical AP and ML measurements solely from the corresponding diameters measured on the Xeroradiograph.® This lack of correlation is attributable to three variables:

1. The methods that practitioners use to obtain their clinical diameter measurements vary, resulting in a var-

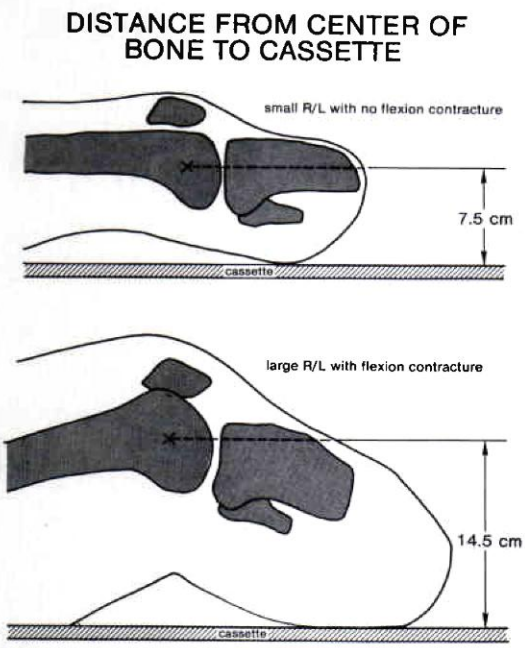


Figure 11. Variation in the distance possible from the center of the femoral condyles to the Xeroradiograph® cassette.

iance of as much as 3/8" in the clinically measured AP and ML dimensions of a given patient.

2. The amount of soft tissue thickness at the knee is quite different from one patient to the next.
3. The extent of magnification that occurs on the Xeroradiograph® varies among patients and is due to the vertical distance of the patient's knee from the Xeroradiography® cassette. That distance is determined by:
   a. The size of the patient's residual limb.
   b. Presence of a knee flexion contracture (Figure 11).
   c. The amount of soft tissue compression of the residual limb where it contacts the cassette.

Thus, using identical radiographic technique, magnification of the image on the Xeroradiograph® may vary between six and 14.5 percent (Figure 12).

The amount of magnification and, hence, image dimensional distortion of the

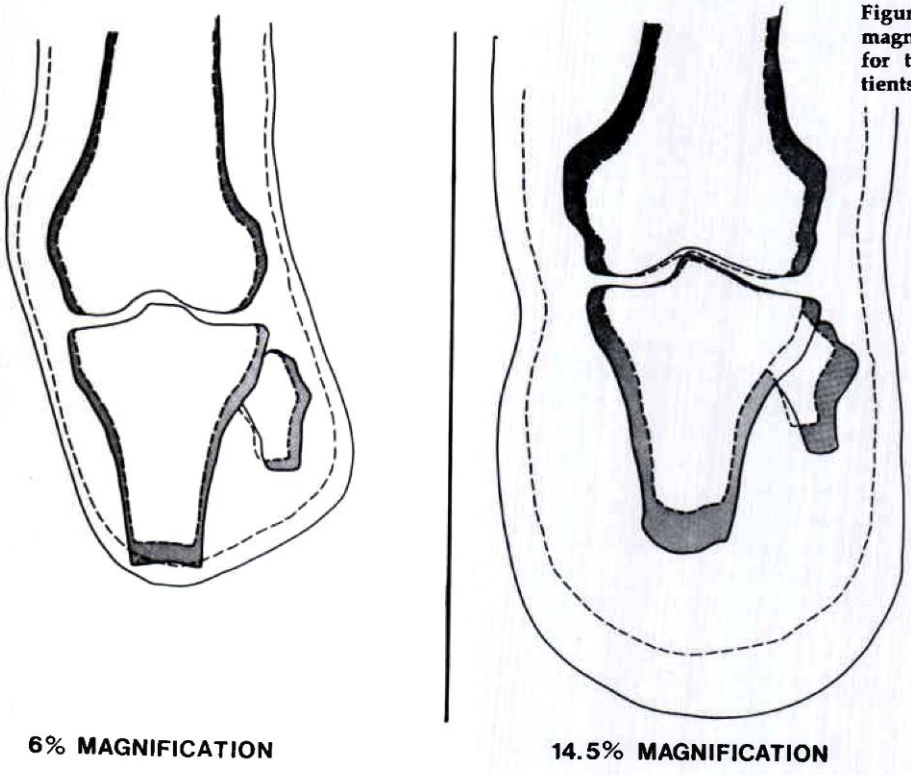


Figure 12. Extent of magnification possible for two different patients.

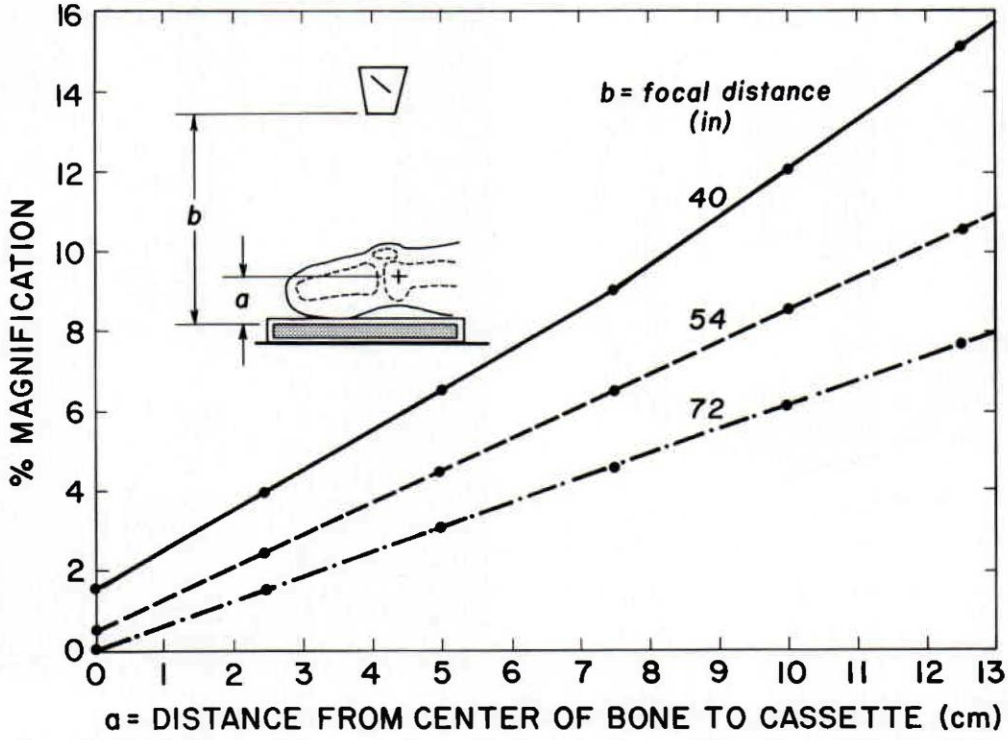


Figure 13. Graph showing the amount of magnification occurring on a Xeroradiograph® for focal tube distances of 40, 54 and 72 inches. Note that magnification is minimized with a small-boned patient (where a = 5 cm.) and the focal tube distance is large (where b = 72 inches). Even so, under such optimal conditions, the Xeroradiograph® will be magnified three percent.

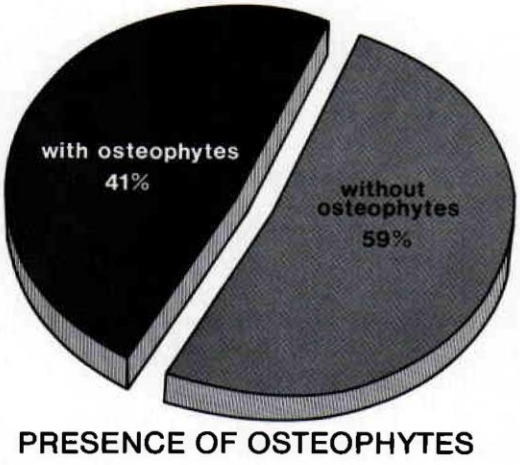


Figure 14. Graph illustrating the percentage of the surveyed adult below knee population who have osteophytes on their distal tibias and/or fibulas.

AP and ML diameters, also depends on the focal tube distance to the cassette† (Figure 13). Although most radiology offices can only accommodate 40-54 inches, a 72-inch focal tube distance will reduce magnification to a minimum.

In summary then, magnification is minimized with a small-boned patient who has no knee flexion contracture and some soft tissue compression (i.e., a = 5cm). In addition, magnification is diminished when the focal tube distance is large (i.e., b = 72 in.). Even so, in such an instance, the Xeroradiograph® will be

†The authors obtained the data for (Figure 13) as follows:

A radiographic ruler was imaged on Xeroradiography® at 0cm, 2.5cm, 5cm, 7.5cm, 10cm and 12.5cm from the cassettes for each of three common focal tube distances—40 inches, 54 inches, and 72 inches. The linear magnification was then determined by measuring the ruler's image on each of eighteen Xeroradiographs® and computing the percentage enlargement.

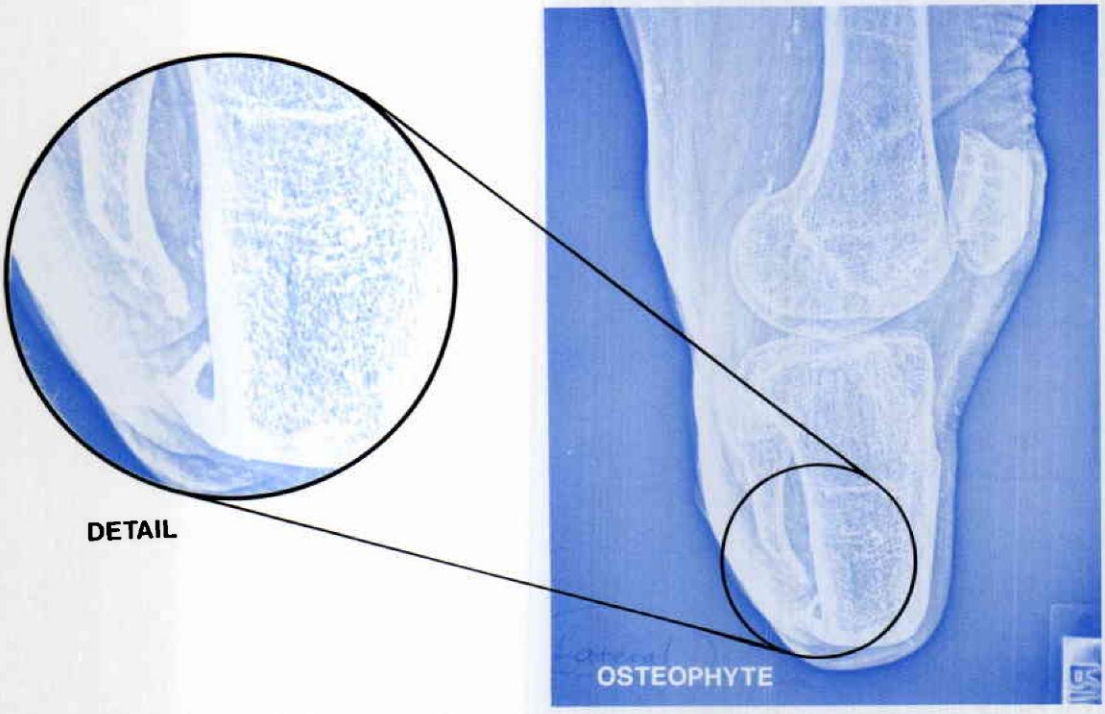
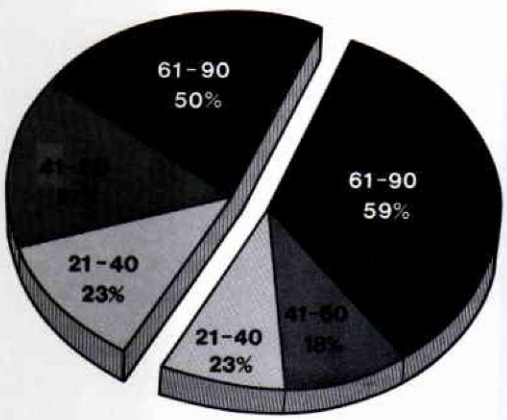
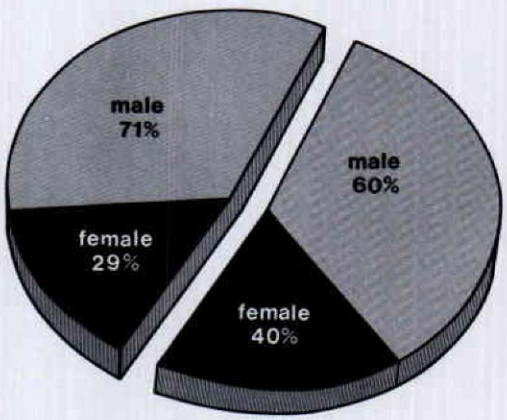


Figure 15. Xeroradiograph® with an osteophyte clearly present on the distal tibia and fibula. Inset: closeup of the osteophyte.



DISTRIBUTION BY AGE

Figure 16. Breakdown of patients' ages for osteophyte population versus non-osteophyte population. Patients' age at amputation had little or no bearing on whether osteophyte formation would occur. Statistical profile of our patient population is comparable to that of 1974 amputee survey.[5]



DISTRIBUTION BY SEX

Figure 17. Sex of the patient had no significant effect on the patient's tendency toward osteophyte formation.

magnified three percent. Exact correlation of clinical and Xeroradiograph® measurements, therefore, is possible only with time-consuming computations.

INCIDENCE OF OSTEOPHYTE FORMATION

A review of the Xeroradiographs® for ninety-two adult below knee amputees bore out surprising information. Namely, on 41 percent of the patients, osteophytes were present on either the distal tibia and/or fibula (Figures 14 and 15). For many of these patients, the osteophytes seemed to pose no fitting problems. For others, the prosthetist used the Xeroradiograph® information together with test socket fittings, and, later, a gel liner, to avoid fitting problems. In two cases, patients required residual limb revisions to have the osteophyte resected. Without the use of Xeroradiographs,® prosthetists have no means of ascertaining the presence, location, and size of osteophyte formation on the patient's bony anatomy.

CAUSE OF OSTEOPHYTE FORMATION

A comprehensive statistical review of the charts for the surveyed below knee amputee population was performed to identify the cause(s) of osteophyte formation. Neither the patient's age (Figure 16), sex (Figure 17), cause of amputation (Figure 18), nor tibia length (Figure 19) seemed to be a reliable predictor of osteophyte formation. In fact, three bilateral below knee amputees exhibited osteophytes on one residual limb and none on the other.†

In the absence of any specific reference in the orthopedic literature to this phenomenon as a sequela to amputation surgery in adults, our impression is that osteophyte formation in adult amputees is decidely not bony overgrowth as found in juveniles.[9] Radiographically, osteophyte formation appears grossly similar to the heterotopic ossification seen as a complication following other types of surgical resection.[12] It is not clear whether osteophytes in residual limbs are an outgrowth from the periosteum or from the cortical bone. The authors feel that the unwanted ossification may result from the manner in which the bone is handled during amputation surgery.

Some orthopedists have expressed interest in conducting a retrospective study to assess the effect that myoplasty has in dis-

†The three bilateral below knee patients were male. Two of the patients' amputations were due to dysvascular causes and were performed at different times. Both amputations of one patient were performed by the same surgeon. The amputations for the other patient were performed by different surgeons. The third patient's amputations were due to trauma and were performed concurrently.

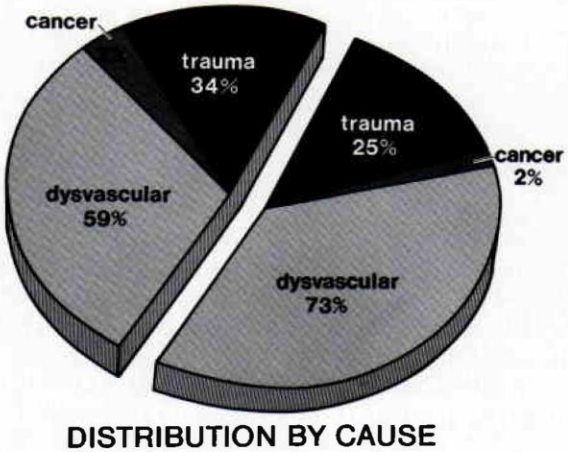


Figure 18. Cause of amputation had no significant effect on the patient's tendency toward osteophyte formation.

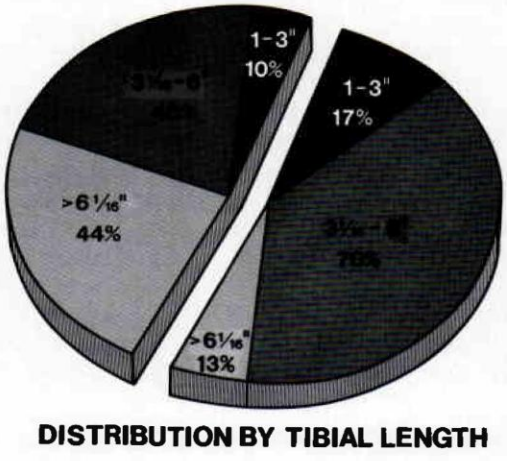


Figure 19. Length of the patient's tibia was not an effective predictor of whether osteophyte formation would occur.

couraging osteophyte formation. Further investigation that conclusively identifies the cause of the osteophyte formation phenomenon is warranted in the interest of the amputee's comfort and of optimal amputation technique.

REQUESTING XERORADIOGRAPHS®

To obtain useful Xeroradiographs,® specific instructions must be provided to the radiology technician. We have found that the request form which is pictured (Figure 20) is useful and assures that the necessary projections will be provided to the prosthetist. Although only AP and lateral views are necessary, internal and external oblique views are useful for visualizing bony anomalies in additional planes.

It has proven to be difficult for some radiology technicians to obtain true lateral projections of the below knee residual limb. This can be attributed to the technician's failure to note inadvertent axial rotation of the knee when taking the picture. This oversight is obviously due to the absence of the foot on the extremity for axial rotational reference. A true lateral projection is also sometimes elusive since sidelying on the hard surface of an x-ray table can prove to be difficult for the unilateral patient and certainly is so for the bilateral below knee amputee.

Furthermore, exposure values are critical and must be specified to any radiology service if quality Xeroradiographs® are to be obtained. The exact selection of exposure may be modified for specific machines as well as for patients of varying sizes. The radiology technician must select a setting of 120 kilovolts (kV) but may vary the setting for milliamperes/seconds (mAs). Generally, however, the specifications in the technical information of the request form (Figure 20) usually assure maximum prosthetic usefulness of the Xeroradiographs®.

METHOD

In this prosthetic practice, standard protocol calls for all below knee patients with mature residual limbs to obtain their Xeroradiographs® prior to casting. The prosthetist, then, has the best available anatomical information with which to commence his work.

If, following the fitting of at least two dynamic transparent test sockets, fitting problems persist, a weight-bearing Xeroradiograph® may be requested to identify the source of the problem. This order is indicated in the special instructions box on the request form (Figure 20). The inner surface of the socket or socket liner may be highlighted easily with self-adhesive copper foil tape† which is used for its radiopacity. For maximum information regarding socket fit, the patient's residual limb may be imaged in the prosthesis full weight-bearing and partial weight-bearing. Of course, the weight-bearing Xeroradiograph® is also useful when evaluating an ill-fitting, definitive prosthesis of a patient new to the office.

The extent of the osteophyte formation appears to be well-defined six months past amputation, like that of heterotopic ossification following total hip replacement.[3] Hence, subsequent Xeroradiographs® are unnecessary for purposes of identifying osteophyte formation if previous ones are on file.

CONCLUSION

The most important advantage of Xeroradiography® is patient management. Since the unique anatomy of a given patient is more observable, the prosthetist approaches his patient with more information and, therefore, greater confidence. That confidence is communicated to his patient.

With the addition of Xeroradiography® to the prosthetic armamentarium, the prosthetist can enhance as well as advance his skills. He becomes a better anatomist, noting the unique bony anatomy of each patient. Even the experienced prosthetist is often surprised by the Xeroradiograph®

†Copper foil tape 3/16" × 1 mil. Venture, Tape, 123 Moore Road, Weymouth, Massachusetts 02189. The copper foil is available in stores selling stained glass supplies.

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Van Nuys, California 91411
Phone (213) 988-0033

PATIENT

DATE

TYPE OF X-RAY EXAMINATION

☐ Xeroradiograph ☐ Radiograph
☐ Plain film (soft tissue technique)
☐ Plain film (for bone detail)

REGION OF X-RAY EXAMINATION

☐ RT ☐ Below Knee Residual Limb ☐ Above Knee Residual Limb ☐ _____
☐ LT _____

VIEWS

☐ AP
☐ LATERAL
☐ INTERNAL OBLIQUE
☐ EXTERNAL OBLIQUE

☐ WRITTEN REPORT

SPECIAL INSTRUCTIONS

INSTRUCTIONS TO RADIOLOGIST

1. Use negative mode.
2. All views to include the entire amputation stump and the next proximal joint.
3. Have knee extended and hip in neutral position.
4. Try to prevent tissue distortion from leg resting on table.
5. It is important to have a *true* AP and Lateral view.
6. Label all views.
7. All films should be given patient to return to our office.

TECHNICAL INFORMATION

Development method: Negative Mode
Focal cassette distance: 40 inches
Average exposure:
Single phase—50 MAS, 120 KV
Three phase—25 MAS, 120 KV

Processor and conditioner should be the same settings as used in negative mode mammography.

PRESCRIBING PHYSICIAN

CERTIFIED PROSTHETIST

Figure 20. Xeroradiography® request form routinely used by the authors.

of a familiar patient and finds the new information beneficial. And while evaluating the patient who is new to him, the prosthetist will find himself groping less for information. With Xeroradiography,® he becomes a better informed professional. Still, Xeroradiographs® are no replacement for skill and experience. Like transparent test sockets, Xeroradiographs® should become an integral part of prosthetic practice.

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Finally, Monalee Luth's talents in both graphic arts and photography were indispensable.

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New Trends in the Rehabilitation of Lower Extremity Amputees

Richard T. Goldberg, Ed.D.

Reprinted from *Rehabilitation Literature*, Vol. 45, No. 1–2, January–February, 1984. Used by permission, National Easter Seal Society.

INCIDENCE AND CAUSE OF AMPUTATION

The exact number of new amputees is unknown. With certain exceptions it has not been possible to track new amputees in the United States. The National Center for Health Statistics reported 311,000 amputees in 1970. By 1977, this number had risen to 358,000. Of these amputees, 101,000 involved an upper extremity, and 210,000 involved a lower extremity. There are 43,000 amputations each year.[7]

In 1973–1974 the Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education of the National Academy conducted a study of the amputees known to the American Orthotic and Prosthetic Association (AOPA), including 143 prosthetics facilities located in 39 states.[13] The proportion of lower extremity to upper extremity was 11:1 for both males and females. There was a significant increase in lower extremity amputation when compared with a 1961–1963 study (Glattly[8]) of amputees known to AOPA. There was also a significant increase from Glattly's study in the percentage of persons with below-knee amputations, from 36.8 percent to 53.8 percent, and a significant decrease in above-knee amputations, from 44.1 percent to 32.6 percent.

The proportion of males to females in all amputees was almost 3:1 (72 to 28 percent), probably due to a greater injury rate among males. When limited to disease, the sex ratio dropped to 2.1:1, and when limited to tumor, it dropped to 1.3:1. The proportion of males to females among lower extremity amputees is 70:30 percent.

The distribution of below-knee amputees to above-knee amputees varies by cause. Above the age of 40, above-knee amputees account for about one out of every three amputations. Most amputations for vascular disease in persons above the age of 60 had been performed above-knee prior to 1945. However, as medical and surgical techniques have improved, the decision to operate below-knee for vascular disease has increased. In the National Academy Study of 1973–1974, below-knee amputations accounted for 62.4 percent of all lower extremity amputations. The percentage for each decade in above-knee and below-knee was similar; there was no significant difference according to age.

