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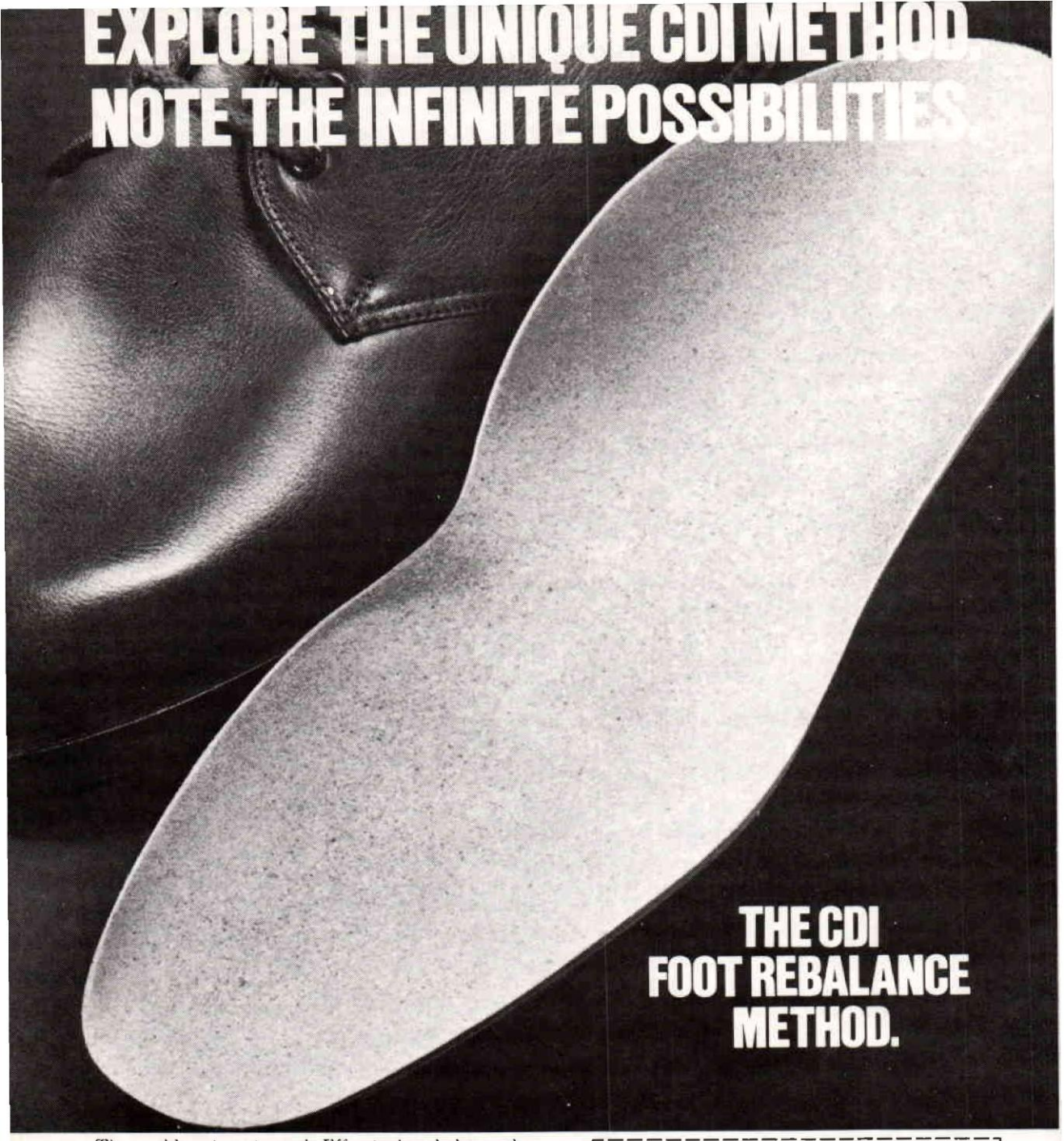

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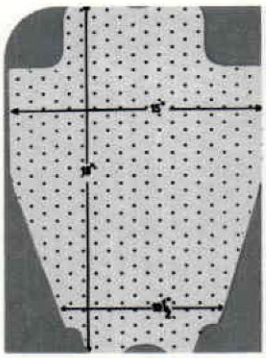