The causes of new amputation are broadly described as trauma, disease, tumor, or congenital. Congenital amputation occurs as the cause in nearly all patients under five years, and it accounts for 2.8 percent of all amputations.[8] Tumors that are malignant and benign tumors where function is reduced may require amputation. This accounts for approximately five percent of all amputations. Malignant tumors may occur in children in the second decade. Amputations due to vas-

cular diseases and infections increased from 58 percent in a previous study to 70.3 percent in the National Academy Study of 1974. Amputations due to trauma account for 22.4 percent of all amputations. This is a slight decrease of 11 percent from a previous study. The largest percentage of cases due to trauma occur in ages 41 and 50, whereas the largest percentage of cases due to disease occur in ages 61 to 70. Although the Kay and Newman study[13] reported multiple amputations, these accounted for only 3.3 percent of the cases, and will not be discussed in detail in this article. Disease was the cause of reamputation in 41 percent of the cases.

REHABILITATION OF THE LEG AMPUTEE

The rehabilitation of the leg amputee requires a multidisciplinary team that treats the medical, psychological, social, and vocational aspects of amputation. Friedmann states that "the primary determinants of success in the treatment of the limbless are the generality of care an amputee receives and the amputee's innate characteristics."[7] Care begins at the preoperative stage and continues until the amputee is helped to readjust to social and vocational roles in the community.

Before amputation the person must be prepared to confront the reality of surgery, but not all its potential consequences. The results of surgery should not be presented all at once to the patient. After amputation, the patient may be given a few facts at a time until he or she has a chance to acknowledge the extent of the physical changes.

In older textbooks on the subject, the goal was to help the patient "accept his loss."[25] Stages of adjustment to amputation proceeded from denial to depression to acceptance of loss. In recent years, the stage theory has been questioned as a uniform analogue for all amputees. Some may not proceed through the same stages of adjustment. Others may never reach the final stage: acceptance of loss. For some patients, healthy denial is an adaptive mechanism that enables them to cope with the multiple losses resulting from amputation. They may deny their disability for the rest of their lives. There is nothing wrong with this method of coping—it works for some people. Rehabilitation professionals must learn to respect the individuality of each amputee and to help each amputee to gain optimal acceptance of the disability.

Early postoperative care requires breathing exercises along with exercises in a prone position in bed for the remaining limbs, on parallel bars, on a frame, and finally on crutches.[11] Immediate fitting of a pneumatic pylon (temporary prosthesis) may permit the patient to walk within a few days after amputation. It also enables the physical therapist and rehabilitation medicine specialist to judge whether the patient can tolerate an artificial prosthesis.

Some patients have difficulty in adjusting to the pylon either because of the poor healing condition of the stump or because of a combination of physical and psychological problems. Patients with heart conditions and elderly patients in poor general health may not tolerate the physical demands of walking with a pylon. From a psychological viewpoint, immediate fitting with a pylon may provide equivocal results. On the one hand, it may inspire confidence in the patient that he or she can eventually learn to walk with a permanent artificial prosthesis. On the other hand, it may not permit enough time for adjustment to loss of a limb. Some patients may require a period of mourning for their lost bodily part before fitting of a pylon. This period may go on for many weeks after amputation; it is a normal reaction to amputation.[4] Too early fitting of a prosthesis cuts short the mourning period and may prevent the patient from integrating the loss with body image. Moreover, some patients who may tolerate a lightweight pylon cannot tolerate a permanent prosthesis.

The phenomenon described as *phantom pain* may occur whether or not there is immediate prosthetic fitting. Many previous studies purported to show that phantom pain really did not exist in a material sense. It was hypothesized that the amputee re-

constructed a mental image of his amputated limb. The image stimulated the sensation of pain which, in turn, reinforced the awareness of a lost bodily part. Current thought is that phantom pain may be attributed to electrical nervous impulses transmitted from the nerves in the stump. When an immediate postoperative prosthesis is fitted, phantom pain is lessened and the patient is better motivated to complete his prosthetic training program.[21]

AMPUTATION PROGRAMS

Rehabilitation of the amputee is optimally achieved by referring the patient to an amputation center. In the United States, several centers are associated with rehabilitation departments, Veterans Administration hospitals, and orthopedic departments in general hospitals. In the United Kingdom, patients may be referred to a community and artificial limb and appliance center. There is a clear advantage to centralizing the professional services for the treatment of amputees, as demonstrated in the following evaluative studies.

Malone and others[16] evaluated the results of two groups of lower extremity amputees who underwent a rehabilitation program at the Tucson Veterans Administration Medical Center and the University of Arizona Health Sciences Center. From July, 1975, to July, 1979, 119 patients underwent 143 lower extremity amputations. For study purposes, these patients were divided into two groups: a group with amputations between July, 1975, and June, 1977; and a group with amputations between July, 1977, and June, 1979. The first group underwent rehabilitation prior to the establishment of the amputation center. The second group underwent amputation in the amputation center. There were no significant differences in age or sex between the two groups. The difference between postoperative mortalities was not significant (one died in group one, four in group two). Amputation level was determined prior to amputation by Xenon skin blood flow tests. The use of Xenon clearance is a measure of capillary skin blood flow for purposes of amputation level selection and predictions of wound healing.

There was a significant difference in primary amputation healing between groups one and two: 63 percent and 97 percent. The overall rehabilitation time was significantly reduced in group two compared to group one: 30.8 days compared to 128.4 days. The rehabilitation time for below-knee amputation was significantly improved in group two compared with group one: 32.5 days compared to 132 days. There was a rehabilitation rate of 100 percent in group two for patients who could walk before amputation. All of them used their prostheses successfully for one to 18 months following discharge. Length of hospitalization was significantly less for group two than for group one (38.1 days compared to 65.8 days). These comparisons indicate the greater program effectiveness of an amputation center in treatment of postoperative amputees within the same institution.

In a clinical study of amputations of the lower limb at the rehabilitation and artificial limb center, K.G.'s Medical college in Lucknow, India, Agarwal and others[1] found that proper postoperative care and rehabilitation were conducive to greater gains. A retrospective study of 525 cases of lower limb amputations showed that the majority of amputations (65.3 percent) were due to trauma (train accidents), 20 percent were due to vascular disease; and seven to eight percent were due to neoplastic lesions. Fifty-seven percent of the cases were below-knee, and 34 percent were above-knee. Stumps of satisfactory length were found in 40 percent of below-knee and 68.2 percent of above-knee cases. Proper postoperative care had been lacking in persons amputated at other centers. The amputation center provided a more efficient, cost-effective way of treating patients.

Few studies examine the economic impact of an amputation program. An ambitious study by Malone and others[17] analyzed the treatment records of the 172 hospital systems of the Veterans Administration to determine the cost impact of alternative methods of theory. The cumulative

cost for patients undergoing 1,933 below-knee amputations in 1976 was nearly 25 million dollars. The authors extrapolated from their experience with 142 below-knee amputations for vascular occlusive disease and/or diabetes mellitus in 133 patients. Their program employed immediate post-operative prosthesis with accelerated rehabilitation for postoperative management. Their results showed no postoperative mortality, 89 percent amputation healing, and 100 percent prosthesis rehabilitation of all unilateral below-knee amputees, with 93 percent rehabilitation of all bilateral below-knee amputees.

Based upon their program results, the VA system could save 18 million dollars by reducing the average hospital stay to 32 days. In the centers at the VA Hospitals, in Tucson and San Francisco, the average time from surgery to rehabilitation had been reduced from 125 to 32 days. Using the per diem cost of $116 per day for 125 days , the minimum cost for the VA section as a whole was $24,899,980. Using the minimum cost of $116 per day for 32 days, the average cost would be $7,175,296.

The authors point out, of course, that the development and maintenance costs of a modern amputation center will be substantial.[17] The need for nuclear medicine to do Xenon flow studies, the need for rapid fabrication of prostheses for physical therapy, and an active rehabilitation program mount up in costs. The total cost to the VA system, when projected over five years, would be $44 million. Nevertheless, even this figure would be less than the current figure of $124 million (at $25 million per year). Therefore, the initial investment is well worth the total cost. Moreover, the ultimate benefits to the patients in terms of accelerated rehabilitation must be balanced against costs. The savings to the VA system over five years was projected to be 80 million dollars.

ABOVE-KNEE AMPUTATION

In a prospective, randomized trial of the ability of physical therapists to manage the immediate post-operative dressing of patients with sarcoma receiving above-knee amputations, Thorpe and others[23] evaluated the characteristics of wound healing, post-operative gait, duration of pain, course of rehabilitation, and psychological adjustment. In addition, the authors evaluated the effect of immediate ambulation compared with delayed ambulation on rehabilitation. All patients with a diagnosis of lower extremity sarcoma were eligible for the study. Treatment was given by the Surgical Branch of the National Cancer Institute, Bethesda, Maryland. In a 2×2 factorial design, one factor was type of ambulation (immediate versus delayed), the other factor was type of treatment agent (physical therapist versus certified prosthetist).

The results of the study indicated that there were no significant differences with respect to age, sex, average stump length, pre- and post-operative gait characteristics, and average number of days to healing. Phantom limb sensation, phantom pain, and wound pain were evaluated in the four groups. Less analgesia was used in patients treated by therapists compared with patients treated by prosthetists. Non-phantom pain was significantly less in patients with delayed ambulation treated by a prosthetist than in patients with delayed ambulation treated by a therapist. No psychological differences were found among the four groups. Patients with casts applied by therapists used their prostheses more than patients with casts applied by prosthetists. Time to prescription of final prosthesis was not statistically significant among the four groups. Most patients were ready for final prosthesis 70 days after the operation, a 46-day improvement over historical NIH controls not fitted with rigid dressing. The authors concluded that the reason for success by physical therapists compared to certified prosthetists was that therapists remained continually in the hospital while the patient was undergoing rehabiltation. The in-house therapist is more enthusiastic, more accessible, and more communicative with the surgeon. The authors also suggested that ambulation shall begin at the time of suture removal,[23] al-

though there is no contraindication to immediate ambulation to pylon.

In a study of 59 above-knee amputations, stump healing was correlated with the local skin perfusion pressure.[10] "SPP is measure preoperatively as the external pressure required to stop isotope washout using ^{131}I- or ^{125}I- anti-pyrine mixed with histamine." It has been shown that wound complications in below-knee amputations can be predicted by preoperative measurement of local SPP. This study was undertaken to predict wound complications in above-knee amputations and to aid in the selection of stump length. Sixty-two above-knee amputations for gangrene or intolerable pain at rest were studied over a two-year period. Forty-five persons did not have diabetes mellitus; 17 persons did have diabetes mellitus. Nine patients had a previous contralateral major amputation; in 15 patients a major amputation at a more distal level had failed, 14 of them below the knee, one through the knee. Forty-nine patients were walking prior to the above-knee amputation.

Fourteen patients (24 percent) died during hospitalization following amputation; six patients died with severe wound infections of the stump. Six patients died with well healed stumps and two died with sutures not yet removed from stumps. Skin perfusion pressure below 30 mmHg was predictive of 82 percent of cases with severe wound complications. In 48 cases with SPP above 30mmHg, only four cases (eight percent) suffered severe wound complications. Patients returned to their own homes in 58 percent of the cases. Forty-one percent of 49 patients who could walk prior to amputation could walk with a prosthesis following above-knee amputation. The average length of time from amputation to rehabilitation was 15.8 weeks. Twenty patients who were discharged as walking spent an average of 15.3 weeks in the hospital. Eight patients who failed at an attempt to walk spent 24.1 weeks in the hospital. The authors concluded that wound healing correlated significantly with the pre- and post-operative skin perfusion pressure. The findings with respect to an SPP below 30 mmHg presented to the selection of a short stump in cases of inadequate blood supply in a weak patient. "Only if the blood supply is inadequate should a long stump, which is more comfortable during sitting and when moving in bed, be chosen."[10]

BELOW-KNEE AMPUTATION

Despite the attempt to preserve circulation to the lower extremities, each year there are approximately 30,000 amputations in the United States. The majority of lower extremity amputees are below-knee amputees in which an effort is made to preserve the knee joint even in patients with marginal circulation due to arterial occlusive disease. Preservation of the knee joint in older patients may make the difference in ability to walk great distances.

The records of 50 patients with below-knee amputation for arterial disease performed at the New England Medical Center from 1971 to 1979 were examined to determine how many went on to successful rehabilitation and independent ambulation.[3] The patients ranged in age from 49 to 89, with a mean of 67 years; 43 patients (86 percent) had ulceration or necrosis involving the foot or toes, and seven patients had rest pain without tissue loss. Twenty-seven patients (54 percent) had diabetes mellitus. Other illnesses included angina, congestive heart failure, chronic obstructive lung disease, hemiparesis, and senile dementia. The classification of patients into five functional categories for rehabilitation was made. These categories were: 1) complete independence, 2) patient requires a cane, 3) patient requires a crutch or walker, 4) patient was independent in a wheelchair and in transfer, and 5) complete dependence. Age, operative method, and preoperative functional limitations were compared with healing and rehabilitation outcome.

The results indicated no operative deaths. Major complications occurred in 14 patients (28 percent). There was a cumulative five-year survival rate of 60 percent. Overall rate of healing was 86 percent, pri-

mary healing was 66 percent. Early stump complications occurred in 17 patients; late stump complications occurred in seven patients. The average length of stay in a short-term care facility was 43.5 days. Thirty-five percent required amputation of the other limb within three-and-a-half years. Follow-up of 43 patients, whose stumps ultimately healed, was maintained for eight years with an average of 3.4 years. Twenty-five unilateral amputees (71 percent) were ambulatory with a prosthesis at time of follow-up. Ten unilateral amputees who were walking prior to amputation were not ambulatory. Four patients at first used a prosthesis but later discarded it for a wheelchair. Of eight bilateral amputees, two below-knee amputees were ambulatory with prosthesis, and two were not ambulatory. One below-knee and above-knee amputee was ambulatory with prosthesis, but another three who combined below-knee and above-knee were not ambulatory. Factors associated with successful rehabilitation were the condition of the oppositive limb, coexistent disease, postoperative complications, and healing failure.

Patients should be evaluated preoperatively by functional assessment scales in order to assess the impact of amputation on self-care, mobility, energy requirements, and family adjustment. This may be especially helpful in cases in which the chance of a nonhealing below-knee amputation is high. In this paper, a more formal functional assessment was not completed. A classification of patients by five categories of ambulation was completed.

Fleurant and Alexander[5] evaluated the outcomes of 353 below-knee amputees resulting from diabetic or ischemic gangrene, trauma, osteomyelitis, malignancy, Buerger's disease, or congenital malformations. Eighty-seven percent resulted from diabetic or ischemic gangrene. Sixty-five percent had diabetes; 20.7 percent arteriosclerosis; and 10.3 percent experienced trauma. Fifty-eight of the 353 patients were treated at one institution and were analyzed separately—32 men and 26 women. A total of 63 amputations was performed; seven double amputees, five double below-knee and one patient with above- and below-knee amputation. An immediate postoperative prosthesis was applied in almost all cases.

The healing rate was 82.8 percent; primary healing rate was 73.3 percent. These figures compare favorably with studies by Malone[17] and Castronuovo.[3] Mortality was five percent. A permanent prosthesis was fitted on 288 patients; 253 of them were fitted within 31 days. Successful rehabilitation was measured in terms of the ability to lower the level of amputation and to achieve primary healing. The ability to preserve the knee joint contributes to survival after amputation and to greater rehabilitation. If a patient has gangrene at the knee or severe fixed contraction at the knee joint, he should not be given a below-knee amputation, since vascularization cannot be accomplished after surgery. Other factors militating against below-knee amputation are thrombosis of the popliteal artery, poor bleeding after skin incision, and segmented systolic arterial pressure below 70 millimeters of mercury. If a patient has diabetes mellitus, it is important to educate him or her both pre- and post-operatively on the importance of care for the other foot.

One of the major problems of lower extremity amputation is to provide sufficient circulation to the leg prior to amputation. By increasing circulation to the leg, a surgeon can perform an amputation more distantly, healing after amputation is increased, and ambulation and functional independence are enhanced.

In a study of 150 arterial reconstructures performed for peripheral ischemia at the Harborview Medical Center, University of Wahington School of Medicine, Johansen and others[12] found that successful arterial reconstruction can lower the amputation level and improve rehabilitation potential. Ten of 36 patients who had gangrene of the lower extremity underwent arterial reconstruction prior to amputation. Nine of the 10 patients were long-term survivors, and eight of these nine were rehabilitated to independent gait. Six had procedures which permitted limited amputation at the level of the foot. One died of a complication resulting from chronic hemodialysis; prior

to death, he underwent limited amputation of the foot. On the whole, amputation level was performed at least one level lower than originally recommended by clinical tests before arterial reconstruction. The authors concluded that arterial reconstruction preserved limb length and increased independent gait by prosthesis.

Skin perfusion pressure (SPP) can predict wound healing in below-knee amputations. As with prediction of above-knee wound healing, SPP can predict wound complications and can be used to select better candidates for amputation at a lower level.

AMPUTATION FOR CANCER COMPARED TO VASCULAR AND TRAUMATIC AMPUTATION

Until recently, rehabilitation of the person with lower extremity cancer was not a common procedure. According to Glattly[8] and Reinstein,[19] cancer and benign tumors may account for only five percent of all amputations. Nevertheless, within the age range 10-19, cancer is the most frequent cause of amputation.[19] With the advent of the latest surgical procedures, more persons are surviving cancer and consequently greater attention needs to be given the management of the cancer patient after amputation.

Following amputation, the patient is given exercises to strengthen the upper extremities and the other, uninvolved lower extremity. When there is no incidence of cancer having spread to other systems and organs, the patient will be fitted for a Canadian hip disarticulation prosthesis. When cancer has already metastasized or when there is a question of spread, then a permanent prosthesis may or may not be provided, depending upon life expectancy, general health status, energy requirements for gait walking, the psychological outlook of the patient, and the financial resources—both public and private—available to the patient. A patient may be provided with a temporary prosthesis for the available life expectancy period, or may be given a wheelchair.

Reinstein[19] compared the psychosocial adjustment of the cancer patient with the patient with peripheral vascular disease and with amputation after trauma. In cases involving trauma, the patient awakens after surgery and is confronted with sudden loss of an extremity. No preparation has been given. The patient may proceed through the classic stages of shock, denial, and depression, as originally outlined by Dembo, Leviton, and Wright.[4] The patient may be expected to "mourn" the amputated limb as something valuable, something which up to a few hours before surgery was functioning well, an object to be prized by the outside observer. It may take many months, even years, for the patient to adapt to the amputated limb; it may never happen.

The patient with peripheral vascular disease, on the other hand, expects the amputation, may be prepared for it, and is resigned to it as a means of saving his life. The patient will feel depressed, of course, but will adapt more quickly to the loss.

The patient with amputation due to cancer is in a unique position, because he or she may be uncertain about the immediate future. Cancer may spread or may hold the potential of threatening life in the near future. Even when surgery has been successful, the patient may feel the Damocles' sword above him at all times. Apprehension about the future causes anxiety, hostility, and depression.[9] Of the three causes, cancer presents the most difficult course for adjustment.

In a retrospective study of 199 amputations for malignancy performed at the Mayo Clinic between 1965 and 1969, Subbarao and McPhee[22] reviewed their case histories to determine diagnosis, level of amputation, duration of hospital stay, complications during hospital stay, whether immediate prosthetic fitting was done, whether or not patients received a permanent prosthesis, and the interval between amputation and prosthetic fitting. Patients were asked whether they were wearing their prosthesis, whether they changed occupations or returned to the same job, and whether they attended school.

The results showed that 51 percent (102 patients) died within the five years' interval. Of the 115 dead at follow-up, 93 were due to cancer related causes: four to heart attack, one to another cause, and 17 unknown causes. The probability of surviving one year with a prosthesis was .886, compared to .586 without a prosthesis. This is not a causal relationship; it only indicates an association between survival and prescription of a prosthesis. There were 77 survivors. Of the 77, 66 had a prosthesis. Thirty-eight of them were able to return to full-time normal activities; 17 were able to return to 75 percent of normal activity; three to 50 percent; one to 25 percent; and one had no normal activity. Thirty-nine used their prosthesis all waking hours; four for most of the day; one for less than four hours per day; two for only an hour or two; and 16 never wore their prosthesis. Thirty-seven used their prosthesis to the best advantage; 16 felt their prosthesis was useless.

In the past, amputation for malignancy was not encouraged, since it was felt that the life expectancy of the patient did not justify the expense. Also, higher level amputations were performed on patients with cancer and they were often not fitted with a prosthesis. The study by Subbarao and McPhee shows that cancer clients can be fitted with a prosthesis and that within five years 49 percent have survived.[22] Compared to the mortality in vascular amputees, which ranges from 19 percent within 30 days[2] to 50 percent in five years,[24] cancer patients survive favorably for comparable periods. Moreover, patients who lose a lower extremity due to vascular disease have a 33 percent chance of losing the extremity on the other side within five years. The rehabilitation of vascular amputees, as measured by good functional outcomes in independent lifestyle, is not significantly better than cancer amputees, and in some studies, less successful.[14]

FUNCTIONAL ASSESSMENT OF AMPUTEES

The functional changes of amputees following surgery have been recently evaluated by Kegel,[14] Kegel, Webster, and Burgess[15] and O'Toole, Goldberg, and Ryan.[18] Kegel, Carpenter, and Burgess[14] showed that below-knee amputees were significantly more independent than above-knee and bilateral amputees. The authors measured the activities of daily living (ADL) in amputees by means of a questionnaire mailed to 350 patients (at least three months after discharge to a maximum of 12 years) who had undergone a variety of lower extremity amputations at several Seattle hospitals. The level of functional achievement was related to the site of amputation, age, and cause of amputation. ADL activities were categorized by percentages of responses to items on the questionnaire.

As age increased, functional level of independence decreased. Below-knee amputees were more independent than above-knee and bilateral amputees, but above-knee amputees were not more independent than bilateral amputees. There was a significant interaction between age and level of amputation, indicating that the above-knee amputee's functional independence decreased more rapidly with age, when compared to the below-knee amputee. With respect to cause, patients with amputation for tumor were functionally more independent than patients with amputation due to congenital disease, trauma, and peripheral vascular disease.

Kegel's study,[14] was very well done. The major limitations were that data were collected retrospectively after a minimum of three months' discharge, and that there was no way of comparing their functional independence from admission to discharge. Also, patients were asked to report their own level of independence, without corroborative evidence by a health professional.

In a study of the recreational activities of lower extremity amputees, Kegel, Webster,

Means and Standard Deviations for Barthel, PULSES, and ESCROW of Lower Extremity Amputees on Independent Subjects

(n = 45)

	Mean PULSES Score	*Mean Barthel Score*	*Mean ESCROW Score*
One month before admission	9.77		
Admission		66.15	13.40
Discharge	11.46	94.20	12.59
Follow-up at six months	10.58		15.10

Table 1.

Significant Differences in Functional Outcomes of Lower Extremity Amputees from Pre-Admission to 6 Months Follow-up

(n = 45)

	t	*df*	*p*
PULSES			
Pre-admission to discharge	4.68	44	0.001**
Pre-admission to follow-up at six months	1.98	26	0.05*
Discharge to follow-up at six months	0.81	26	0.42
ESCROW			
Admission to discharge	1.21	31	0.23
Admission to follow-up at six months	1.93	27	0.06
Discharge to follow-up at six months	2.44	24	0.02*
BARTHEL			
Admission to discharge	16.45	43	0.001**

*$p < .05$
**$p < .001$

Table 2.

and Burgess[15] reported the participation of 100 amputee patients in recreational activities. Corroborative data were supplied by 10 physical therapists and six prosthetists. Sixty amputees were active in some form of recreational activity. Forty of them wore a prosthesis while participating in sports. Their activities included snow skiing, swimming, fishing, bowling, hunting, golf, horseback riding, and jogging. Level of amputation and sex did not make a significant impact upon their ability to participate in recreation. The most active patients were younger and had undergone amputation for trauma. The study presents new statistical analyses of amputees' recreational activities.

In order to evaluate the changes made by 60 peripheral vascular amputees from admission to six months' follow-up after attending a rehabilitation hospital, O'Toole, Goldberg, and Ryan[18] designed a prospective study of functional outcomes measured at one month prior to admission, discharge, and six months after discharge. A secondary purpose of the study was to test the differences between above-knee and below-knee amputees in their physical, emotional, and psychosocial independence. Three standardized instruments were used for functional assessment: the Barthel Index—consisting of 15 measures of self-care and mobility, ranging in score from 0 to 100, and yielding two subtotals of self-care and mobility and a combined score; the PULSES Profile—consisting of physical, sensory, intellectual, and emotional components, and ranging in score from 6 = the highest score, to 24 = the lowest score; and ESCROW—consisting of six categories that measure the degree to which the patient may require social supports, ranging from 6 = the highest score, to 24 = the lowest score. The sample was further divided into a paired group of 15 patients who were admitted twice for rehabilitation and an unpaired group of 45 independent subjects. All data were subjected to *t*-tests for unrelated and related pairs in order to test the differences in functional independence over successive intervals. A two-way analysis of variance was used to test the interaction of above-knee versus below-knee amputation with the four test periods.

Table 1 shows the means and standard deviations on the functional assessment measures for the 45 independent subjects. Table 2 shows the significant differences on the three measures from one month before admission to follow-up.

Significant Differences in Functional Outcomes of Lower Extremity Amputees on Paired Subjects

(n = 15)

	Mean Admission	*Mean Discharge*	*t*	*df*	*p*
PULSES					
Pre-admission to discharge	10.6	12.8	2.60	14	0.02*
BARTHEL					
Admission to discharge	70.5	80.5	2.84	14	0.01**

*$p < .05$
**$p < .01$

Table 3.

Significant differences occurred on PULSES from pre-admission to six months follow-up, and on Barthel from admission to discharge. There was no significant difference on ESCROW from admission to follow-up, though there was a significant difference between discharge and follow-up. The differences on the Barthel were in favor of an increase in independent function. This finding indicates change in function as a result of the rehabilitation intervention. PULSES showed a decrease in independence from pre-admission to discharge, but then a subsequent increase in independence from discharge to follow-up at six months. However, patients did not return to their pre-amputation level before admission. This finding indicates that more social services could be offered them in the community. PULSES gives a profile of strengths and weaknesses; as a summary score for independent function it is not as useful as Barthel. The pre-admission scores were taken prior to amputation; the decrease shows the drop in function from the pre-morbid level to post-amputation. Changes in ESCROW, especially their ability to make decisions (0), showed that their need for support decreased while in the hospital but after they moved into the community they declined to their original level.

There were no significant differences attributed to amputation level on any functional measure at any testing period. However, above-knee amputees had a greater proportion of angina, whereas below-knee amputees had a greater proportion of depression, as measured by chi square tests of association.

The results for the paired subjects were approximately the same, as shown in Table 3.

The only significant differences occurred with respect to Barthel (admission to discharge) and PULSES (pre-admission to discharge). On Barthel, patients increased their scores; on PULSES Profile they decreased their scores. The authors concluded that patients with vascular disease who underwent amputation made moderate gains in their functional outcomes from admission to discharge and from discharge to six months follow-up. Some gains were made in psychosocial functioning, although some patients adapted poorly as their physical condition worsened six months after discharge. Their need for social and economic supports increased significantly after they were living in the community for at least six months. This finding is understandable; once they left the protective setting of the rehabilitation hospital, they required help with housing, transportation, and homemaking. An unexpected finding was that the level of amputation had no impact on functional outcomes and rehabilitation progress. We can only speculate that patients may adapt to their disability on the basis of psychological mechanisms, irrespective of the level of amputation. Additional studies need to be conducted to test this observation.

Patients with less functional limitations—for example, below-knee amutees—may have more difficulty in adapting to their disability than patients with more functional limitations, such as above-knee or bilateral amputees. The closer one approaches normality, the more difficult it is to accept deviation from the norm. Any new study must extend beyond functional assessment measures of physical, sensory, self-care, and mobility independence.

SEXUAL ADJUSTMENT

In our culture the worship of the beautiful young body results in defamation of any deviation from the normal. Amputation poses an additional threat: loss of a body part is symbolic of castration, and ultimately of death. Little empirical evidence is available on the sexual adjustment of the lower extremity amputee. Reinstein, Ashley, and Miller[20] interviewed 60 amputees (39 men, 21 women) after they became independent in ambulation by prosthesis. The patient's medical history, social situation, and past and present sexual behavior were reviewed. Frequency of sexual intercourse before and after amputation was obtained in interviews as reported by the patient to the interviewer.

Thirty men (77 percent) reported decreased sexual intercourse following amputation, including 17 who had not resumed intercourse after amputation. Of the 28 men who had reported having intercourse at least once a week before amputation, nine reported no change after amputation. Eight women (38 percent) reported decreased sexual intercourse following amputation, including seven who had not resumed sexual relations. Decrease in sexual relations was significantly greater for above-knee male amputees. Cause of amputation and difficulty in positioning were not significant factors in decreased sexual activity. Regularity of sexual activity in marriage was a significant determinant in the resumption of sexual relations; more unmarried patients were affected than married patients.[20] The results of this study raise the question whether psychological factors, such as loss of self-esteem, impaired body image, and lowered sense of masculinity or femininity may be more closely related to decreased sexual relations than are the physical factors involved in decreased mobility, difficulty in positioning, and impaired sexual functioning.

VOCATIONAL REHABILITATION

Vocational adjustment after amputation has depended on the previous vocational development of the amputee. Persons with realistic vocational plans; professional, managerial, or clerical skills; stable work history; and vocational interests allied with aptitudes and a realistic acceptance of disability tend to adjust better following amputation. Persons who relied on their physical ability may be required to make an adjustment to sedentary work. Lower extremity amputees are less impaired than upper extremity amputees. With proper fitting of a prosthesis and with gait training, a lower extremity amputee can be taught to ambulate sufficiently well to return to his former job with some modifications. A job sample evaluation arranged by the state vocational rehabilitation agency may be used to determine whether the amputee can return to former employment.[6] Persons requiring a job change should be referred to their local state rehabilitation agency.

Even when amputation does not affect a person's ability to conduct his or her job or to engage in social and recreational activities or to live independently, it still has an enormous impact on a person's self-esteem. Feelings about body image, sexuality, and interpersonal competence that may have been buried for years suddenly reawaken. The professional worker, the business executive, the secretary whose vocational skills are unimpaired may focus their attention on the loss of normal physical appearance. What before was taken for granted now must be compensated for by camouflaging their disfigurement. They require psychological counseling to adapt to their work environment.

SUMMARY AND CONCLUSIONS

The rehabilitation of a lower extremity amputee requires a multidisciplinary approach that is optimally achieved by referring the patient to an amputation center or a rehabilitation department in a general hospital or in a rehabilitation facility. Although several measures have been used to predict for successful rehabilitation outcome after amputation, including Xenon

clearance, local skin perfusion pressure, above-knee versus below-knee amputation, age, diabetes mellitus, angina, depression, obesity, and lesion on the other foot, none of these measures has been completely successful with amputees with various etiologies. Level of amputation is not an important predictor with vascular amputees whose general physical condition and advanced age (mean of 70 and above) are better indicators of rehabilitation outcome. Amputees due to tumor (malignant or benign) are functionally more independent than amputees due to congenital disease, trauma, and peripheral vascular disease.

Functional assessment scales are used to evaluate the changes after amputation in self-care, mobility, social supports, physical condition, and intellectual adaptability. Nevertheless, we concluded that current measures do not include many psychological aspects of disability, such as measures of body image, self-esteem, control of one's environment, and changes in values. New assessment scales must include the psychological, sexual, and vocational aspects of adjustment to amputation. Amputation has an enormous impact on social adjustment, evern when functional changes on current assessment scales cannot be demonstrated.

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Orthotics and Prosthetics, Volume 39, No. 1, pgs. 41–46.

A Laminated Ultralight Prosthesis

by Drew Hittenberger, C.P.
Robert Putzi, C.P.O.

INTRODUCTION

Weight, like any other component, is a factor in prosthetic design, but it has been only until recently, with the advent of more sophisticated materials, that weight reduction has drawn so much attention. Initially designed for the geriatric amputee, techniques were developed to reduce as much of the weight of a prosthesis as possible.

In 1976, Moss Rehabilitation and Rancho Los Amigos Hospitals developed the below knee ultralight prosthesis. Made of polypropylene, the ultralight was 65 percent higher than a conventional prosthesis. Despite the weight reduction, however, the ultralight was not widely accepted because of its lack of durability and difficult fabrication procedure.

In 1979, Wilson and Haslam introduced the AFP (adaptive fixation prosthesis) endoskeletal system, and in 1980, Roman and Mott developed a hollow laminated prosthesis. These and other ultralight techniques (Leimkuehler, 1982) have and will continue to be developed as the need for lightweight prosthetic systems increase.

The following article presents a hollow lightweight (1½ to two pound) below knee prosthesis that can be used by the geriatric as well as the aggressive amputee. Its fabrication and prescription criteria will be discussed.

FABRICATION

Fabricate a liner on the case in the usual manner. Then laminate a socket using four layers of nyglass (623 T11 Otto Bock) one layer of fiberglass (616G3 Otto Bock) and acrylic resin (617H19 Otto Bock). Use only acrylic resin for this prosthesis.

Select a Pedilan foot (1S19 Otto Bock) of the appropriate size and enlarge the bolt hole using a $^{25}/_{64}$ inch drill, then attach the Pedilan foot to an endoskeletal pylon using a 10mm bolt. The Pedilan foot provides the same function as the SACH foot and weighs less (Figure 1).

Figure 1. The Pedilan foot provides SACH foot action yet weighs considerably less.

Figure 2. Components assembled for dynamic alignment.

Figure 3. Remove the endoskeletal pylon after dynamic alignment is complete.

Figures 4 and 5. Fill the void with rigid polyurethane foam.

With the endoskeletal components and socket held in place, attach the alignment block (5R1 Otto Bock) to the socket using rigid polyurethane foam (617H12 Otto Bock) as shown in Figuure 2. (NOTE: Leave the PVA bag on the socket prior to foaming so that the foam can later be removed from the socket).

Reinforce the foam/attachment block junction with fiberglass tape and dynamically align the prosthesis. Caution should be taken at this point to make sure this is accurate because once the prosthesis is finished, it is impossible to make any alignment changes.

After the prosthesis is dynamically aligned, remove the pylon and attachment block (Figure 3). Separate the socket from the attachment block by cutting the foam just proximal to the block, and fill the void between the socket and the foot with rigid polyurethane foam (Figures 4 and 5).

Shape the foam accordingly, taking into account that the circumferential measurements need to be ½ inch smaller than the contralateral measurements to allow for the thickness of the outer lamination (Figure 6).

Hollow out the plantar surface of the keel ⅛" and pull a below knee nylon over the foam and socket to make a smooth surface. Apply a PVA bag over the nylon and seal it distally, along the plantar surface of the foot. Then laminate a preliminary socket using, in the following order, one layer of nyglass, one layer of fiberglass, one layer of nyglass, and acrylic resin. Once the lamination is hardened, split the shell down the back using a cast saw (Figure 7). To avoid cutting the socket, it may be necessary to split the shell with a knife in the socket area. Remove the shell from the foam and trim it proximally around the MP area of the foot. (NOTE: There must be a one to two inch overlap of laminated material between the socket and shell).

Once trimmed, place the shell back on the foam and mark its location (Figure 8). These marks must be as accurate as possible, otherwise the alignment will be off. Remove the trimmed shell from the pros-

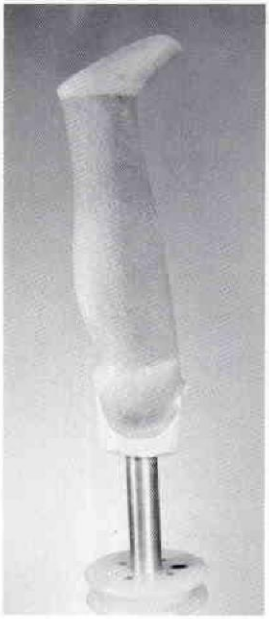

Figure 6. Shape the foam accordingly.

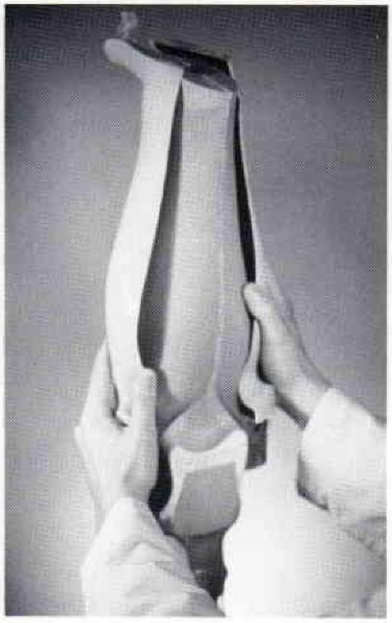

Figure 7. Cut the preliminary shell posteriorly and remove it from the foam mold.

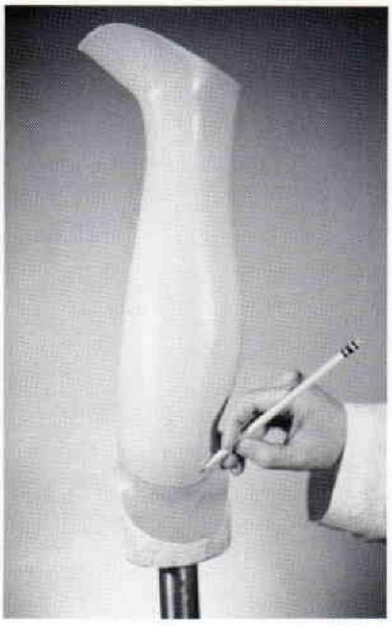

Figure 8. Mark the location of the shell on the socket.

Figure 9. Bond the posterior seam together along the inside.

thesis and bond the posterior seam together along the inside using three layers of one inch wide fiberglass webbing and acrylic resin (Figure 9). If the fiberglass cannot be placed inside the foot section, seal it along the recessed plantar surface. Remove the foam from the socket and glue the preliminary shell to the socket using sealing resin (Otto Bock 617H21) (Figure 10). Be certain that all the location marks match up.

Drill a 3/8 inch hole in the metatarsal area of the foot. Be careful the drill doesn't grab

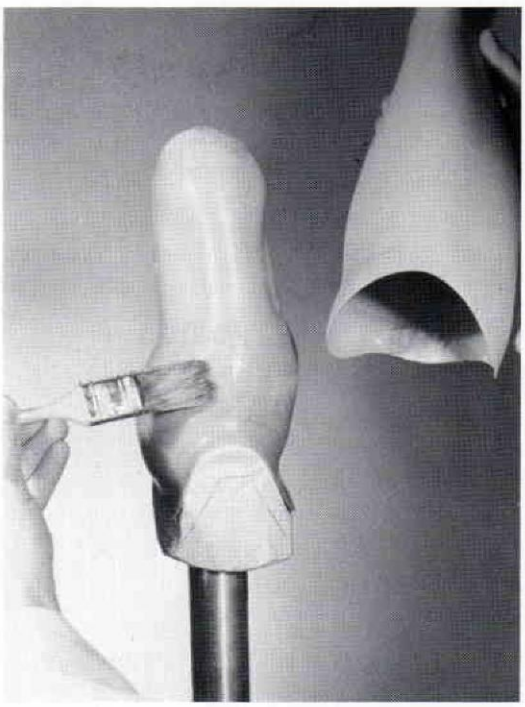

Figure 10. Glue the preliminary shell to the socket.

Figure 11. Drill a ⅜ inch hole in the metatarsal area of the foot.

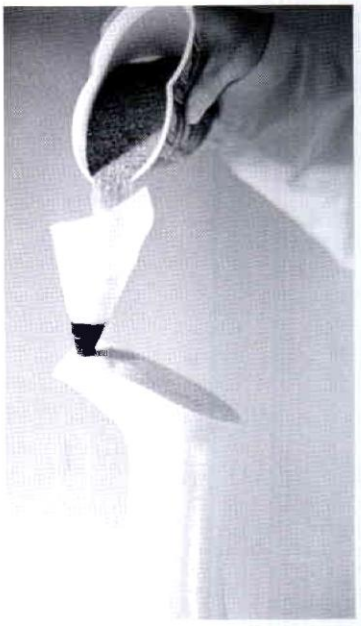

Figure 12. Fill the entire prosthesis with sand.

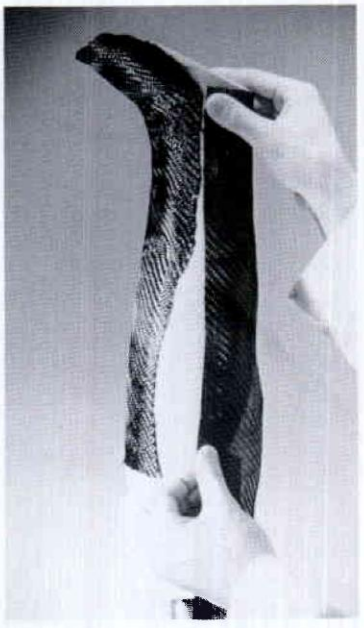

Figure 13. Reinforce the prosthesis with several layers of carbon fiber.

and go through the dorsum of the foot (Figure 11). Fill the prosthesis with sand and seal the hole with masking tape (Figure 12). The sand will keep the shell from collapsing during the second lamination.

Sand the prosthesis to insure a good bond between the outer laminations, and smooth down all ridges between the socket and preliminary shell. Then laminate the secondary socket using, in the following order, two layers of carbon fiber (Otto Bock 616G12), one layer of fiberglass, and two layers of nyglass and acrylic resin. Carbon fiber is a high strength, low modulus (stiff) material that produces a strong and lightweight prosthesis.

The carbon is put down first because its black color has a tendency to bleed through if left on the top. Cover with several layers of fabric. Lay the carbon around the foot, ankle and proximal brim, and anterior and posterior section of the calf (Figure 13). To do this, first determine the shape or size of the carbon needed and run a piece of double-faced tape (3M #950) along the cutting edge. Cut down the middle of the tape, remove the paper backing, and stick the piece of carbon in place. This technique keeps the edges from unraveling and keeps the fabric in place during lamination. Do not run the carbon into the ears of the supracondylar socket because it makes them too rigid; and don't run the carbon around the edge of the prosthesis because it makes trimming difficult.

The amount of vacuum used during the final lamination should be kept to a minimum. Even with the sand, if too much vacuum is applied during the final lamination, the outer shell will collapse. Once the final lamination is complete, redrill the hole in the bottom of the foot and drain out the sand.

Sand the plantar aspect of the prosthesis and attach the foot using sealing resin. Fill the crack between the foot and the prosthesis with flesh/light brown latex caulk or a mixture of sealing resin and solkafloc.

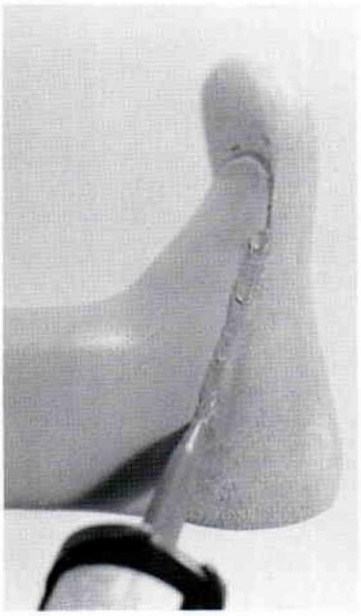

Figure 14. Fill the crack between the foot and shell with latex caulk or sealing resin.

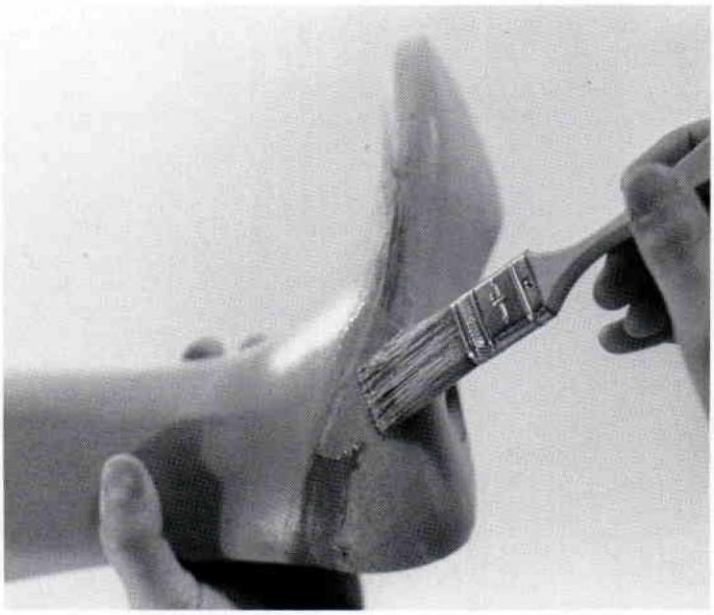

Figure 15. Paint the foot with ultra dip.

Once dry (30 minutes), paint the foot with Ultra-Dip (ATCO) and let dry for 30 minutes (Figures 14, 15, and 16).

DISCUSSION

There are indications and contraindications for any prosthesis and this ultralight unit is no exception. Several factors need to be considered before prescribing and/or fabricating this device.

The question of weight versus durability needs to be addressed. It is hard to design a prosthesis that is lightweight without compromising durability because as durability increases, weight also increases. What is desired is high strength and low weight. The question of just how strong a prosthesis needs to be so that the materials can satisfy this requirement while keeping the weight to a minimum remains to be seen, because the strength requirement depends so much on the level of activity of the particular patient.

While this prosthesis is designed to be durable enough for the geriatric amputee, it can also be modified for the more active amputee by adding several layers of carbon and fiberglass around the ankle and calf section (e.g. for a construction worker, use six layers of carbon). This ability to vary the strength of the prosthesis is very important because it allows the prosthetist to customize the device depending on the patient's level of activity.

One drawback of any ultralight system is that it is more time consuming to fabricate. Unlike other systems, this technique doesn't require any new equipment or fabrication skills because it uses conventional laminating procedures. This technique doesn't require hollowing out like other techniques, and has minimal amount of weight distally, which decreases the pendulus moment of the prosthesis.

This prosthesis is not recommended for the newer amputee, however, because it lacks adjustment capabilities. While minor modifications are possible through limited grinding and/or heating of the socket, it is not possible to change the alignment once the prosthesis is complete; therefore, more time needs to be spent evaluating and dynamically aligning this prosthesis.

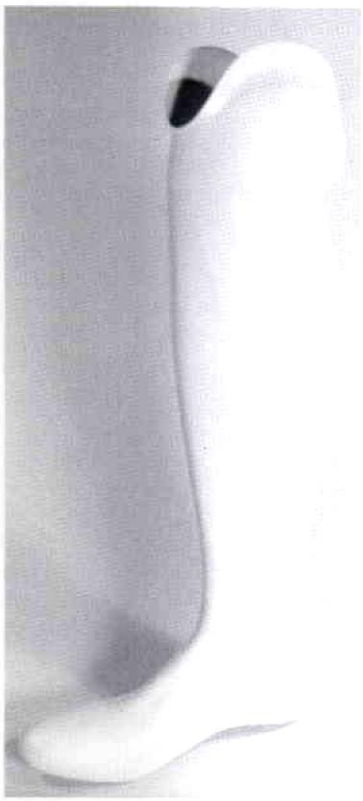

Figure 16. The finished prosthesis weighs between 1½ and 2 pounds.