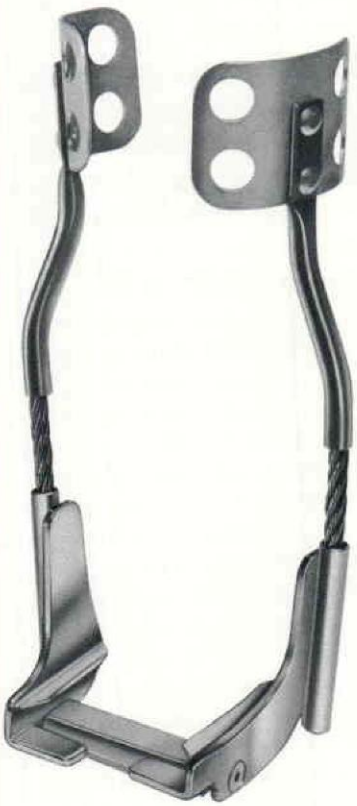

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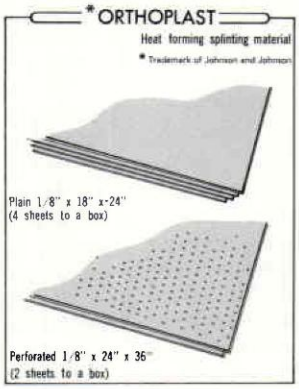

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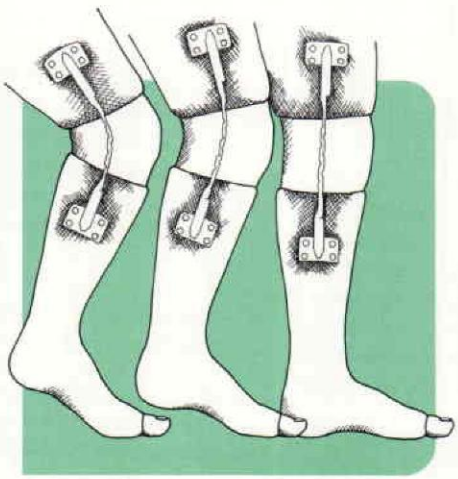

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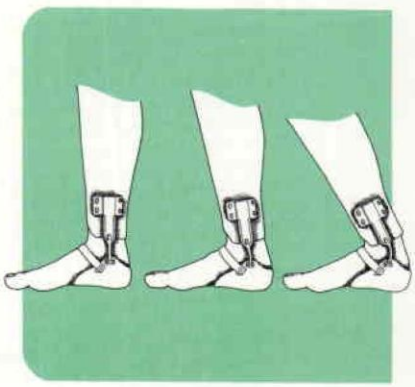

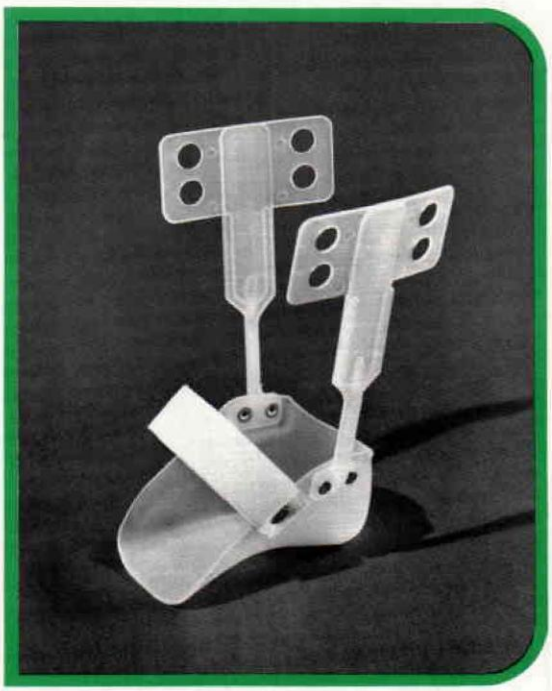

PART NO.
1S296

Small Left	Small Right
Medium Left	Medium Right
Large Left	Large Right

The Plastic Shoe Insert is designed to allow early ambulation with fractures of the tibia and fibula. A Velcro strap holds the brace securely, still allowing free plantar flexion and dorsal flexion that is necessary for proper circulation. It can be worn with most shoe styles without modification. Flexibility of the insert permits ease in cleansing the foot and changing socks.