CONCLUSION

There has been much interest recently in weight reduction as the need for and the ability to make lighter weight prosthetic systems is increased. This article has presented one such ultralight fabrication technique and has discussed its critical factors of design such as durability, weight and fabrication. It is hoped that others will continue to improve ultralight fabrication techniques because the need for these systems is increasing.

ACKNOWLEDGMENTS

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Lower Extremity Amputation Problems: Etiology, Manifestations, and Prevention

by Gustav Rubin, M.D., FACS
Malcolm Dixon, M.A., R.P.T.
Erich Fischer, C.P.

INTRODUCTION

It is the purpose of the authors to document, in a concise chart format, a selection of amputation problems encountered by the Clinic Team at our Center, with suggestions for prevention and treatment. Such problems for the amputee may be caused by any of the individuals concerned with his care.

Under ideal circumstances, a surgeon qualified to do amputation surgery will select the most appropriate level for amputation and properly contour the amputation stump;[1] a hospital team will provide efficient rehabilitation; a prosthetist will achieve a satisfactory fit; and the amputee, fully informed about the function of his prosthesis and its components, will ambulate in relative comfort, and will cooperate in a follow-up to allow adjustments to be made for anticipated changes.

Unfortunately, ideal circumstances do not always exist. This paper is presented as a plea to prevent those relatively small, yet significant, number of deviations from less than ideal circumstances. When the amputee has the potential to ambulate, and to ambulate well and relatively comfortably, it is his right to be given the fullest opportunity to realize that potential.[2]

The type of trauma and, in the case of disease states, the character of the neurovascular involvement, will affect the surgeon's decisions. A very effective method for determining the optimum amputation level for the vascularly impaired limb is that of employing xenon[133].[3]

THE SURGEON

Chart I

When the surgeon has been presented with a patient, whose limb has sustained extensive trauma of a degree which mandates amputation, his choices are frequently limited. The status of the traumatized limb may require surgical ingenuity and maximum use of the remaining anatomic structures to contour a residual limb that will provide optimum function. He should not, however, insist on saving all length when such heroic measures will result in a poor residual limb. For an individual of average height, a six inch below-knee residual limb is far more desirable than an amputation eight to 10 inches in length. The feature was discussed many years ago by Thomas and Haddan in their text, "Amputation Prostheses," but is still overlooked. In the case of below-knee am-

CHART I: THE SURGEON

Etiology	Manifestations	Treatment and/or Prevention
Overenthusiastic dedication to saving all length particularly in case of: 1. Circulatory impairment (Figure 1).	1. Circulatory impairment of residual limb: intermittent claudication, pallor, pain, breakdown of soft tissues.	1. (a) Length of residual limb should be consistent with circulatory status, as, for example a 4" B/K residual limb with adequate circulation is preferred to a 6" or 8" residual limb with precarious circulation. (b) Gel socket for the B/K amputee with precarious circulation. (c) Quad socket prosthesis for the B/K if above, (b), is inadequate. (d) Revision if conservative measures fail or overall situation will be improved by revision.
2. Short partial foot amputations such as Chopart (Figure 2).	2. Chopart causes problems in satisfactory fitting, unless equinus deformity is prevented or corrected.	2. Ankle fusion will improve Chopart alignment and weight bearing status, as will tibialis anticus transplant. (Prostheses are available for Chopart and Lisfranc).
3. Excessively long B/K amputated distal to the gastrocnemius tendon junction. Occasionally confusing a long B/K with a Syme amputation (Figure 3), or an ankle disarticulation with a Syme (Figure 4).	3. If excessively long B/K: poor soft tissue coverage, and tendency to breakdown of soft tissue.	3. Revision if conservative measures fail.
4. Retention of a short A/K residual limb of less than 5cm. (Figure 5).	4. Difficulty in fitting a very short A/K with a Canadian hip hip disarticulation prosthesis. Hip joint must be placed forward of usual position, resulting in uncosmetic appearance when patient is clothed.	4. (a) If the surgeion anticipates an A/K residual limb of less than 5cm. during the surgical procedure, he should proceed with true disarticulation. (b) If the prosthetis is presented with a less than 5 cm. A/K residual limb, a modified Canadian hip disarticulation prosthesis can be fabricated.
Deviation from accepted amputation procedures as: 1. Tibial crest not properly bevelled distally (Figure 6). 2. Fibula left longer than tibia. 3. Quasi-Syme amputation. 4. Stripping and shredding of periosteum. 5. Improperly contoured residual limb with poor placement of surgical suture line and adherence of scars to bone. 6. Poor skin coverage of potential weight-bearing areas or limb-socket interface support areas (Figure 7). 7. Inadequate stabilization of Syme pad (Figure 8).	1. Tibial crest not bevelled distally is a potential cause of breakdown of B/K residual limb (Figure 9); adequate relief is necessary. 2. Fibula prominence—pain and fitting problems. 3. Quasi-Syme—inability to end bear (Figures 3, 4, 7). 4. Stripped and shredded periosteum may yield spurs. 5. Scars poorly placed may result in soft tissue breakdown (scars attached to bone, Figure 10, invaginated scars, scars over patellar tendon of B/K or beneath medial tibial flare).	Quasi-Syme must be fitted as a long B/K—or revised. Spurs may be accommodated by proper relief in prosthesis. (Rarely is revision necessary for spurs). Poorly placed or attached scars should have proper reliefs in socket and proper suspension to minimize piston movement and traction on attached scars. Surgical correction may be needed. A relief should be provided in the prosthesis. If not adequate, then surgical correction.

CHART I: THE SURGEON (continued)

Etiology	Manifestations	Treatment and/or Prevention
Nerves not properly treated to allow retraction of distal ends to protected or pressure free areas.	Painful neuromata exposed to socket pressure.	Revision if prosthetic fitting procedures are unsuccessful, i.e. use of appropriate relief.

putations, they reported that "amputations below the middle of the leg are to be condemned. The additional bone length offers no advantage in leverage, and the longer stumps are apt to be tender and are prone to vascular difficulties with edema and ulceration of the end of the stump."[4] Saving all length should be an axiom followed with discrimination.

Useful functional length should not be sacrificed. When the amputation is elective, it is the responsibility of the surgeon to make a very careful determination of the level of amputation, particularly, to avoid an above knee amputation if a functioning below knee residual limb can be salvaged. Although it is not possible to cover every eventuality, the chart refers to important problems.

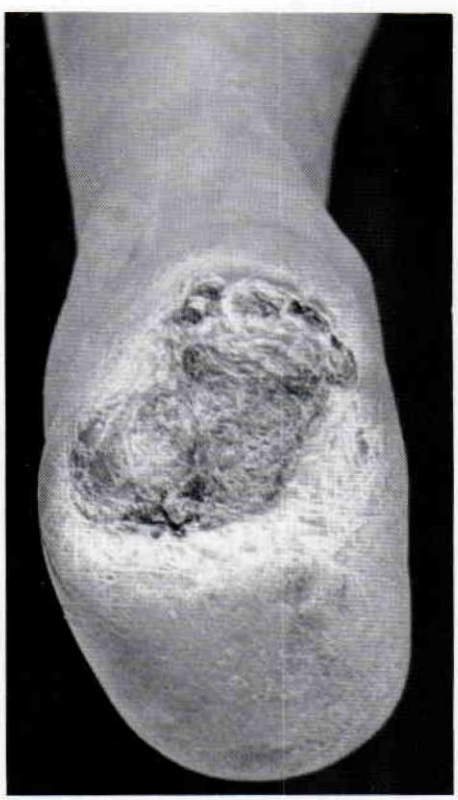

Figure 1. This vascular amputee would have benefitted with a more proximal amputation.

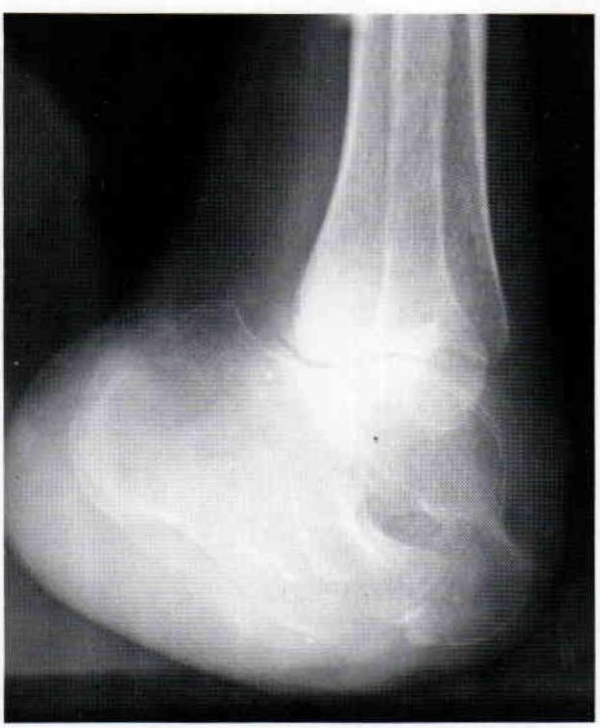

Figure 2. The unmodified Chopart, in equinus, provides the amputee with a poor weight-bearing surface, unless the equinus has been prevented by either ankle fusion in a functional position or tendon transplantation to prevent the equinus deformity.

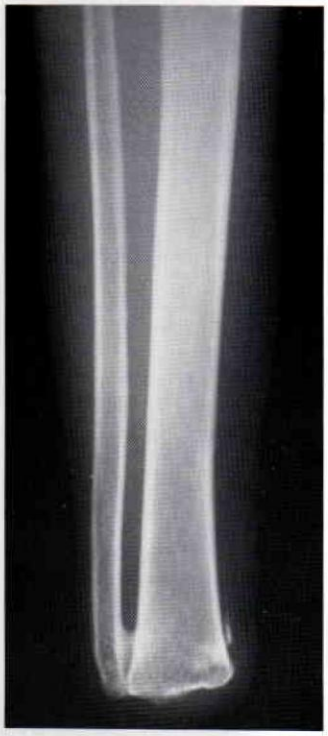

Figure 3. This amputation is just proximal to the true Syme level[3] and had to be fitted as a long B/K.

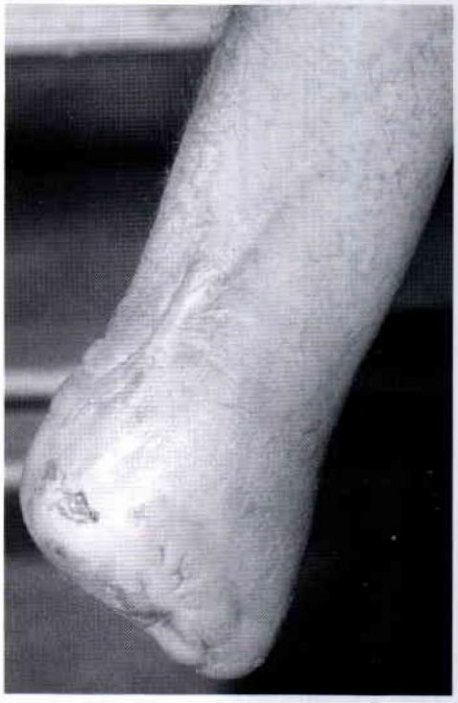

Figure 4. Although this ankle disarticulation amputee was fitted with a Syme prosthesis with maximal proximal PTB support, he continued to have residual limb problems and rejected reamputation to the below-knee level.

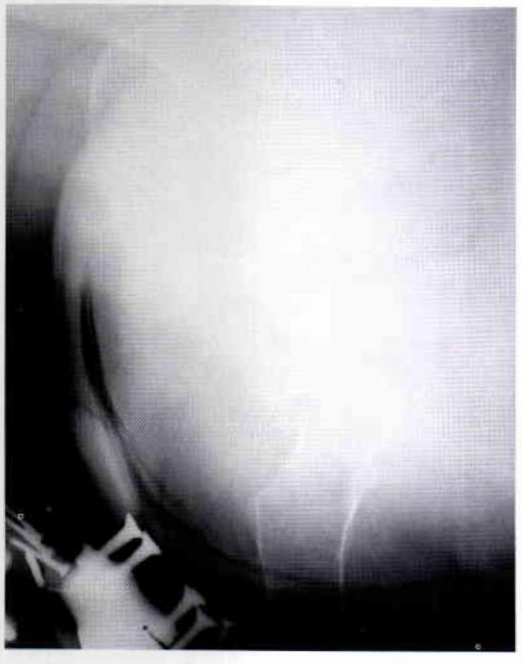

Figure 5. This amputee, as demonstrated on the x-ray, had to be fitted with a modified Canadian Hip Prosthesis because of the retained short residual limb.

Figure 6. The distal anterior crest should be properly bevelled. A sharp bone prominence causes overlying skin problems.

Figure 7. (left) Poor skin coverage of underlying bone will be recurring cause of skin breakdown.

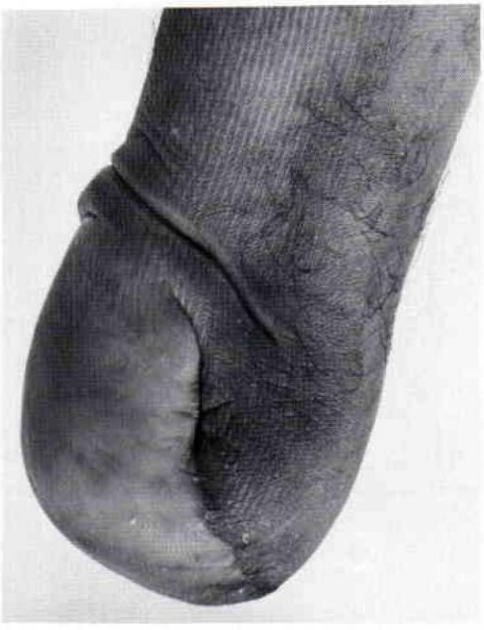

Figure 8. (right) Inadequately stabilized Syme pads frequently interfere with distal weight-bearing and are often associated with painful callosities at the scar margin.

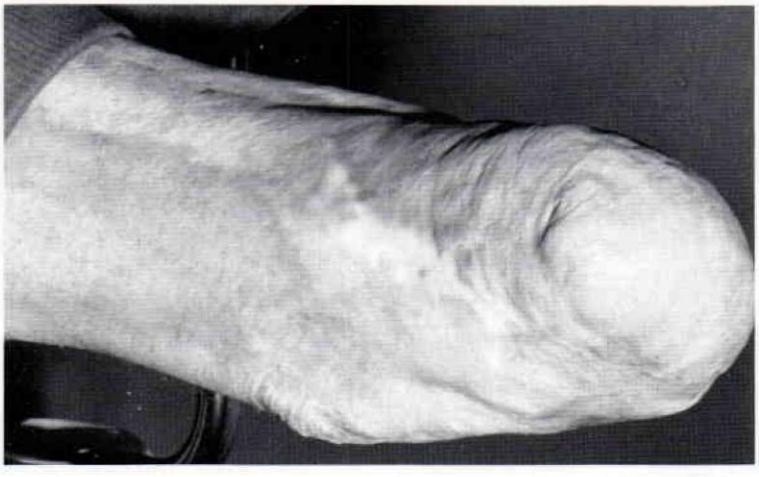

Figure 9. Soft tissue appearance of lack of bevelling of the tibia crest distally (see chart).

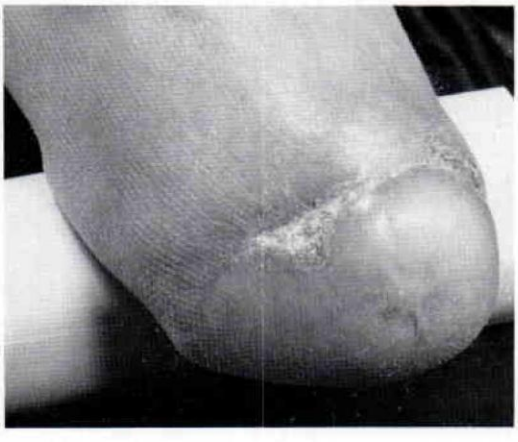

Figure 10. When the scar is adherent to the underlying tibia, it is not unusual for soft tissue piston motion, during ambulation, to result in episodes of soft tissue breakdown. It is almost impossible to toally eliminate small amounts of piston motion.

THE PROSTHETIST

Chart II

Many of the more frequently encountered problems traceable to the prosthetist are listed in the accompanying Chart. The prosthetist has a major responsibility for the optimum rehabilitation of the amputee. Less than total satisfactory fit, alignment, and suspension may cause any variety of problems such as those referred to in the chart. A large selection of prosthetist related problems has been detailed. There will undoubtedly be areas of controversy particularly with reference to the posterior of the socket. At our center we eliminate the popliteal bulge entirely, but at other centers this is frequently retained. When this bulge is exaggerated, as in the illustration, problems may arise.

CHART II: THE PROSTHETIST

Etiology	Manifestations	Treatment and/or Prevention
Lack of total contact (Figure 11).	Distal edema with subcutaneous induration and eventual "peau d'orange" appearance. When chronic this produces distal tissue "weeping," ulceration, and gait deviations.	Achieve total contact with soft distal pad which should be repeatedly replaced as shrinkage progresses, so that total contact is maintained.
1. Improper socket configuration with localized pressure on bone prominences (Figure 12). 2. Inadequate suspension with piston movement.	1. Irritation, abrasion, and ulceration. 2. Callosities. 3. Bursal enlargement.	Modify prosthesis to: (a) Relieve local pressure area in socket, and (b) Minimize pistoning by correcting suspension system. (c) Stabilize residual limb in socket. (d) Apply material such as Op-site® or Tegaderm® to skin of irritated area to protect skin from shear, and use DAW prosthetic sheath.
Brim margin soft tissue pressure and shear (Figure 13).	1. Inclusion cysts which can become infected (usually anterior A/K brim level and posterior B/K brim level. 2. Abrasions.	1. Rotator or SAFE foot. 2. Bring flesh rolls into socket if possible. 3. Padded A/K brim. 4. Flare brim in appropriate areas. 5. Use of DAW sheath.
Pressure on bow-stringing tendons (Figure 13).	1. Irritation over abductor longus in A/K socket. 2. Irritation over hamstrings. 3. Irritation over prominent tensor fascia lata in PTS.	Provide adequate channel in socket with appropriate flaring of brim.
Choking.	Hourglass edema, pain, and potential soft tissue breakdown.	Modify socket to remove hourglass constriction, or replace socket if uncorrectable.
A/K valve malfunction or improper selection.	Localized valve area irritation.	1. Change spring. 2. Relocate valve9
Uncured glue of insert or uncured plastic of the plastic laminate socket.	Skin redness and irritation at contact area.	Proper caring. Use of DAW sheath.
Poor alignment (Figure 14).	Gait abnormalities.	Re-align.

CHART II: THE PROSTHETIST (continued)

Etiology	Manifestations	Treatment and/or Prevention
Excessive popliteal pressure secondary to incorporating central bulge in socket for theoretical relief of hamstrings, but with actual interference with popliteal neurovascular structures (Figure 15).	Claudication and limited activity.	Febricate prosthesis with total elimination of mid-posterior eocket bulge as illustrated.
Excessive patellar tendon bar prominence of sharp patellar bar (Figure 16).	Soft tissue breakdown (Figure 17).	1. Ambulate on crutches pending skin recovery. 2. Modify patellar tendon bar.
Excessive prominence of Scarpa's triangle bulge (should be especially avoided in sockets of elderly A/K amputees).	Interference with function of neurovascular structures, numbness and/or claudication.	Modify socket; decrease bulge.
Inadequate relief over distal lateral A/K residual limb.	Callosity or abrasion & pain distal lateral A/K residual limb.	Provide relief locally or a build-up above the area. Check suspension and correct if piston movement is present.
Low placement of the supracondylar wedge of PTS.	Soft tissue irritation, redness, and ulceration if neglected (Figure 18).	Adjustment and proper placement of wedge. (pistoning will occur if too high).

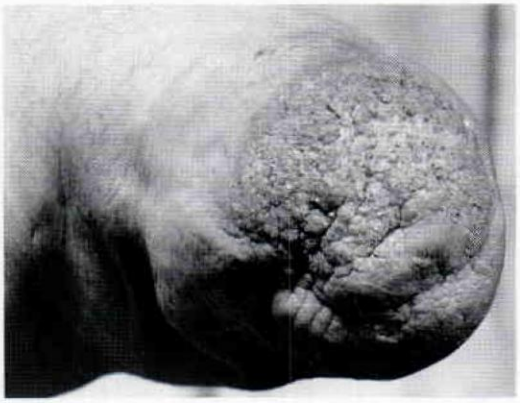

Figure 11. Repeated episodes of distal edema produce a "peau d'orange," or orange skin effect. This is known as verucous hyperplasia.

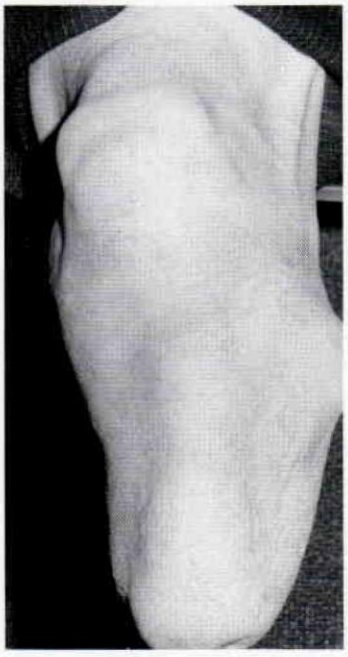

Figure 12. Bursal formation over the fibula head (see chart).

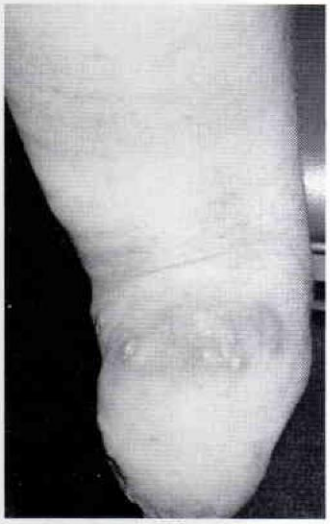

Figure 13. (left) Inclusion cysts secondary to pressure and shear at posterior brim margin.

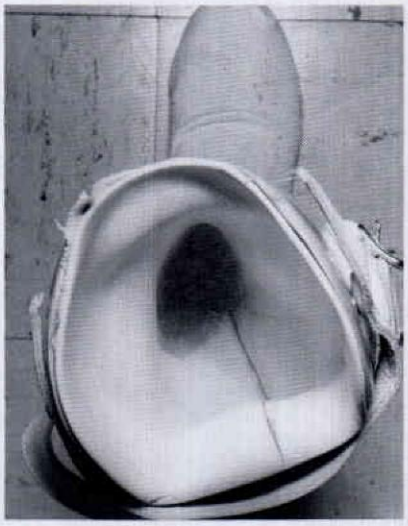

Figure 14. (right) An unusual alignment of a B/K prosthesis fabricated for a patient who did not have a fractured femur, knee, or tibia which would have distorted the anatomical structures and might otherwise have required alignment modifications.