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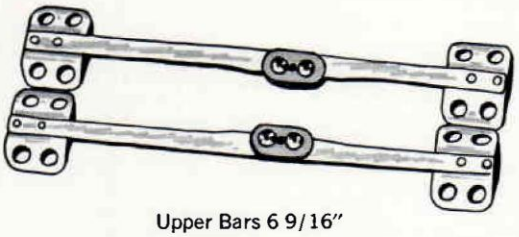

Upper Bars 6 9/16″

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AVAILABLE WITH LOCK 1A298-L

2T402 ALIGNMENT JIG

Will accomodate most all Fracture Braces

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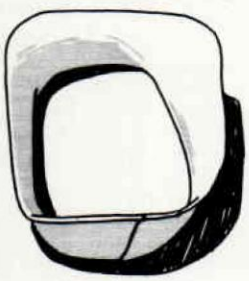

2L 243-S
2L 243-M
2L 243-L

Small	16″ to 19″
Med.	19″ to 23″
Large	23″ to 28″

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Cast Boot
Small
Medium
Large

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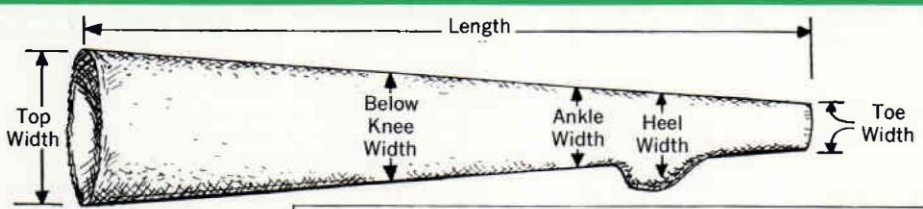
Two necessary for each cast.



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3-Ply Weight
Orlon/Acrylic 95.25%
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Closed Toe (not pulled up)
Fleecy (Fleeced inside and outside)

Length	Top Width	Below Knee Width	Ankle Width	Heel Width	Toe Width
36″	6″	4½″	3½″	5″	3″
35″	9″	5″	4″	6″	3½″
39″	9″	5″	4″	6″	3½″
42″	9″	5″	4″	6″	3½″
46″	9″	5″	4″	6″	3½″
46″	10″	6″	4½″	6½″	3½″

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In Memoriam

HECTOR W. KAY 1909-1975

Hector W. Kay, Acting Executive Director, Committee on Prosthetics Research and Development, National Academy of Sciences, died suddenly on the evening of March 31.

How do you say goodbye to someone who has had such an impact on your life? As a very young prosthetist, I first met Hector Kay while he was involved with the NYU Field Study on the upper-limb prosthetics courses that were taught at UCLA. Hector attended our clinics, and it seemed to me that he was almost supercritical of the prostheses. It soon became a challenge for me to be certain that there wasn't anything he could find wrong with my next fitting. It was several months before I began to realize how much joy Hector was getting out of teaching me the value of excellence.

Hector was quiet, always reserved, and, while he never really openly complimented many people, if you knew Hector well you could always tell by that look in his eye, and casual smile on his face, whether or not he approved of what you were doing. There was also never any doubt as to whether Hector's approval was genuine or not because he was a profoundly honest person.

Whatever success I have attained in the field of prosthetics and orthotics, a great deal of it is due to the influence Hector Kay had on my early life as a prosthetist.

The profession will miss him, and certainly I will miss him. I know all prosthetists and orthotists join me in extending sincere sympathy to Hector's family.

RONNEY SNELL

Orthotics and Prosthetics, Vol. 29, No. 2, pp. 3-16, June 1975

RELATIVE INCIDENCES OF NEW AMPUTATIONS
Statistical Comparisons of 6,000 New Amputees[1]

Hector W. Kay[2] and June D. Newman[3]

Because of the methods employed in the delivery of health services in the United States, it has not been practical to conduct accurate census studies of the amputee population; and, except for data on Veterans Administration beneficiaries, little is known generally about the characteristics of individuals who have lost their limbs.

In 1964 Dr. Harold W. Glattly published the results of a survey of new amputees *(1)* he conducted with the assistance of members of the American Orthotic and Prosthetic Association (AOPA) during the period October 1, 1961–January 31, 1963. Data were obtained on more than 12,000 amputees who presented themselves for fitting of an artificial limb for the first time. The study was the first of its kind, and the results have been of interest and use to many practitioners, research workers, and administrators.

In 1973-74, the Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education (CPRD-CPOE) conducted an identical study to determine whether the characteristics of the current amputee population were any different from those recorded by Glattly.

Procedures identical to those used in the first study were employed so that valid comparisons could be made.

In his study Glattly found that there was no change in the ratios obtained when data from the first 5,000 cases were compared with those obtained from the total sample of 12,000. In the 1973-74 study, data from the first 1,654 cases were analyzed *(2)* and compared later with data from 5,830 cases. Because there were no practical differences in the ratios obtained, the study was concluded.

Thus, it is felt that the data presented accurately reflect current incidences of amputation practice. However, it should be emphasized that neither this study nor the one reported by Glattly was conducted in conformance with scientific sampling techniques.

A comparison of the new reading with Glattly's final report reveals some apparently significant changes in amputation statistics, as well as some situations where very little change seems to have occurred during the past 12 years.

METHOD

One hundred and forty-three prosthetics facilities, all members of AOPA, in 39 states and the District of Columbia, participated (Fig. 1). Two simple data-collection forms were devised by Dr. Glattly. To gather the same type of information, similar forms, updated for computer programming, were used in the current study (Figs. 2 and 3). The participating facilities were provided packets of the forms, which contained original data slips to be retained by them for future reference, as well as carbon copies in the form of addressed and stamped postcards for mailing to CPRD-CPOE. Participants were instructed to complete a card on each new amputee for whom an original prosthetic device was provided. Amputees furnished with a replacement prosthesis were not recorded in either study. Card No. 1 was used for single amputations or multiple amputations done simultaneously for a single cause. Card No. 2 was prepared for cases in which more than one amputation was done at separate times for either the same or different causes—for

[1]This report was prepared as part of the work under Contract V101-(134)-P-75 between the Veterans Administration and the National Academy of Sciences, and Contract No. SRS 72-6 between the Social and Rehabilitation Service, Department of Health, Education, and Welfare, and the National Academy of Sciences.

[2]Assistant Executive Director, Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education, Division of Medical Sciences, Assembly of Life Sciences, National Academy of Sciences—National Research Council, Washington, D.C. 20418.

[3]Editorial Associate, CPRD-CPOE.

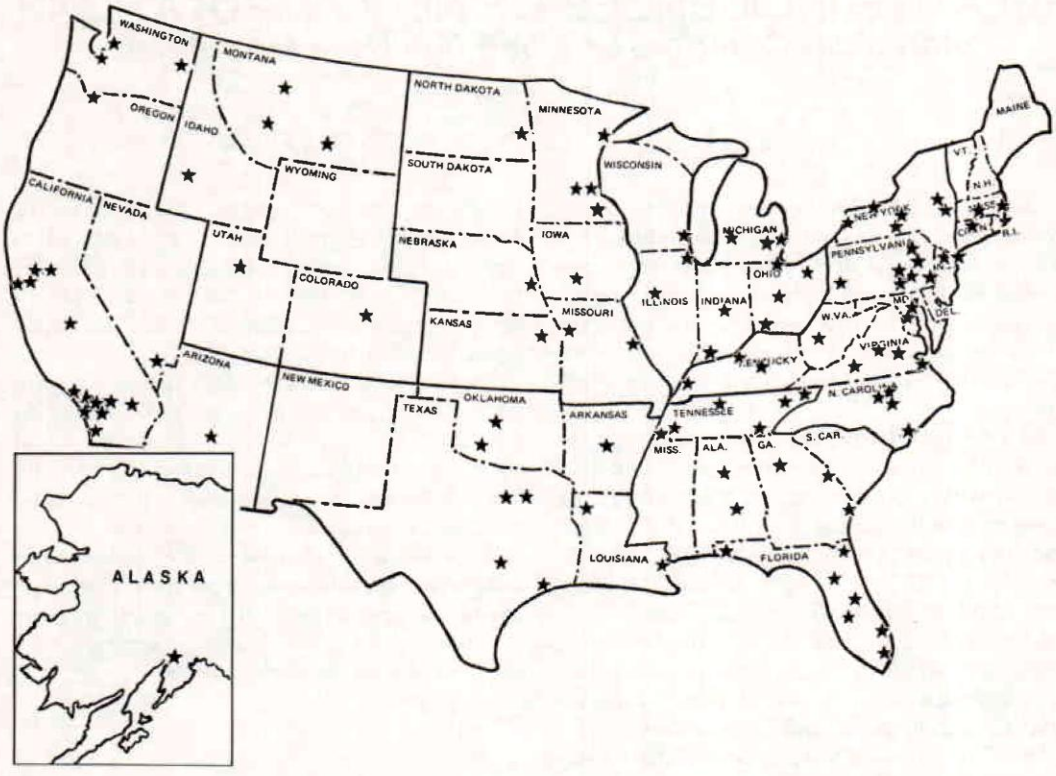


Fig. 1. Distribution map showing locations of prosthetics facilities participating in Amputee Survey.

example, an individual who had a below-knee amputation revised at a later date to the above-knee level. This type of patient represents a "new" case in the sense that his above-knee limb remnant had never been fitted previously. To indicate sex, site, and causes of amputation, numbers adjacent to the appropriate information were circled.