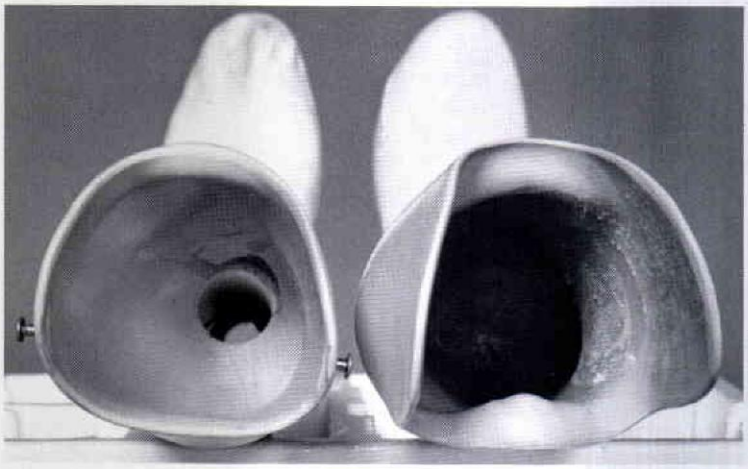

Figure 15. At our Center we have eliminated the posterior popliteal bulge. The distal opening, in this instance, was covered by a soft total contact pad and the opening provided a receptacle for the moisture of excess perspiration.

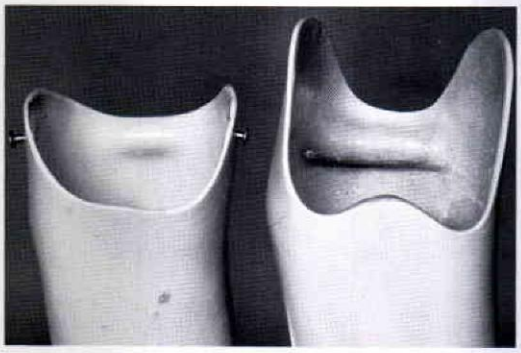

Figure 16. Excessive patellar bar prominence may cause skin breakdown.

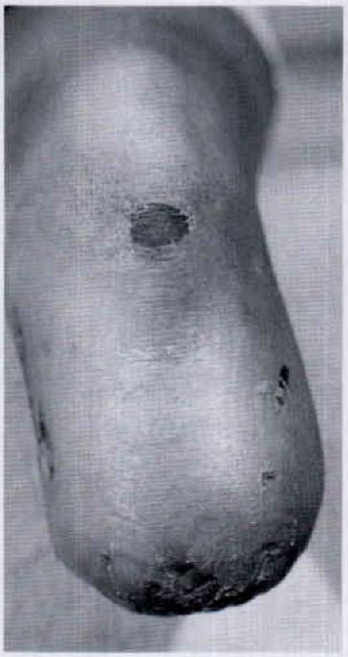

Figure 17. Encrusted skin ulceration over a prominent patellar bar and distal choking with edema and soft tissue breakdown (see "choking" under Chart II).

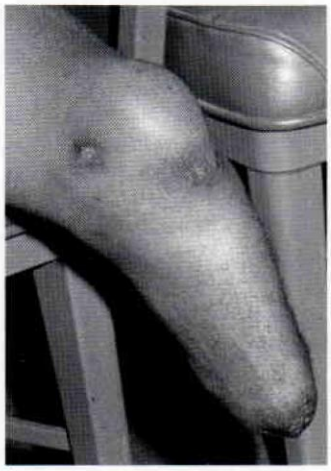

Figure 18. Improper placement of supracondylar wedge of PTS.

THE PATIENT

Chart III

The patient may, himself, be the source of his own difficulties, usually because of carelessness or neglect of instructions. Patients are told to be seen by the clinic team or prosthetist at the first sign of residual limb irritation. Nevertheless, they will often wait and come in after blister formation or even soft tissue breakdown and ulceration have developed.

There are occasions when the residual limb has been so contoured that revision is indicated but the patient refuses further surgery. It is necessary in these cases to warn the patient about the potential for breakdown, so that he may observe certain areas more carefully than he might do otherwise. Examples of this are the excessively long below knee residual limb with poor distal circulation or the inexcusable retention of an excessively long fibula on which the patient refused another operation.

The patient must understand that he is an important member of the clinic team and his subjective responses will be carefully listened to and acted upon when appropriate. Warning signs are: discomfort over bone prominences, redness, swelling, pain, or other manifestations of irritation. These signs should be heeded before breakdown occurs. This may be most likely to occur over the fibular head, tibial crest, or distal anterior tibia of the below-knee amputee, or over the distal lateral aspect of the residual limb of the above knee amputee, if the prosthesis has not been properly fabricated, modified, or fitted.

CHART III: THE PATIENT

Etiology	Manifestations	Treatment and/or Prevention
Progressive maturation of residual limb. (Residual limb shrinkage is anticipated and desirable following amputation). As shrinkage occurs fit is lost, the residual limb displaces downward in the socket, bone prominences will abut (and piston over) socket contours designed to conform to the undisplaced residual limb.	Irritation and skin breakdown with ulceration if neglected. (Pain and discomfort in such areas of the A/K amputee's residual limb as the pubic ramus and the distal residual limb; and in such areas of the B/K residual limb as the hamstrings, inferior pole of the patella, distal stump and fibular head, in particular) (Figures 19 and 20).	1. Add residual limb sock (or socks) of appropriate ply to elevate residual limb and reachieve fit. (May increase pressure over bony prominences if overdone) 2. Place proper modifications in selected pressure tolerant areas of the insert or socket to relieve bone prominences and accommodate for areas of soft tissue shrinkage, 3. Or new socket.
Hyperhidrosis.	Maceration distally: Potentially a milieu for fungal infection (Figure 21).	1. For B/K use open mesh-ventilated socket, or if tolerated, open end ventilated socket. 2. For A/K convert suction to semi-suction. Frequent change of residual limb socks necessary. 3. Medication locally if fungus.

CHART III: THE PATIENT (continued)

Etiology	Manifestations	Treatment and/or Prevention
Poor hygiene (dirty residual limb, dirty socket, and dirty residual limb socks) and total neglect.	Irritated, scaly, weeping and odorous residual limb.	Proper daily cleansing of residual limb, socket, and residual limb socks. Report to prosthetist and/or surgeon as soon as problems begin, without delay.
Excessive gain in weight.	Loss of fit due to upward displacement of residual limb may result in distal edema secondary to loss of total contact and also pressure on displaced bone prominences which are no longer appropriately positioned in relation to the socket.	Refer for medical evaluation and possible weight control. Adjust, refit, or replace prosthesis.
	There may be the development of flesh rolls with irritation and breakdown at the brim and soft tissue interface with a tendency to formetion of sebaceous and inclusion cysts which may become infected (Figures 13 and 22).	Use padded brim and flare brim for A/K. Flare posterior brim for B/K. Chronic cysts also may require surgical excision. (Also see "Prosthetist" chart with respect to choking.).
Mentally incompetent patients (drugs, alcohol, mental impairment).	Improper donning of socks and prosthesis and inability to recognize problems with subsequent soft tissue breakdown.	Careful, close, and frequent observation and assistance in-hospital or by attendant.
Excessive loss in weight.	Similar to "progressive maturation" above.	1. If intentional and to be maintained, and if socket modifications or residual limb sock additions are not adequate, then new socket should be fabricated to accommodate for the new situation. If not intentional, then a temporary prosthesis. 2. Refer for medical evaluation if weight loss unplanned.
Improper donning of residual limb socks with a wrinkling fold within socket particularly over unpadded bone.	Wrinkling causes pressure areas with soft tissue irritation and potential breakdown.	Proper instruction in donning residual limb socks, and adequate follow-up.
Changing to shoes of different heel heights from those with which prosthesis was fitted.	1. Instability. 2. Poor gait. 3. Introduction of improper pressure areas.	Properly instruct patient to avoid changing heel heights unless the foot-ankle unit can be readily adjusted or will adjust to the difference.
Acceptance of delivery of a prosthesis without clinic team checkout.	Any of the multiple problems referred to previously.	See preceding presentation. An experienced clinic team's checkout procedures would be preventive.

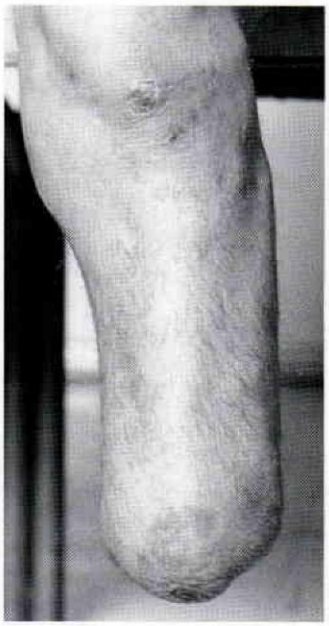

Figure 19. If the patient does not add a residual limb sock after shrinkage occurs, downward displacement of the residual limb in the socket may cause abnormal pressure on the distal pole of the patella as well as irritation of the distal limb.

THE THERAPIST AND NURSE

Chart IV

Pre- and post-amputation in-hospital care are the responsibility of the therapist and nurse under the guidance and control of the amputating surgeon. Chart IV includes some of the more obvious aspects of their responsibilities. In addition, the therapist will also be responsible for teaching the patient many other essentials, such as: how to fall and how to rise from the floor, how to use crutches or a cane when

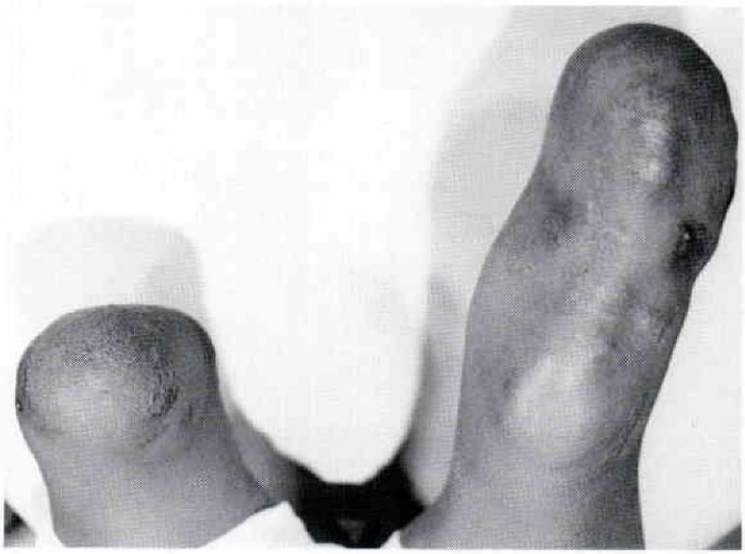

Figure 20. (right) Piston motion of the residual limb in the socket often produces abnormal pressure manifestations over the fibular head.

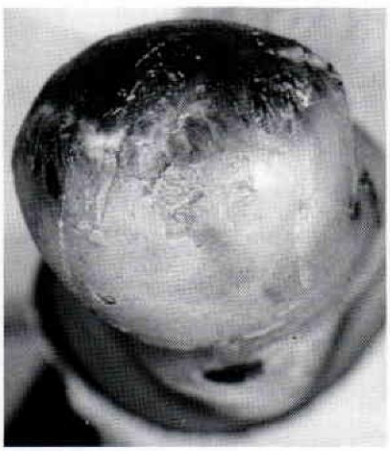

Figure 21. (left) Maceration secondary to hyperhidrosis.

Figure 22. (right) Flesh roll. This amputee gained weight and lost fit.

necessary, how to wrap the residual limb, and how to use simple hygienic measures in residual limb care. There is never a reason for one frequently encountered post-amputation problem to occur, such as the flexion contracture that is, unfortunately, seen too often. This should be avoided with proper nursing and therapy care.

Very often, it is a capable, sensitive, and experienced therapist who will take the opportunity to understand and discuss with the patient the psychological impact of his amputation. He will be aided in the process if other actively functioning, rehabilitated amputees are brought in to talk with the amputee and to demonstrate how they have coped with their amputations and have returned to society as active working family members of that society. There is no better way to help the new amputee diminish the psychological impact of the loss of a limb than by other amputees demonstrating that there will be a future for him.

CHART IV: THE THERAPIST AND NURSE

Etiology	Manifestations	Treatment and/or Prevention
Inadequate instruction in gait.	Improper use of sophisticated knee components: faulty gait; fear of weight bearing.	Instruction, particularly with the hydraulic units.
Neglect of basic principles of pre & post amputation care.	1. Flexion contractures (Figure 23). 2. Pressure sores at bed rest. 3. Swelling of residual limb.	Follow established procedures for pre- and post-amputation follow-up and therapy. If, for example, contractures are not correctable, the prosthetist's ability to fit will be determined by the degree of contracture as related to residual limb length, for example, a 5cm. B/K residual limb at 30° can be fitted, but a 15cm. B/K residual limb with a similar contracture can only be fitted at the sacrifice of stability or cosmesis.
Neglect of upper extremity muscle development for potential crutch walkers.	Weakness of upper extremities and instability with crutches.	Course of therapy directed at achieving upper extremity muscle development.

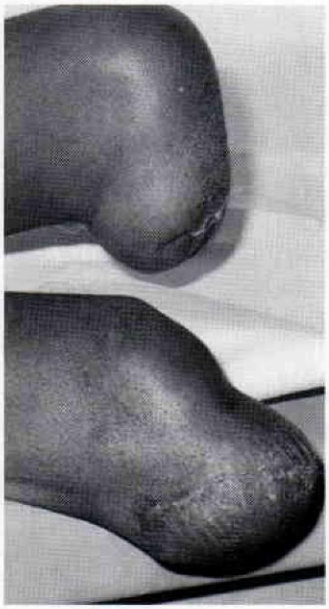

Figure 23. (left) Flexion contractures should not be permitted to develop.

Figure 24. (right) Temporary adjustable above knee socket.

CHART V: THE PHYSICIAN

(acceptable complications secondary to therapy)

Etiology	Manifestations	Treatment and/or Prevention
Radiation therapy or chemotherapy	Edema of residual limb.	1. Temporary adjustable A/K prosthesis (Figure 24). 2. B/K—remove insert and vary number and ply of residual limb socks to conform to extent of edema. 3. Wrapping residual limb when not wearing prosthesis.
Dialysis for kidney failure.	Intermittent edema of residual limb (status before dialysis and after dialysis).	See above.

THE PHYSICIAN

Chart V

Finally, there are certain specific diseases which affect the status of the residual limb, examples of which are mentioned in Chart V. There are a multiplicity of skin problems which have been presented in detail elsewhere (and which may occur anywhere on the body). These become more serious problems when they present themselves on the residual limb. Various skin lesions[5] may be noted such as psoriasis, herpes zoster, or even tumors. These should be treated by a physician or dermatologist in conjunction with the prosthetist. Whenever consultation with an internist, dermatologist, neurologist, or other specialist is necessary, the clinic team should arrange such consultation.

THE CLINIC TEAM

Chart VI

The Clinic Team has the responsibility for not only prescribing a prosthesis and evaluating the finished limb, but also for follow-up and subsequent care. The prosthesis chosen should provide the amputee with optimum function for the particular stage of rehabilitation.[6] As an example, a temporary above knee prosthesis may be an initial prescription with an adjustable polypropylene socket and a single axis knee, but after sufficient limb maturation has occurred, the active amputee should be allowed to progress to a suction socket and a hydraulic knee if appropriate. Unless there is a financial problem, or an unusual special circumstance such as difficulty of access to a prosthetic facility, a vigorous amputee should not be required to ambulate with a single axis constant friction knee. Chart VI illustrates problems which are the responsibility of the clinic team.

CHART VI: THE CLINIC TEAM

Etiology	Manifestations	Treatment and/or Prevention
1. Improper Selection of Prosthetic Components.	Gait Deviations. Increased energy expenditure. Residual limb problems.	Selection of components should be based on many factors including health and physiological age of amputee, status of the residual limb, vocation and avocation of the amputee, home and work environment, availability of sophisticated components, and facility of access to prosthetic repair shop.
Lack of consideration of problems with contralateral limb.	Instability may be introduced by previous cardiovascular accidents (CVA's), muscular dystrophies, and neurologic or joint pathology, amongst others.	Individual evaluation and treatment, such as possible orthoses, as necessary and shoe modifications.
Lack of consideration of secondary problems with ipsilateral limb.	Malunion of fractures with deformity at fracture site will require appropriate consideration by prosthetist to achieve optimum alignment. CVA, flexion contracture, edema secondary to therapy for Ca, Kidney dialysis, etc., will cause gait deviations if not considered.	Prosthetist must take all such problems into account during fabrication.
Lack of consideration of general health problems of the amputee.	Cardiac, pulmonary, gross muscular weakness requiring excess expenditure of effort.	Refer to appropriate medical consultant for evaluation and opinion.

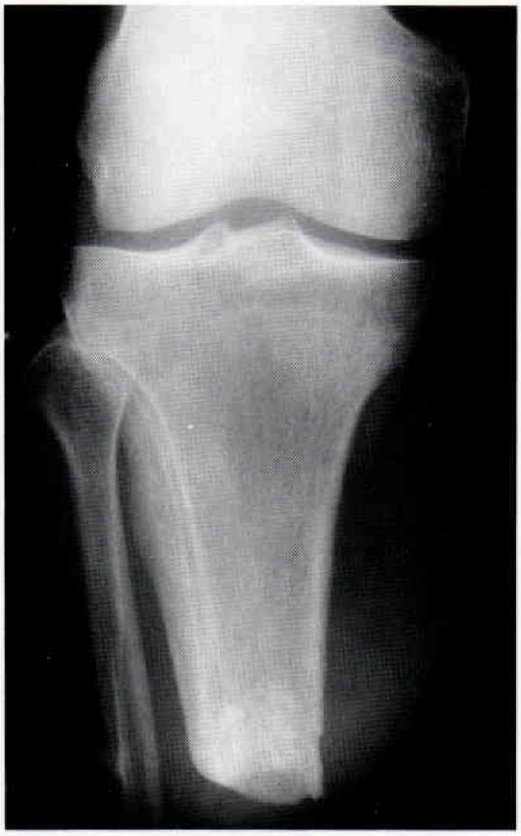

Figure 25. Excessively long fibula and poorly contoured distal tibia (see Chart I, items 1 and 2 under Etiology).

SUMMARY

The prevention and treatment of amputation problems is a basic goal of everyone concerned with the care of the amputee. Fortunately, such problems are the exception rather than the rule. But when they do occur, these problems may be catastrophic for the amputee, requiring lost time from work, and even, if no other solution is satisfactory, limb revision (Figure 25). This may mean that the patient will have to start the entire process all over again.

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Contemporary Trends in the Orthotic Management of Legg-Calve-Perthes Disease

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

INTRODUCTION

In 1895, the German physicist Wilhelm K. Roentgen discovered x-rays. The subsequent era saw an explosion of medical knowledge and many lively controversies over credit for various discoveries. Not the least of these was over who should receive credit for describing osteochondrosis of the hip and for differentiating it from tuberculosis of the hip. Echoes of the controversy can be found even today in its more popular name: Legg (1910), Calve (1910), Perthes (1910), Waldenstrom (1909) disease. This is more commonly shortened to Perthes disease or Legg-Perthes disease, or even abbreviated as LCPD.

To this day the etiology of LCPD is obscure, and over the years new treatment techniques have evolved. This paper is intended to explore some of these issues from the point of view of the clinical orthotist, with particular emphasis being given to ambulatory non-surgical treatment and to some of the various orthoses used.

THE DISEASE

Legg-Calve-Perthes disease is described as self-limiting avascular necrosis of the epiphyseal center of the hip and of idiopathic origin.[1] It is said to affect four times as many boys as girls (it is said, however, to be more severe in girls), and while it may occur anytime between the ages of two and 15, the maximum incidence is between the ages of five and seven. Bilateral involvement occurs in 10-15 percent of the cases seen, and there is apparently a relatively low incidence among blacks.

It has been concluded that there is not a genetic factor in the majority of patients but that patients with LCPD in general are undersized and of delayed skeletal maturity for their age.[2, 3, 4]

LCPD is said to proceed in four phases:

- Following interruption of the blood supply, growth in the epiphyseal center ceases and bone dies. This period lasts a period of months or in some cases longer than a year, and is called the quiet phase, as

the child is pain-free and no deformity takes place.

- Blood supply to the involved area is reestablished and old bone is resorbed while new bone is deposited. The new bone is malleable and responds in shape to the forces exerted upon it. During this phase pathologic fractures of the subschondral bone or subluxation of the hip may occur. It is also during this phase that the child is seen. He may walk with an antalgic or painful gait and complain of pain or tenderness of the hip. In some instances, the pain may be referred to the knee. There is disuse atrophy of the proximal thigh and limitation of motion about the hip involving abduction and internal rotation. This period lasts from one to four years.
- Bone resorption ceases and bone deposition continues. The new bone is still malleable.
- The final phase is a residual period following healing. If the joint has been subjected to abnormal forces and joint incongruity has occurred, degenerated joint disease may eventually develop.

McAndrew and Weinstein evaluated the condition of 37 affected hips in 35 patients who had been diagnosed as having LCPD.[5] All patients had been seen at the University of Iowa Hospitals and the initial diagnosis was made between 1920 and 1940. At the time of follow up, the patients on the average were 56 years old and the authors concluded that 50 percent of the patients had disabling osteoarthritis. The authors also pointed out that the prevalence of pain and dysfunction in this patient group was ten times that in the general population in the same age group.

In two recent articles Salter, et. al., citing recent research, concluded that LCPD is a complication of avascular necrosis of the femoral head.[6,7] A painful subchondral fracture marks the initiation of LCPD, and resorption of bone occurs in the region under the fracture. The extent of the fracture, therefore, is of prognostic value in predicting the extent and course of the disease. In the absence of a pathological fracture, the authors concluded that an incidence of avascular necrosis resolved without the additional complication of LCPD.

TREATMENT

In the past, a variety of treatment methods have been used with apparently indifferent results. In general these earlier schemes attempted by one means or another to put the hip at rest. Bed rest, slings to hold the leg off the ground, and Knee Ankle Foot Orthoses with patten bottoms and ischial weight-bearing brims have all been tried. Contemporary methods of treatment in general have been designed to exploit the Containment Theory of treatment.

This concept holds that if the diseased hip is held seated in the acetabulum with the femoral head covered as much as possible, then the plastic or malleable new bone will not be subjected to deforming forces. The result is that the child can be permitted full weight-bearing, and activity during the healing process and the femoral head will remain congruent. Interestingly enough, two authors attribute the concept involved to a gentleman by the name of A.O. Parker, and state that it was introduced in 1928–29.[7,8,9] The desired position involves abduction and internal rotation of the femur. A variety of techniques have been developed to maintain this position.

At least two different surgical techniques have been described to address the problem.[7] In one, the Salter innominate osteotomy, the pelvis is cut and wedged so as to reposition the acetabulum over the head of the femur. In the other, an osteotomy of the femur is performed and it is wedged to create a position of varus and internal rotation. While both procedures have their advocates, supporters of femoral osteotomy hold that it affects primarily the diseased segment, that it creates a more functional biomechanical relationship, and that the very fact that the femur is sectioned has favorable implications for the vascular supply, and thus the course of the disease.[10,11] Problems of complications secondary to surgery are apparently quite low, but, as with all surgery, must be considered. Advocates of surgery hold that once the osteotomy heals, the child is free to resume a normal life unencumbered with an orthosis. Some parents may prefer the

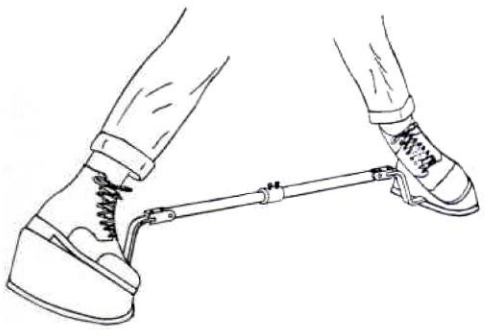

Figure 1. Craig Bar.

shorter treatment time of surgery, while others may fear the possibility of complication and prefer orthotic treatment. The ultimate decision is one to be made by the parents in consultation with the surgeon.

ORTHOTIC TREATMENT*

One of the first of the various orthoses designed to exploit the containment principle is the Craig Bar.[12] This comprises a metal bar connected medially to the patient's shoes by stirrups and ankle joints (Figure 1). The ankle joints are modified to block external rotation and the shoes are wedged to hold the sub-talar joints in neutral. The bar is long enough to produce abduction of the hips and this fact, in combination with the alignment of the ankle joints, creates the position of containment. Writing in 1963, Craig and his colleagues described the orthosis as being used subsequent to casts used to create the same position. It would seem that the Craig Bar has never gained widespread use despite its extreme simplicity, and undoubtedly this is due in part to problems of ground clearance and cosmesis associated with a rigid bar attached to the shoes.

The name most commonly associated with casts for the treatment of LCPD is, of course, Petrie. Petrie and Bitenc described in 1971 their experience treating some 60 children using bilateral long leg casts and "broomsticks" to position the hips in abduction and internal rotation.[13] Treatment of an individual began with hospitalization and bed rest with traction, if necessary, to relieve the muscular spasm and obtain the desired position of correction. In cases of severe abduction contracture, traction was prolonged or abductor tenotomies were performed. When the desired position, 45° of abduction and five to 10° internal rotation in each hip was established, casts were applied and the patient was discharged home to walk with crutches.

Every three to four months, the patient was readmitted for removal of the casts, mobilization exercises, x-rays, and reapplication of the casts. The process was then repeated until healing was completed. The average course of treatment was 19 months, and Petrie and Bitenc's results in 60 cases of children over five years of age were 60.3 percent good, 30.9 percent fair, and 8.8 percent poor.

They compared* this to a series of 108 cases of children treated with recumbency (the phrase they use is "avoidance of weight-bearing," which, from the context in which it is used, is taken to mean bed rest). The results of this series were 48.1 percent good, 16.7 percent fair, and 35.2 percent poor.

This course of treatment with its great demands upon hospital resources and the need for rigid containment of the legs in heavy casts is obviously not particularly satisfactory. As a consequence, alternative means to achieve the same end have been developed.

One of the first of these was the Toronto Orthosis, initially developed in 1966–67.[14] This device held the patient's lower limbs in the desired position by means of thigh cuffs attached to the shoes by a metal framework (Figure 2). The frame was articulated with ball joints aligned to permit knee flexion and thus sitting. The soles of the shoes were mounted on wedged blocks at a 45° angle relative to the floor in the frontal plan. A commercial version of this

*The trilateral orthosis is not discussed as it was considered in some detail in: "Fabrication and fitting instructions: Trilateral Perthes Orthosis," *Orthotics and Prosthetics*, Vol. 37, No. 4, 1983, pp. 24–33.

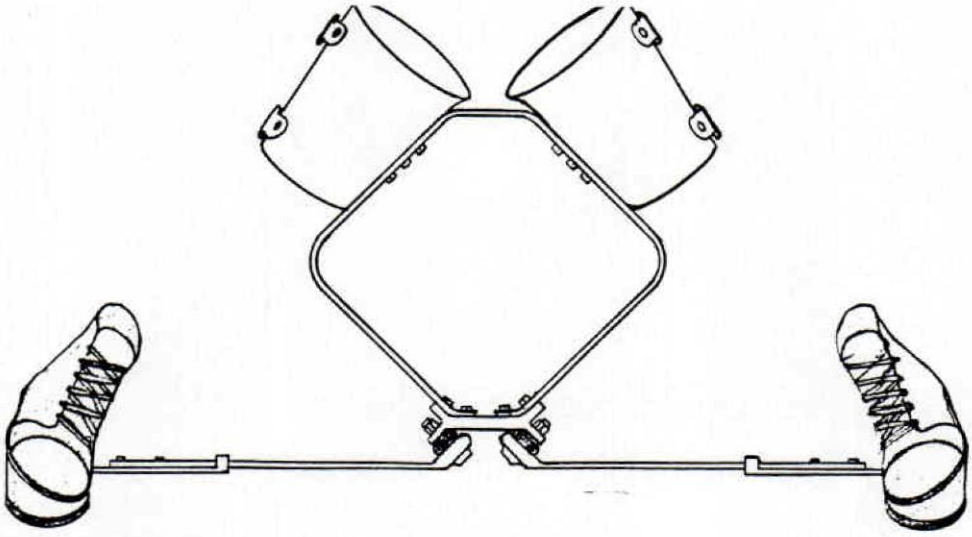

Figure 2. Toronto Orthosis.

orthosis, altered somewhat in structure to facilitate construction and post-fitting adjustments, have been available since about 1969 (Figure 3). This orthosis accomplishes the same end as the Petrie cast and is undoubtedly much easier for everyone to live with. However, the same objections as to cosmesis and use of crutches exist.

The Newington orthosis is very similar in design and was developed at about the same time (Figure 4). Curtis, et. al. apparently initiated their program of ambulatory treatment of LCPD in 1965 with Petrie casts, and very soon resorted to the use of the Newington orthosis.[15] King, et. al. gives the date for first use of the orthosis as 1968.[16] In any event, the orthosis comprised a non-articulated rigid metal framework with overlaps and multiple screw holes for adjustment. To this frame were attached Vitrathene medial shells to support the patient's knees and legs. Numerous cuffs and straps secured the patient to the orthosis. This orthosis was used during the day-time hours. For sleeping, simple lightweight plastic posterior shells were used to hold the legs in the desired position. Crutches were necessary for walking. Components for the orthosis were commercially available for a time, but have been discontinued.

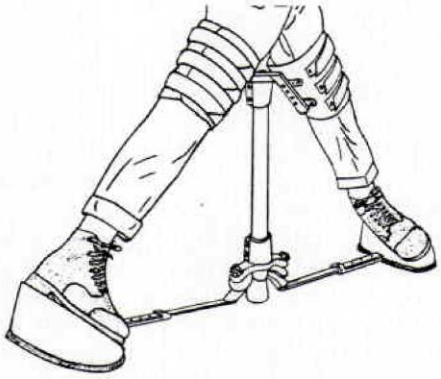

Figure 3. Contemporary commercial version of the Toronto Orthosis.

Curtis, et. al.* utilized an initial period of hospitalization and traction to establish the desired position of abduction and internal rotation. X-rays and arthrograms were used to determine coverage of the femoral head and the amount of angulation necessary to establish maximum coverage. In most instances 45° was necessary but in some cases proved to be too much. In all patients the hips were positioned not in

*In comparing these results of other authors cited in the article, due caution should be taken in drawing any conclusions. Various authors frequently differ in their assessment techniques and grading criteria. Therefore, direct comparisons are difficult and misleading.

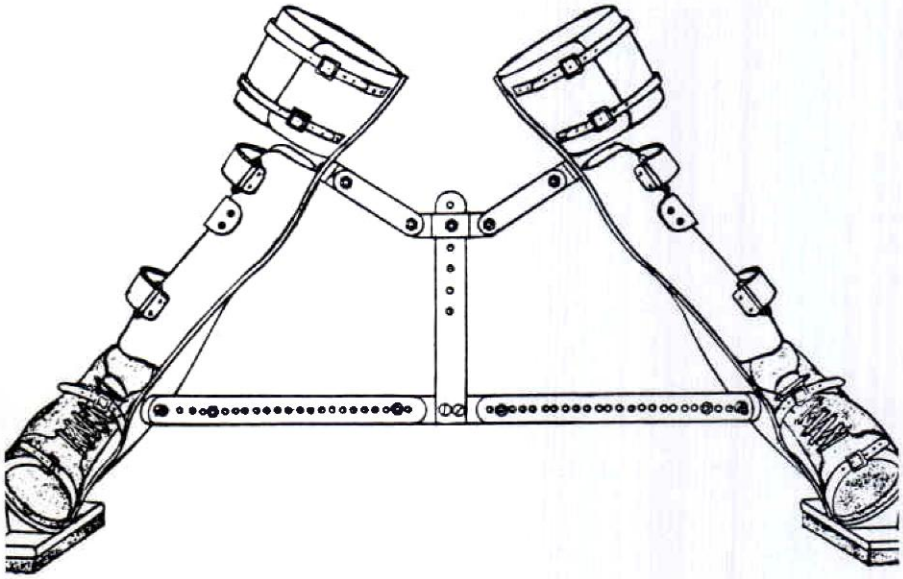

Figure 4. Newington Orthosis.

maximum possible abduction, but rather in ten degrees less in order to avoid pain and synovitis associated with the hips being positioned in maximum abduction.

The authors reviewed their results in nineteen cases. Sixty-three percent of the studies were classified as having good results, 21 percent were listed as fair, and 16 percent were poor. Mean age for onset of symptoms was eight years, one month. Mean age at time of hospitalization was eight years, six months. Course of treatment from hospitalization to removal of the orthosis averages about 20 months.

In 1980, King, et. al. reported on the results of ten years experience with the Newington orthosis.[16] Their sample group consisted of 56 patients (12 female, 44 male). Average age at the onset of symptoms was 7.1 years, with treatment initiated some 4.3 months later. After an initial period of bedrest, traction, and casts lasting on the average 2.2 months, orthotic wear commenced and lasted some 16.8 months. The mean follow-up period from onset of symptoms was 5.2 years, and on the average the children were 12.3 years old at the time of follow-up evaluation. Results were considered good in 32 percent of the cases, fair in 39 percent, and poor in 29 percent.

King and his colleagues also evaluated the results of treating some nine patients with the Scottish Rite Orthosis. Average age was 7.8 years, average time wearing the orthosis was 13.5 months, and time of follow-up was not given. Six hips were classified as good, two as fair, and none as poor. While suitably cautious in drawing any conclusions from such a small population, the authors felt that the Scottish Rite Orthosis gave superior results.

They attributed these superior results to the fact that while both orthoses maintained the position of correction, the Scottish Rite Orthosis was more conducive to active motion of the hip joints. Since anatomical studies have shown that any one time when less than 50 percent of the articular surface of the femoral head is contained in the acetabulum, areas of high pressure and deformity are likely to result from long periods of immobilization in one position. They felt that the Scottish Rite Orthosis with its increased motion, particularly transverse rotation, avoids these problems. In addition to the reasons cited by King and his colleagues, the effects of increased patient acceptance and compliance cannot be discounted.

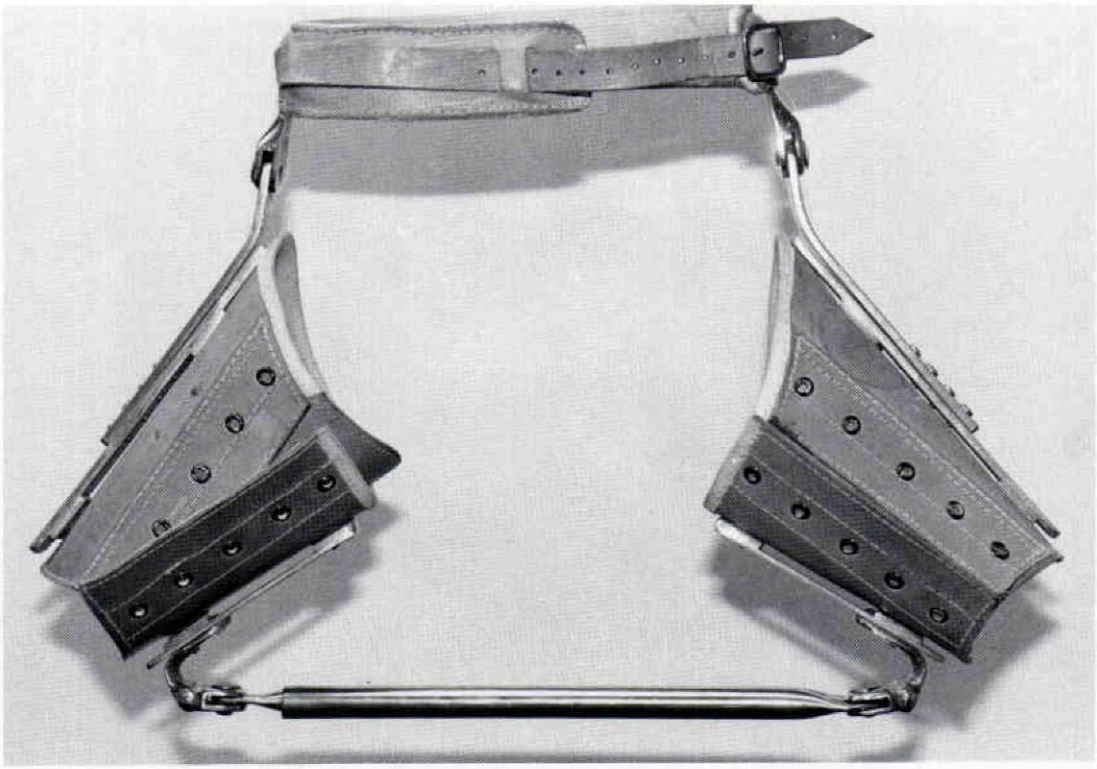

Figure 5. Original Scottish Rite Orthosis. Also known as the Lovell or Atlanta Orthosis.

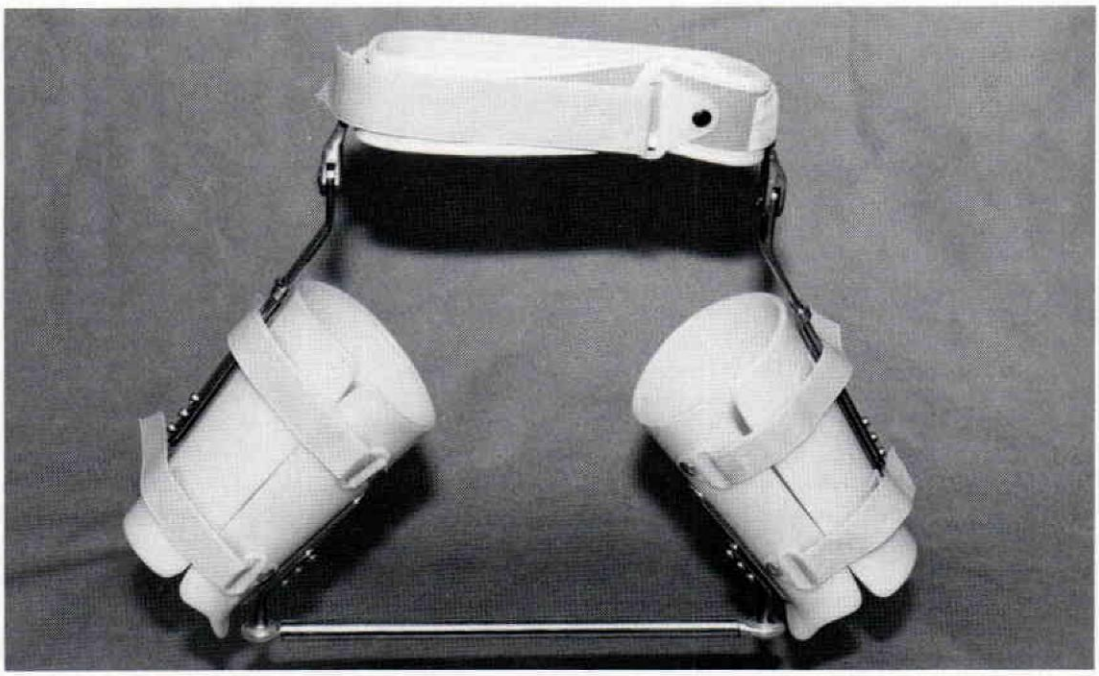

Figure 6. Commercial version of the Scottish Rite Orthosis with telescoping bar and universal joints at each end.

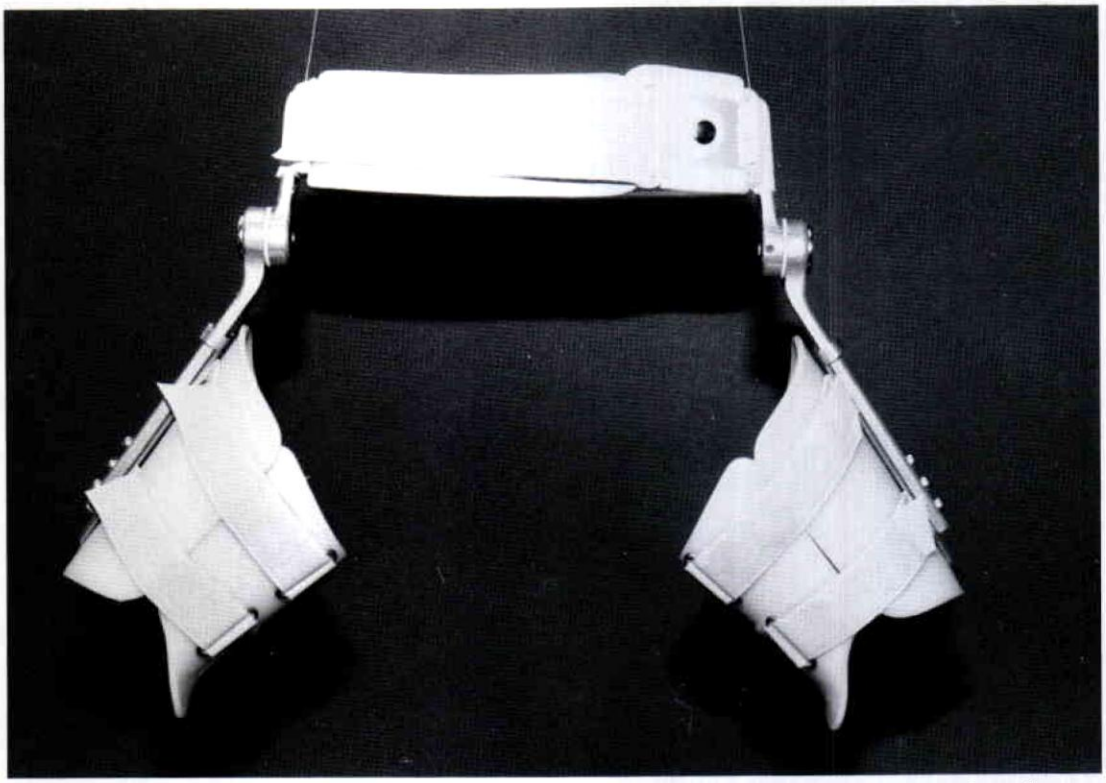

Figure 7. Updated version of the Scottish Rite Orthosis with aluminum thrust bearing hip joints and no telescoping bar.

The Scottish Rite Orthosis was developed initially in 1971 at the Scottish Rite Hospital for Crippled Children in Atlanta and revised in 1974.[17, 18] As used at the Scottish Rite Hospital, the orthosis is fabricated with a metal pelvic band and hip joints with the distal upright of the joints abducted (Figure 5). Medial uprights are connected to the lateral uprights with posterior bands and connected to each other by a telescoping rod with two way joints at each end. Leather thigh cuffs and a pelvic belt complete the orthosis.

A commercial version of the orthosis is essentially the same except that plastic thigh cuffs are substituted for the leather cuffs, eliminating the need for the four posterior bands (Figure 6). In addition, universal ball joints are used on the ends of the telescoping rod instead of the two-way joints used in the Atlanta version. Since its introduction, this version of the orthosis has attained a considerable measure of success with a minimum of reported breakage or failure.

In 1982, a new version with different joints was introduced (Figure 7). Aluminum hip joints in two sizes and with thrust bearings in the joints are utilized. In addition the initial abduction angles are milled into the distal upright, as is the offset angle in the proximal upright. This minimizes the amount of contouring to which the joints need to be subjected, and thus the amount of stress in them. The combination of the two factors, thrust bearings and milled contours, means that it is possible to eliminate the telescoping rod between the patients' knees. Consequently, the child can wear the orthosis beneath his clothing and the fabrication procedure is simpler. Maintenance and breakage have not been a problem since the introduction of this joint.

Purvis, et. al. reported on the results of their series in 1980.[15] Forty-one patients had completed treatment, with 78 percent reporting good or fair results. The average age at the state of treatment was six years, eight months, and the orthosis was worn for an average period of 18.9 months, which included a weaning period of some six months.

The authors stressed the importance of obtaining 40°-45° of bilateral hip abduction to provide coverage of the femoral heads, and stated that satisfactory treatment results could not be assured without adequate range of motion in the hips. As described by Petrie and Curtis, bed rest and traction are used to obtain the proper position and, if necessary, percutaneous adductor longus tenotomies. The authors noted further that while internal rotation control was not possible, the children treated tended to adopt a position of hip flexion which increased coverage of the femoral head.

SUMMARY

The general features of LCPD and aspects of its orthotic management have been discussed. The contemporary period in the orthotic treatment of the disease can be said to have begun with the promulgation of the Containment Theory. Devices for the exploitation of this theory have evolved from the original Petrie casts of the 1950's to the Scottish Rite Orthosis of the 1970's. While a variety of different orthotic designs are used to treat LCPD, in general it would seem that the Scottish Rite Orthosis affords satisfactory correction, while still receiving better patient acceptance than some of the other designs.

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The Development of a New Interface

by Martha Field, M.S.

INTRODUCTION

As changes occur in prosthesis design and fabrication, prosthetic socks must adapt to be compatible with these developments. According to Murphy,[1] the major function of a prosthetic sock is to give comfort and enhance the efficiency of the prosthesis by "providing cling to the residual limb and slide with respect to the socket wall." Over the years, this has been accomplished efficiently by wool socks and nylon sheaths. The three, five, and six ply thicknesses of socks have given adjustment for edema and atrophy, have afforded the resiliency that provides comfort between the socket and the residual limb, and have supported the distal tissue within the closed "toe" of the sock.

New sockets are being fitted more closely, wearers are becoming more active, and the skin condition is being given more attention.[2] As a result, the prosthetic sock function has added the importance of "absorbing perspiration, providing a wick-like action, and allowing for ventilation."[1] To answer these needs, a new prosthetic sock has been developed in a light weight construction.

LITERATURE REVIEW

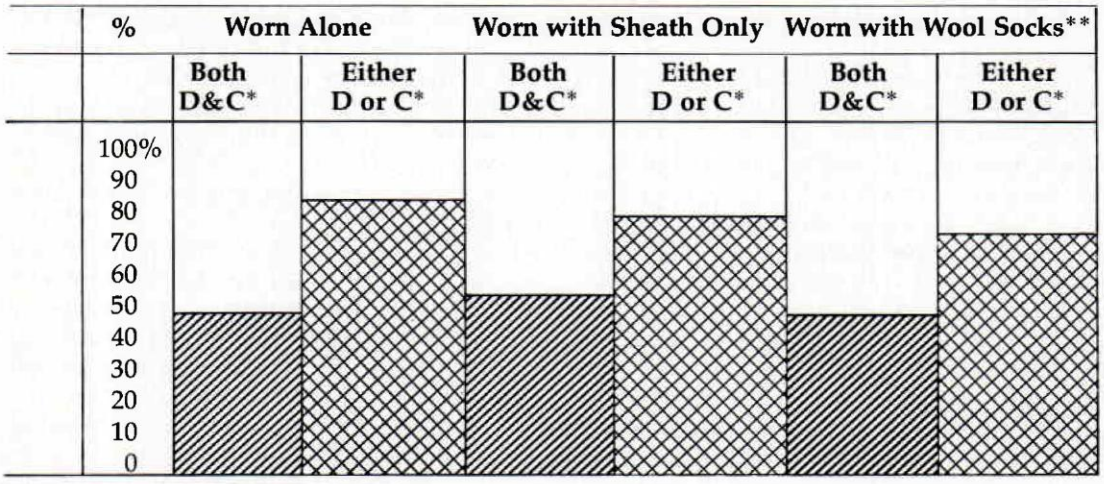
Selecting a fiber content was the first step. Polypropylene olefin, which has become a staple in several major running wear lines because of its wicking ability, was tried. Wicking refers to the drawing of body moisture from the skin up through the fabric;[3] as for example, when it is used for the facings of disposable diapers. With Lycra spandex, the polypropylene had the right amount of elasticity to contour or stretch-out, thus offering wicking, ventilation, and closefit in one yarn.

Prosthetic socks have historically been made by knitting several wool strands of yarns together to achieve desired weights and thicknesses. The size of these wool yarns has been usually between $^1/_{18}$" to $^1/_{16}$" as measured on the worsted system. A sock knitted of one end (strand) of such a yarn is said to be a one ply; two ends, two ply; etc. The three, five and six ply are standard in wool sock production. Other fibers such as cotton, Orlon/acrylic, and Lycra/spandex yarns are knitted to approximate the thicknesses of wool socks. In Orlon/Lycra, two ply and three ply are considered to be equivalent to three ply and five ply wool.[4]

As usage of Corespun yarns (Orlon, cotton or polypropylene with small amounts of Lycra) expanded into socks for fracture casting and orthotic and torso interface, a new thickness-weight designation became important. Socks using Corespun yarn became known as heavy weight, medium weight, and light weight depending on the number of ends and the yarn sizes used. The stretch characteristics of socks knitted from Corespun yarns is related to the thickness-weight designation and to the size of the Lycra core used.

Projecting the available knowledge, a sock of polypropylene fiber with Lycra core in a light weight construction should address a number of objectives, such as the

Effectiveness of Dryness and/or Comfort



*D—Dryness C—Comfort
**One or more wool socks, with or without a sheath

Table I.

reduction of skin moisture, accomodating closer fit, adjustments to edema and atrophy, and provision of a soft interface. After such a sock had been made, the feel suggested the name, "Soft Sock." To determine whether or not the sock achieved the stated goals when worn, a testing program was initiated.

TESTER GROUP

Names of facilities were selected from the files of the knitter. Of the 100 facilities originally contacted, 27 responded by supplying the knitter with the names and sizes of people who would be testers. Each tester received three free Soft Socks packaged with an insert card. The insert card gave pertinent information about the sock and specific care directions. Each tester was requested to make a written evaluation. From the 103 testers, 75 evaluations were received.

Among the respondents, 39 percent were ages 21 to 40 years, 29 percent were 41 to 60 years of age, 24 percent were over 61 years of age, and seven percent were younger than 21 years of age. Sixty-five percent had worn their prosthesis less than 21 years (one facility used socks on new fittings only); 18 percent had worn their prosthesis between 21 and 40 years; 10 percent between 41 and 60 years; and six percent over 61 years. Seventy-eight percent were men; 22 percent were women. Sixty-two percent described themselves as very active, 28 percent as moderately active, and 10 percent as slightly active.

Respondents identified the kind of prosthesis they wore as BK, AK, PTB, PTS, knee disarticulation, joints and corset, below elbow, or of wood construction. Lining materials were listed as follows: 33 Pelite® liners; 14 leather liners; 17 plastic prosthesis with no liner or insert; one silicone gel liner; one wood socket. Eight individuals gave no answer.

RESULTS

Wearing the Soft Sock with a wool sock was originally thought to be most desirable; however, 19 of the respondents said they wore Soft Sock by itself. Of the 56 who said they wore it with other socks, 20 said they wore it with one wool sock, either a three ply, a five ply or a six ply; 12 wore it with a wool sock(s) and a sheath; eight wore it with two (or more) wool socks; six wore it with only a sheath; five wore it with

an Orlon/Lycra or other sock; and five did not specify with what else it was worn.

The specific function of the sock was described as follows: 31 percent said they used it as a liner; 28 percent said they used it as a filler; 16 percent said they used it as a spacer and 18 percent said they used it for more than one of these functions. Two specified its use as a sheath, two as a wicking sock, and three gave no answer.

Two questions on the evaluation were most critical in judging the effectiveness of the sock: 1) Did you notice any improved dryness of your skin when wearing these socks? and, 2) Did you notice any improved comfort of your skin when wearing these socks? Seventy-nine percent indicated improvement in either dryness or comfort; 52 percent indicated improvement in both dryness and comfort. This response pattern was similar whether respondents wore the Soft Sock alone, with only a sheath, or with wool sock(s) (Table I).

Eighty-one percent of the respondents said they would purchase Soft Socks if they were available to them; eight percent said they would not; and 11 percent gave no answer to this question.

Since the Lycra spandex used in the Corespun yarn for Soft Socks has stretch potential several times its relaxed length, a reduction in inventory sizes without sacrificing fit was tested. The new size range is shown in Table II.

Corresponding Sizes

Soft Sock Sizes	Standard Sock Sizes
Child Short	#A
Narrow Short	#B, #0, #1, Length 10"–15"
Narrow Medium	#B, #0, #1, Length 16"–21"
Narrow Long	#B, #0, #1, Length 22"–28"
Regular Short	#1, #2, Length 10"–15"
Regular Medium	#1, #2, Length 16"–21"
Regular Long	#1, #2, Length 22"–28"
Wide Medium	#3 & Above, Length 16"–20"

Table II.

Ninety-four percent of the respondents evaluated the fit as satisfactory; two percent felt the socks were too tight; two percent felt they were too elastic; and two percent gave no answer. Fifty-one percent felt the length was satisfactory; 44 percent felt the socks were too long; and four percent gave no answers.

Care directions were listed on the insert card as follows:

1. Wear fresh socks and sheath each day.
2. Pre-spot socks before washing with mile soal or detergent, and cool water.
3. Fleece side should be inside for washing (wool socks are washed with the fleece side out).
4. Wash with a regular load of white laundry, eight to 10 minutes, warm (not hot) water temperature, ½ cup mild detergent (NO BLEACH). If Ivory detergent is used, use soft or softened water.
5. Rinse in warm or cool water for four to five minutes.
6. After washing, take tip of the toe in one hand, top of sock in other hand, and pull taut to smooth sock.
7. Dry in dryer set on low temperature for 30 to 40 minutes.

Ninety-six percent of the testers said they had no washing problems. Of the three who had problems, one bleached the socks, one complained of the seam failure because of very tight fit, and one lamented a loss of fluffiness even though the socks were handwashed. The loss of fluffiness was further tested by sending three additional socks and asking the tester to be sure socks were washed fleece side in.

Eighty-four percent of the respondents said the washing directions were helpful. Those who responded "no" commented that they "didn't read," "laundered with normal wash," "hand washed with Ivory or a mild detergent," and those who gave no answer commented that "wife does it" or "in hospital." Disturbing was the fact that 31 percent of the testers said they washed their socks after two or more wearings. Maximum number of wearings before washing was five.

CONCLUSIONS

The testers in this study were diverse in age, sex, and in how long they wore their prosthesis. They would seem representative of the general amputee population, although the 62 percent describing themselves as "very active" may be a little higher than average. These testers wore Soft Socks by themselves, with a wool sock(s) (and in some cases a sheath), with Orlong acrylic/Lycra spandex or other socks, and with only a sheath. Soft Sock was worn as a liner, a spacer, and a filler. Some testers stated they wore it instead of a conventional sheath and some wore it specifically as a wicking sock.

The new size range fit this group of testers satisfactorily except for length. As a result of this study, the knitter has reduced the length of the socks in the narrow range. Testers in this study who indicated excessive length of socks in the regular range could have received a better fit from the narrow range. A local tester indicated that the socks would give superior wear if a slight amount of slack is allowed at the "toe," particularly when the prosthesis fits snugly or several socks are being worn.

Care was viewed as no problem by the wearers. However, the knitter would prefer having Soft Socks washed after every wearing by all wearers.

The most significant aspect of the study is that 79 percent of the testers reported improved dryness or improved comfort after wearing Soft Socks. Some comments indicated that these socks fulfill a need which had existed for many years.

ACKNOWLEDGMENTS

Knit-Rite, Inc. wishes to thank all of the facilities who provided testers and follow-through. Other facilities and individuals did their own informal studies and gave us feedback. Such cooperation is so meaningful to us, and, we hope, helpful to those we all serve.

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Quadruple Hip Joint Calipers for Extensive Neuromuscular Disorders

by Lt. Col. B.P. Mathur

INTRODUCTION

Conditions such as poliomyelitis, paraplegia, muscular dystrophy, and spina bifida, at times require attachment of spinal extensions to above knee orthoses.

In the full body orthosis (Figure 1) in which the hip and knee joints are kept locked to maintain the patient in an upright position, it is very difficult for the patient to ambulate. In such circumstances, "Tripod walking" with the aid of crutches is recommended. The energy requirement for such a method of ambulation is considerable and thus limited to short distances. Alternately, the patient may resort to walking by a shuffling mechanism in which he rotates the whole of his trunk and slides one leg forward after the other, in a zig-zag fashion, making it very difficult for the patient to progress.

To overcome some of the above problems and to allow them some mobility within reasonable safety, Quadruple Hip Joints, in which some movement is allowed at the hip, have been introduced in such an orthosis. Such modification makes it possible for the patient to adopt a modified bipedal gait.

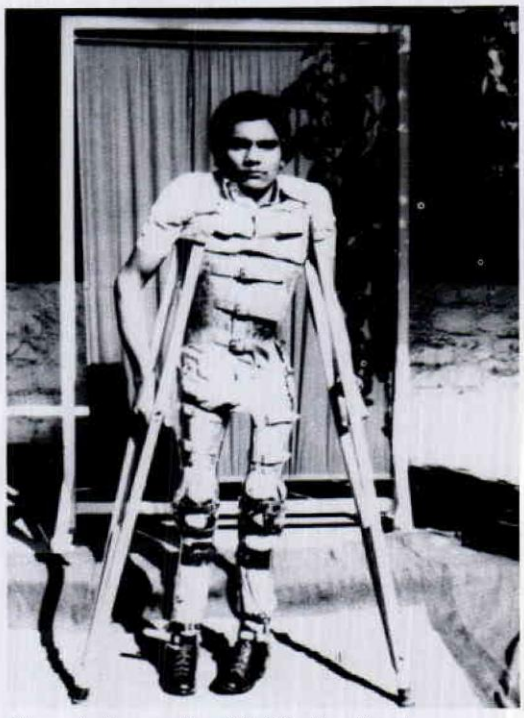


Figure 1. Conventional full body orthosis.

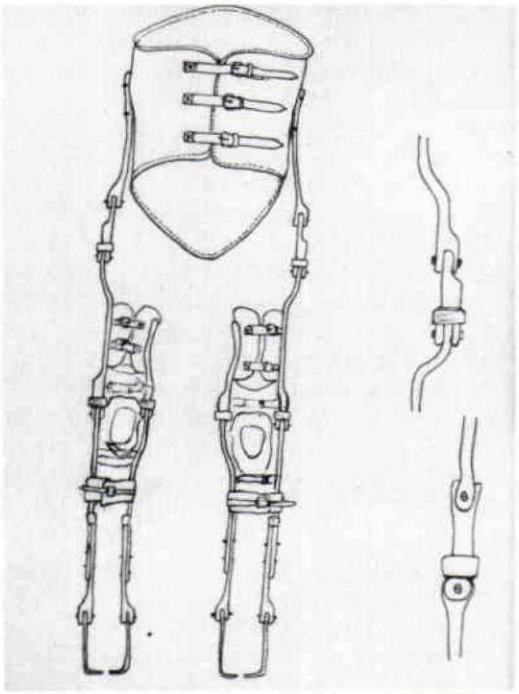


Figure 2. Line drawing of the Quadruple Hip Joints.

QUADRUPLE HIP JOINTS

Instead of two hip joints, as in the conventional bilateral knee ankle foot orthosis, with spinal support, four hip joints, two on either side, have been incorporated in the orthosis designed by the Artificial Limb Centre (Figures 2 and 3).

The lower two hip joints are located at the anatomical hip joints, and are provided with a spring loaded locking mechanism.

Two more hip joints with limited range of movement, allowing about 15° of flexion and extension, are incorporated at the level of the anterior superior iliac spines.

By allowing limited range of movement at the upper free hip joints, it is possible for the patient to adopt a bipedal gait (Figure 4). To ambulate, the patient utilizes his trunk muscles. The forward thrust produced by the shoulder and trunk results in movement of the legs forward, alternately. However, to walk with such an orthosis, they do require the help of walkers or crutches.

Figure 3. A close up of the Quadruple Hip Joints.

Figure 4. A child walking with the help of Quadruple Hip Joint T.L.S.H.K.A.F.O.s.

DISCUSSION

In extensive neuromuscular disorders with involvement of spinal musculature, in addition to involvement of both lower limbs, rehabilitation in walking with the aid of orthoses is a very difficult problem.

Though such patients use wheelchairs extensively and are able to lead a more active life with its help, it is important for them to attain an erect posture and undergo some mobility in order to prevent the complications of confinement to a bed and wheelchair.

Ambulation with the help of conventional whole body orthoses with locked hip and knee joints is very tiring, dangerous, and allows only limited activity. However, it does enable the patient to stand for longer periods of time and allows him to do his work in a standing position. The majority of such cases, after initial enthusiasm, reject such orthoses and resort to a wheelchair life, because in addition to the cumbersome device they have to wear, it really does not help them much in mobility. They are too apprehensive to resort to a tripod walking gait due to the fear of falling down, more so if the patient is overweight, which they tend to become due to prolonged bed rest and lack of physical activity. Futhermore, ambulation in such a manner is too tiring, and thus of little help to the individual.

Introduction of Quadruple Hip Joints, with limited range of movements at the upper hip joints, allows the patient to stand erect as well as ambulate using a modified bipedal gait. When the patient performs shrugging movements with the help of the thoracic and shoulder muscle groups, it results in movement of the supported limbs forward, with the movement taking place at upper hip joints. The patient walks by taking short steps alternately with the aid of crutches or a walker. The patients are able to walk easily, without getting tired, for reasonable distances on flat surfaces, indoors as well as outdoors.

CONCLUSION

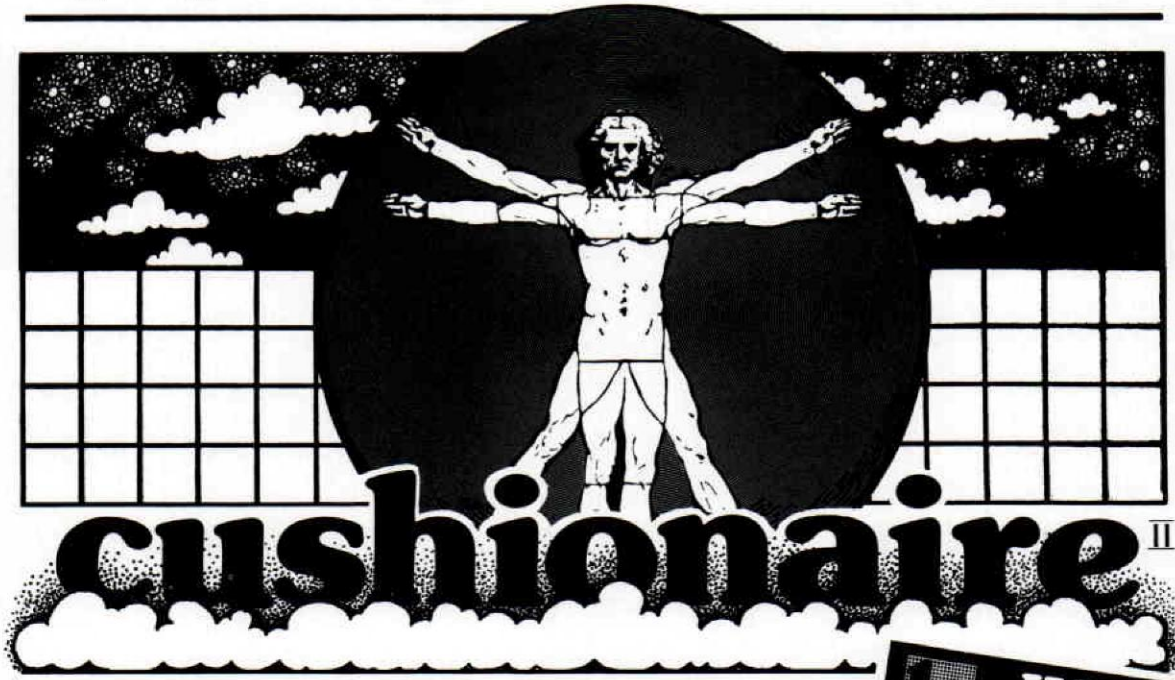
Modification of conventional full body orthoses, by incorporation of quadruple hip joints, has benefitted such severely disabled patients in adopting a more safe and less tiring modified bipedal gait.

Most of the patients fitted with such orthoses were extremely happy and could lead a more active and useful life with the help of orthoses and wheel chairs.

AUTHOR

Lt. Col. B.P. Mathur, M.S., M.Phil. (UK) is a Surgeon & Deputy Commandant, Artificial Limb Centre, Pune-411040, India.

THE ULTIMATE COMBINATION



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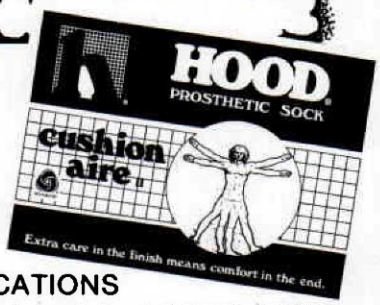

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REVIEWS

A Manual for Above-Knee Amputees, A.L. Muilenberg, C.P.O., and A.B. Wilson, P.O. Box 8313, Houston, Texas 77004, 23 pages, glossary, 1984.

This volume is similar in style and intent to the authors' earlier manual for below-knee amputees. Both books are intended to be used as aides in the process of educating new amputees. As such, they are meant to be adjuncts to discussion between the amputee and the prosthetist, not substitutes. They cover in general fashion the principles of prosthetic management and prescription. It remains the responsibility of the prosthetist and other members of the clinic team to discuss with the patient the specific details of his treatment and to answer any questions that may arise.

This book is well thought out and methodical in its approach, discussing in turn such matters as amputation, the post-surgical period, prostheses, training, bandaging, and hygiene. It does this while avoiding specific recommendations that would only serve to complicate affairs for all concerned. The goal is an educated patient, able to participate in the decision-making process, not one that blindly insists on being fit in a certain way regardless of its suitability to his needs.

Today it is well accepted that education and information is a patient's right and a health care professional's first line of defense against liability suits and future complication. Booklets such as this are essential for any prosthetist/orthotist intent on establishing a patient education program.

The book and its companion, *A Manual for Below-Knee Amputees*, are available from the above address for:

1-4 copies	$2.00 ea. postpaid
5-99 copies	$1.50 ea. postpaid
100 or more copies	$1.25 ea. postpaid

Charles H. Pritham, C.P.O.

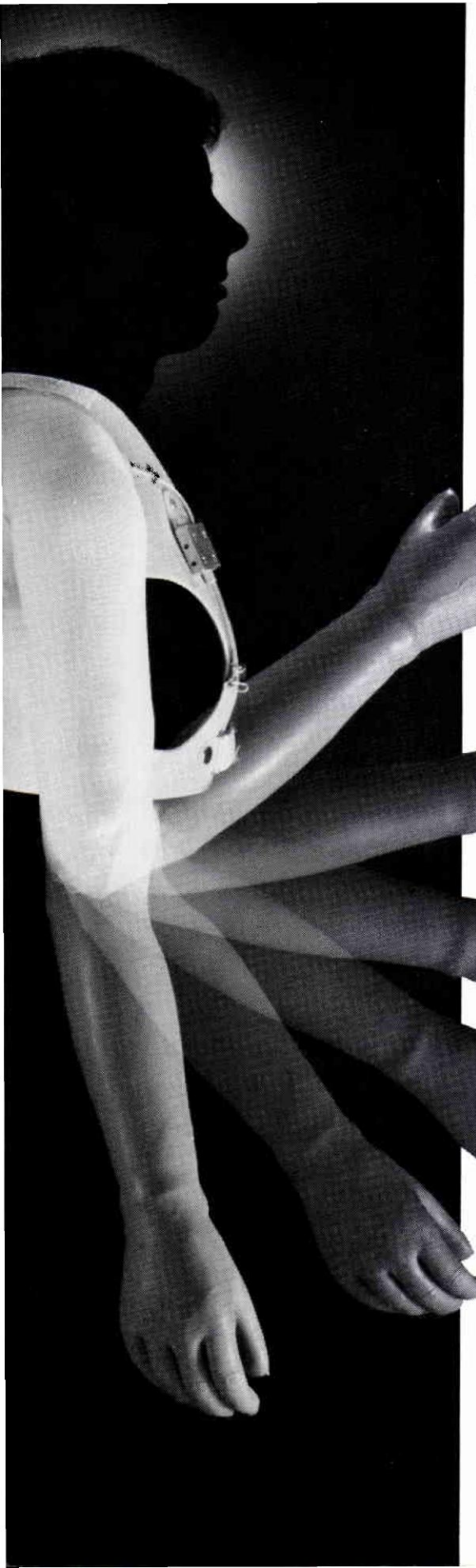
U.N.B. Monographs on Myoelectric Prostheses—An Introduction to Myoelectric Prostheses, R.N. Scott, B.Sc., D.Sc., P.Eng., C.C.E. Edited by A.S. Muzumdar, M.B., B.S., L.M. (IRE), FRCP(C), MCASI, Published by the Bio-Engineering Institute, University of New Brunswick, P.O. Box 4400, Fredericton, N.B., Canada E3B 5A3.

This Monograph by Dr. Scott is certainly up to what we have come to expect from him. The endeavor reminds us of the history of upper limb myoelectric prostheses and then goes on to bring the reader up to the present "state-of-the art." While technical in its presentation, it is an excellent beginners' manual on the subject.

Subjects covered include: myoelectric signals; control systems; electrodes; power supply; clinical and prosthetic considerations.

This first in the series of monographs on myoelectrics certainly is a fine addition to any research or reference library. I can only hope that each succeeding issue can follow in such a grand manner.

Lawrence R. Lange, C.P.O.



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Marshfield Clinic, a large multi-specialty group practice located in central Wisconsin has an immediate *opening for a certified or experienced Prosthetist Orthotist.* CP's and CO's with considerable experience may be considered. Position offers competitive salary, excellent benefits and ideal living environment. Send resume in confidence to: Employment Manager, Marshfield Clinic, 1000 N. Oak Avenue, Marshfield, WI 54449.

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Applications in writing, including the names and addresses of three professional referees, should be sent to the Assistant Registrar (Staffing and Secretariat), Lincoln Institute of Health Sciences, 625 Swanston Street, Carlton 3053, Victoria, Australia. Telephone (03) 342-0222.

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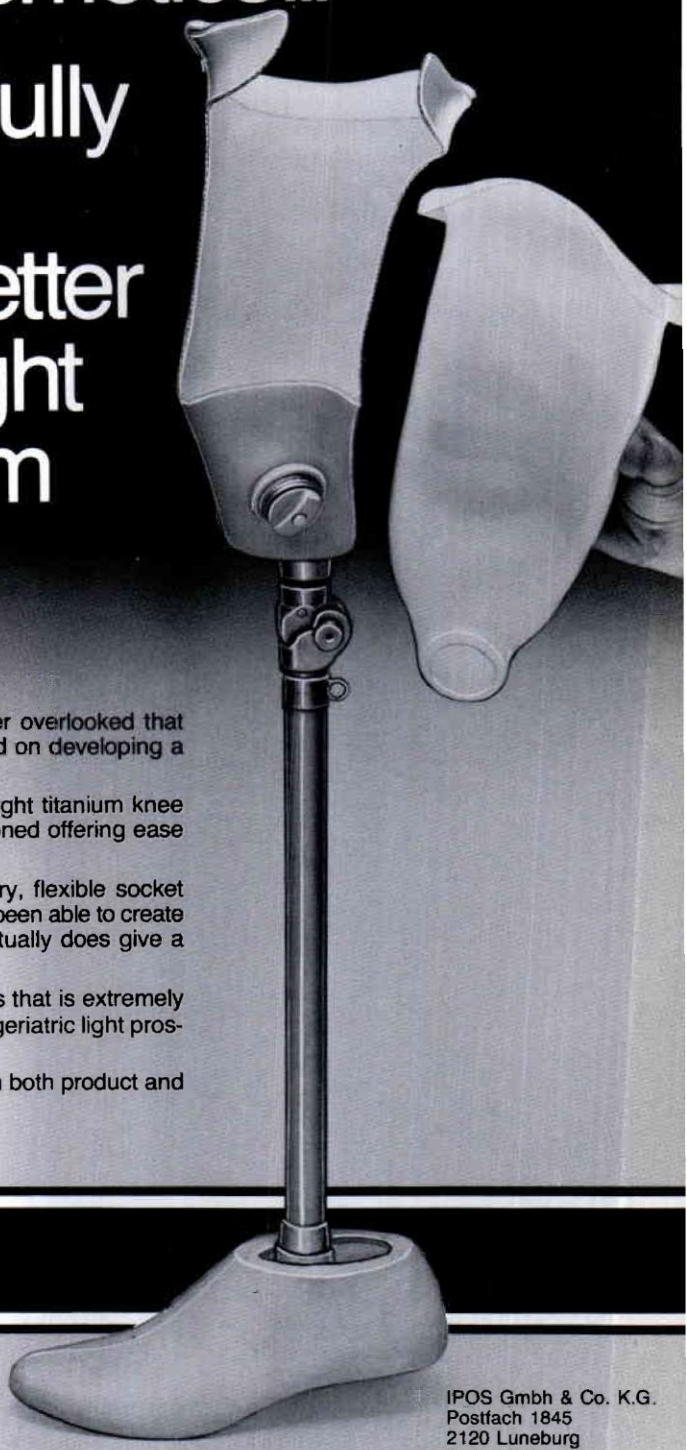

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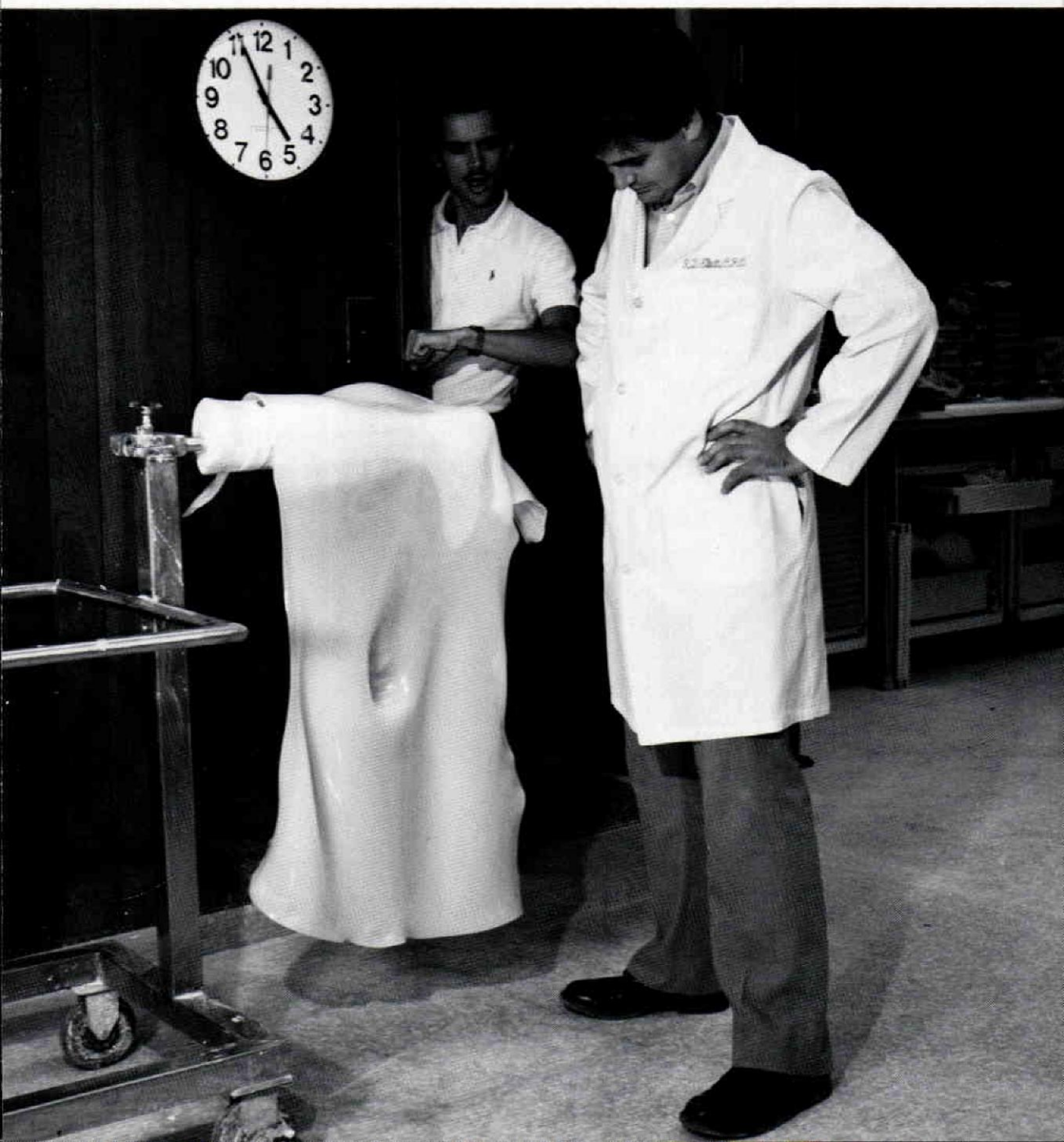

TO: PERSONS WORKING IN REHABILITATION

FROM: SIEGFRIED PAUL, CPO (E), SCIENTIFIC PROGRAM CHAIRMAN

RE: CALL FOR CONTRIBUTED PAPERS FOR THE 1985 ASSEMBLY SCIENTIFIC PROGRAM

The American Orthotic and Prosthetic Association's 800-plus membership consists of firms involved in the design, manufacture, and fitting of orthoses and prostheses. The primary objective of AOPA is to promote high levels of orthotic/prosthetic patient care services to the orthopedically handicapped. To aid in achieving this goal, each year the Association provides a forum, via its annual National Assembly, for orthotics and prosthetics professionals to share information on the many new ideas and/or concepts of or relating to orthotics/prosthetics. Nearly everyone working in orthotics and prosthetics in the United States attends the Assembly, along with many professionals from abroad. The 1985 Assembly will be held at the Town and Country Hotel, San Diego, California, October 14–20, 1985.

AOPA invites all interested persons to submit an abstract(s) for presentation during the Assembly's Scientific Program. The subject(s) for the abstract(s) should be new ideas, techniques, devices, and/or research that have a practical application in orthotics and prosthetics or a related field. Interested persons are invited to submit more than one abstract. Most presenters will be given 15 minutes for their presentation.

If you are interested in participating in the 1985 Assembly, please complete the abstract form on the reserve and return it to the AOPA National Headquarters no later than April 30, 1985.

Don't Hesitate! Do it now and be a part of one of the major rehabilitation education meetings of the year!

Thank you.

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START THE ABSTRACT TITLE HERE USING *CAPITAL LETTERS*. Follow with authors' names, *Business Addresses, Zip codes*. Underline *Speakers'* Name.

Leave a space between heading and abstract proper. Indent as shown. Keep all lines as wide as possible without touching or going beyond the lines at either side. Keep the text in one paragraph. If literature citations are needed, insert them in parentheses and not as footnotes. Credits, if any, should be added at the end of the abstract, but not as a new paragraph. Before submitting your abstract, check format, nomenclature, and spelling.

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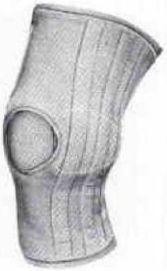

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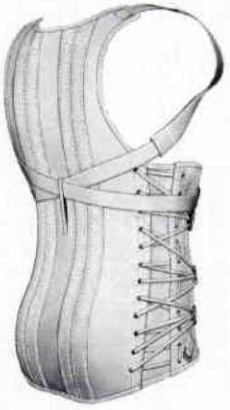

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New Features Added to Journal

Orthotics and Prosthetics, AOPA's quarterly scientific publication, enters its 39th year of publication in great shape. Readership has never been higher, and the consistency of the content from issue to issue has never been greater. As the dawn of its fifth decade approaches, the editorial staff would like to introduce some new features that will help make *Orthotics and Prosthetics* more responsive to the needs of today's practitioner.

With the on-going innovations in the field, sometimes it's difficult to keep up with everything that is going on. While *Orthotics and Prosthetics* works hard to present articles detailing these innovations new ideas, often the idea (and the problem that necessitated its invention) will predate the formal scientific treatment—such is the nature of this very practical science.

To help keep practitioners informed of these up-to-date developments, *Orthotics and Prosthetics* is instituting a New Products Section, devoted entirely to orthotic and prosthetic devices and ancillary products that have been introduced in recent months. New products to be listed in this category must meet a set of strict guidelines in order to be published. These guidelines will help to insure that those products published in the section are of the greatest relevance to the practitioner, and are presented in a fair and unbiased manner.

Orthotics and Prosthetics is also instituting a reader's forum, wherein practitioners and other interested readers may voice opinions, comments, and complaints related to *Orthotics and Prosthetics* and the profession as a whole. Members of the editorial staff will be chosen to respond to these letters, as well as writing editorial comment themselves. The forum will focus on the leading topics of the day, all from a scientific viewpoint.

We hope that these changes will make *Orthotics and Prosthetics* even more accessible to our readers. If you have any questions about these ideas, or any other suggestions concerning the journal, please write to the National Headquarters of AOPA.

U.S. Postal Service 1984 Statement of Ownership, Management, and Circulation (as required by 39 U.S.C. 3685)

Orthotics and Prosthetics is published quarterly by the American Orthotic and Prosthetic Association, 717 Pendleton Street, Alexandria, Virginia 22314. Subscription prices are $24, $28, and $48 annually.

The headquarters of the publishers is the American Orthotic and Prosthetic Association, 717 Pendleton Street, Alexandria, Virginia 22314, which is also the name and complete address of the publisher.

The Editor is Lawrence R. Lange, CPO, Orthotics and Prosthetics Department, Shriners Hospital for Crippled Children, 8400 Roosevelt Boulevard, Philadelphia, Pennsylvania 19152. The Managing Editor is Christopher R. Colligan, 717 Pendleton Street, Alexandria, Virginia 22314. *Orthotics and Prosthetics* is owned by the American Orthotic and Prosthetic Association, 717 Pendleton Street, Alexandria, Virginia 22314.

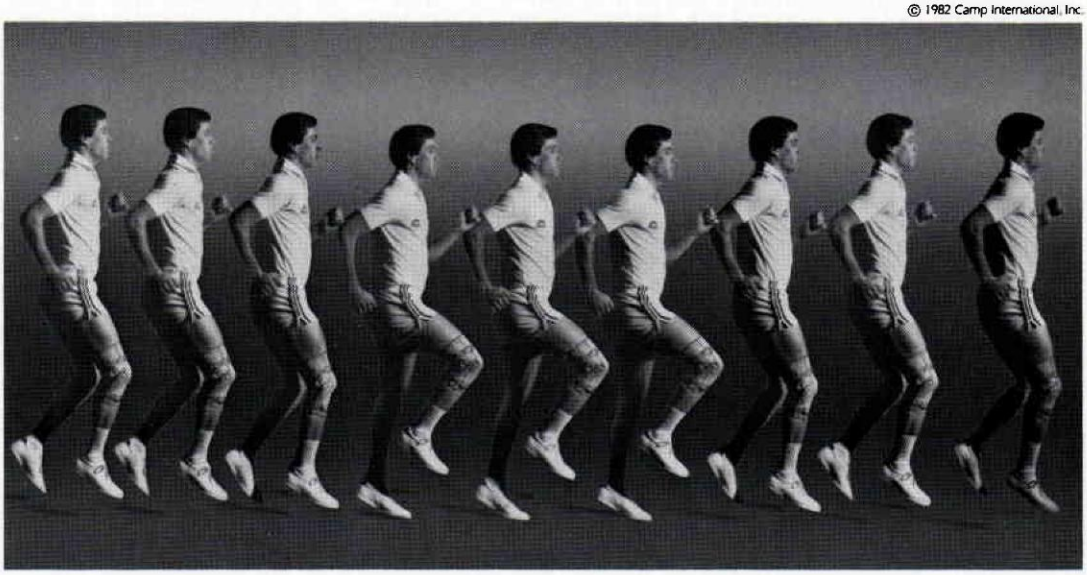
The average number of copies for each issue during the preceding 12 months was 3,675, of which 85 were distributed through paid circulation, and 3,396 were distributed through mail circulation—giving a total of 3,481 paid circulation. Free distribution averaged 55 copies, for a total distribution of 3,536. There were an average of 139 copies not distributed.

For the issue nearest the filing date of 9/19/84, 5,800 copies were printed. There were 120 distributed through paid circulation, and 3,436 mail circulations, for a total of 3,556. There were 2,000 copies distributed by other means, making a total of 5,556 copies distributed. There were 244 copies not distributed.

I certify that the statements made by me above are correct and complete.

Christopher R. Colligan
Managing Editor

STABILITY IN MOTION



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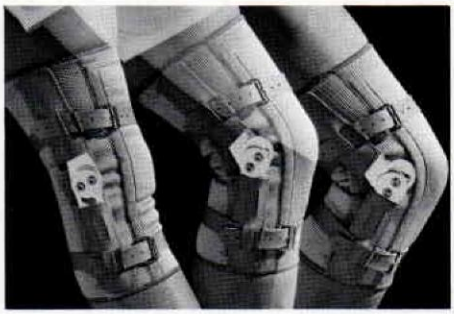

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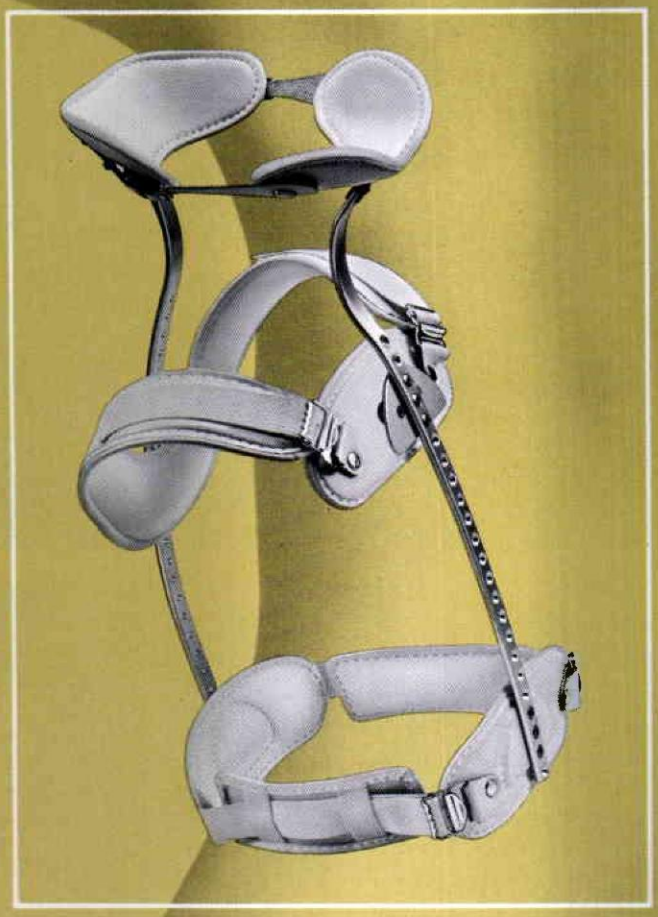

J-22 TWO-POST ORTHOSIS for stabilizing cervical and upper thoracic regions. Spinal orthoses are our only product. They are only available through ethical dispensing orthotists. Because of this we have the motivation and the skill to provide you with the highest quality orthoses possible for maximum acceptance by your doctors and patients. And we back you up with 24-hour delivery of your prescription orders anywhere in the country. Plus, we have a price structure to make our service your most profitable way to fill prescriptions. Florida Brace Corporation, P.O. Box 1299, Winter Park, Florida 32789.

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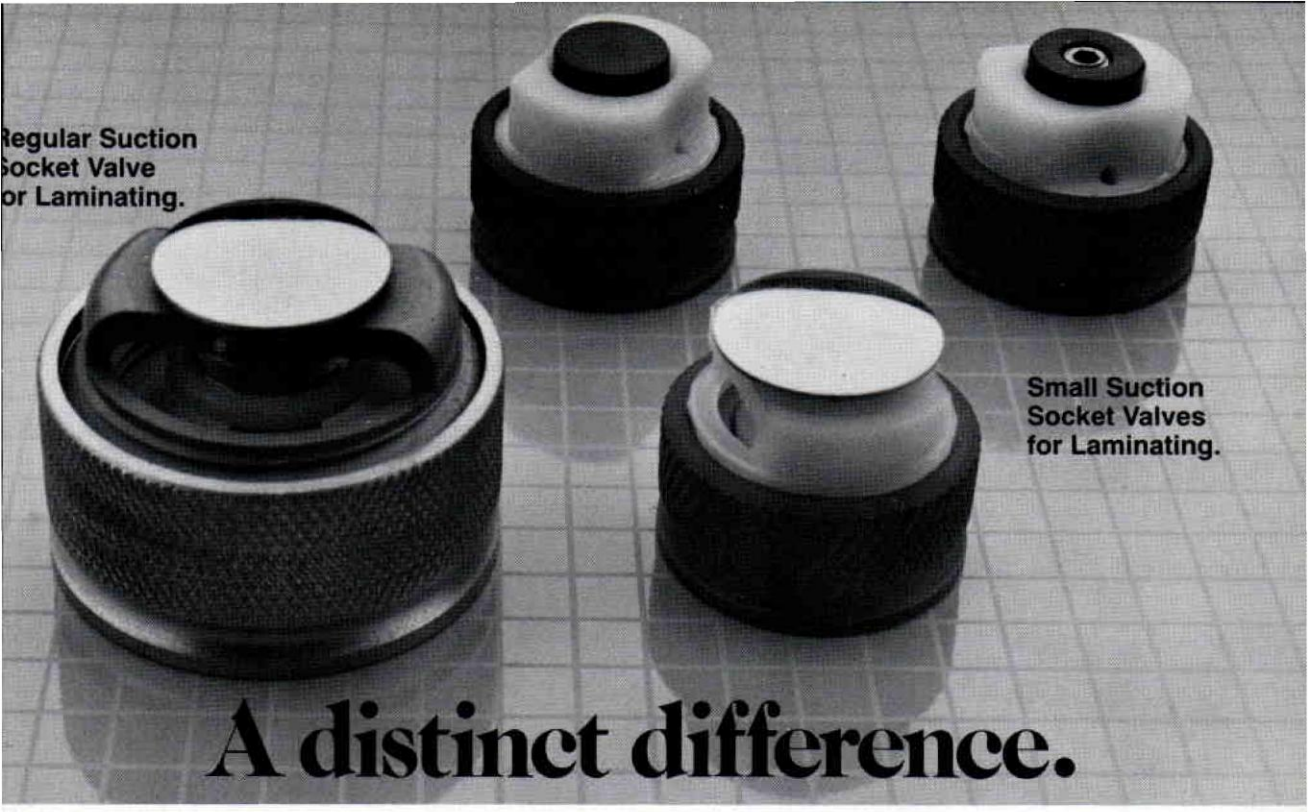

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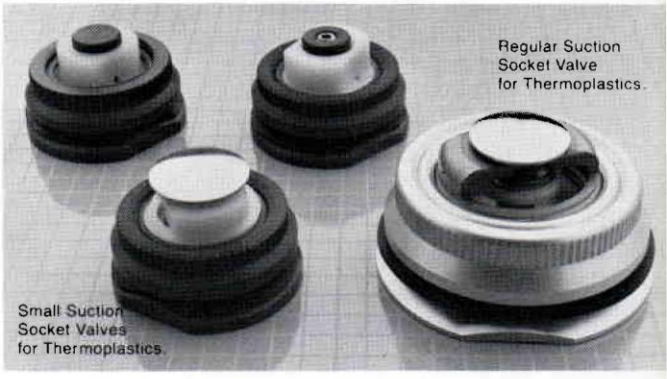

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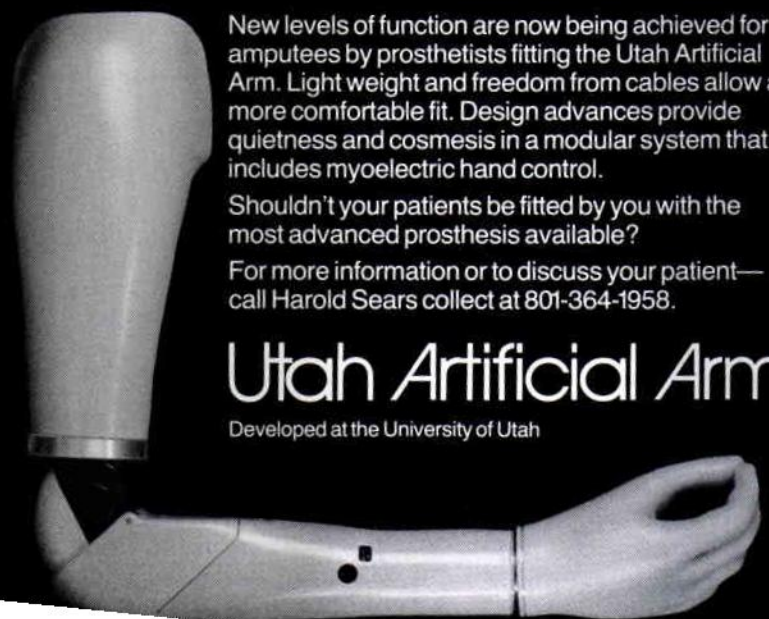

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GERIATRIC AND SPORTS MEDICINE

To: ORTHOTISTS/PROSTHETISTS
From: 1985 AOPA ASSEMBLY SCIENTIFIC PROGRAM COMMITTEE

TOPICS

- Sports Medicine
  Orthotic principals in preventive and post-operative care of foot, ankle, and knee.

- The Geriatric Amputee
  Total patient management . . . prosthetic considerations, i.e. new develpments in prosthetic technology and total care concepts.

The American Orthotic and Prosthetic Association (AOPA) invites all interested persons to submit one or more abstracts on the subjects outlined above for presentation during the Association's National Assembly Scientific Program.

Sports Medicine and The Geriatric Amputee are two of the most widely discussed topics in orthotics and prosthetics today. The Assembly Scientific Committee, in issuing this special call for papers, wishes to emphasize the importance of these two topic areas. Each subject will feature an expert as a keynote speaker.

Each year, the Association provides a forum, via its National Assembly, for orthotics and prosthetics professionals to share information on new ideas and concepts of or relating to orthotics and prosthetics. Speakers are given approximately 15 minutes for their presentations. The 1985 Assembly will be held at the Town and Country Hotel, San Diego, California, October 14–20, 1985.

Please complete the abstract form on the back side of this page and return it to the Scientific Program Committee no later than **April 30, 1985.** Follow the guidelines below for your abstract.

American Orthotic and Prosthetic Association—Abstract Guidelines:

START THE ABSTRACT TITLE HERE USING CAPITAL LETTERS. Follow with author's name, business address, zip code. Underline Speakers' Name.

Leave a space between heading and abstract text. Keep all lines as wide as possible without touching or going beyond the lines at either side. Keep the text within one paragraph. Cite literature at the end of abstract, but not as a new paragraph. Double check format, nomenclature, and spelling before submitting. Abstract must be typed.

American Orthotic and Prosthetic Association
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TITLE OF PAPER:

AUTHORS: (Underline speaker)

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AUDIOVISUAL REQUIREMENTS:

___ 35mm slides
___ Overhead projector
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