Causes of amputation were grouped under four categories:

Trauma. Amputations due to physical and thermal injuries, and to infection following injury.

Disease. Amputations due to vascular diseases and infections.

Tumor. All types of growths for which an amputation is performed.

Congenital. Only cases in which prostheses were fitted were included. The type of prosthesis was used to determine the "amputation" level.

FINDINGS

SEX

Glattly found that, in the total survey population, the ratio of males to females undergoing amputation (Table l) was better than 3 to 1 (77 to 23 percent). In the present study the proportion of males had dropped slightly, with a corresponding proportional increase in females (72 to 28 percent).

Glattly concluded that the disparity in amputation rates for males and females was attributable largely to the fact that amputations by reason of injury occurred nine times as frequently in males as they did in females (Table 2). In the current study males still predominated, but the trauma ratio had dropped to 7.2 to 1. The proportion of males to females coming to amputation because of disease had dropped slightly—2.6 to 1 versus 2.1 to 1, but it is somewhat doubtful whether this change is of any significance.

CPRD-CPOE/AOPA AMPUTEE SURVEY 1973-74 **Case**

Name_____ Code_____

State_____ Age_____ Sex: M F

Date of Most Recent Amputation_____ Site_____ Cause_____

Date Prosthesis Furnished_____

PRIOR AMPUTATION(S)			
	Date	Site	Cause
First			
Second			
Third			

ORIGINAL – RETAIN IN YOUR FILE

Fig. 2. Amputee Survey Card No. 1. Data form for single amputations and multiple amputations resulting from a single cause at the same time.

CPRD-CPOE/AOPA AMPUTEE SURVEY 1973-74 **Case**

Name_____ Code _____ (1-3) (4-6)

State_____ Age_____ (7-8) Sex: (9) M F

Date of Amputation(s)_____ (10-15) Date Prosthesis Furnished _____ (16-21)

SITE(S) OF AMPUTATION							
RU (22)		RL (23)		LU (24)		LL (25)	
1	SD	1	HD	1	SD	1	HD
2	AE	2	AK	2	AE	2	AK
3	ED	3	KD	3	ED	3	KD
4	BE	4	BK	4	BE	4	BK
5	WD	5	S	5	WD	5	S

CAUSE OF AMPUTATION (26)
1 Trauma
2 Disease
3 Tumor
4 Congenital

ORIGINAL – RETAIN IN YOUR FILE

Fig. 3. Amputee Survey Card No. 2. Data form for multiple amputations of the same limb, occurring serially at different times from the same or different causes.

Table 1.

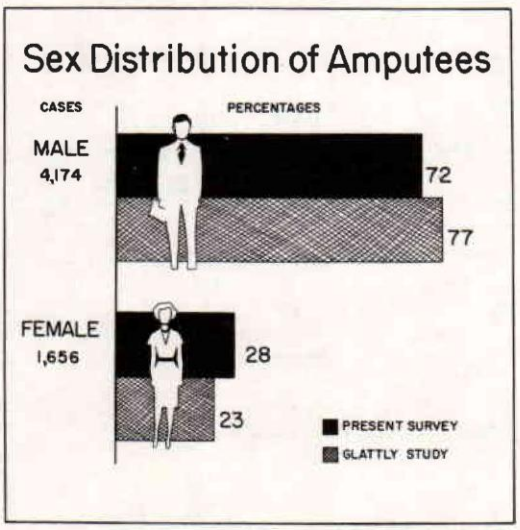


Table 2. Ratios Of Males To Females In Relation To Cause Of Amputation.

	Current Study	*Glattly Study*
Trauma	7.2 to 1	9.2 to 1
Disease	2.1 to 1	2.6 to 1
Tumor	1.3 to 1	1.2 to 1
Congenital	1.5 to 1	1.2 to 1

Distribution of new amputations by cause and sex is considered in somewhat more detail in Table 3. Here, some significant changes have occurred. In the total population (male and female) the percentage of amputations deriving from trauma dropped from Glattly's 33.2 percent to 22.4 percent in the present study, and substan-

Table 3.

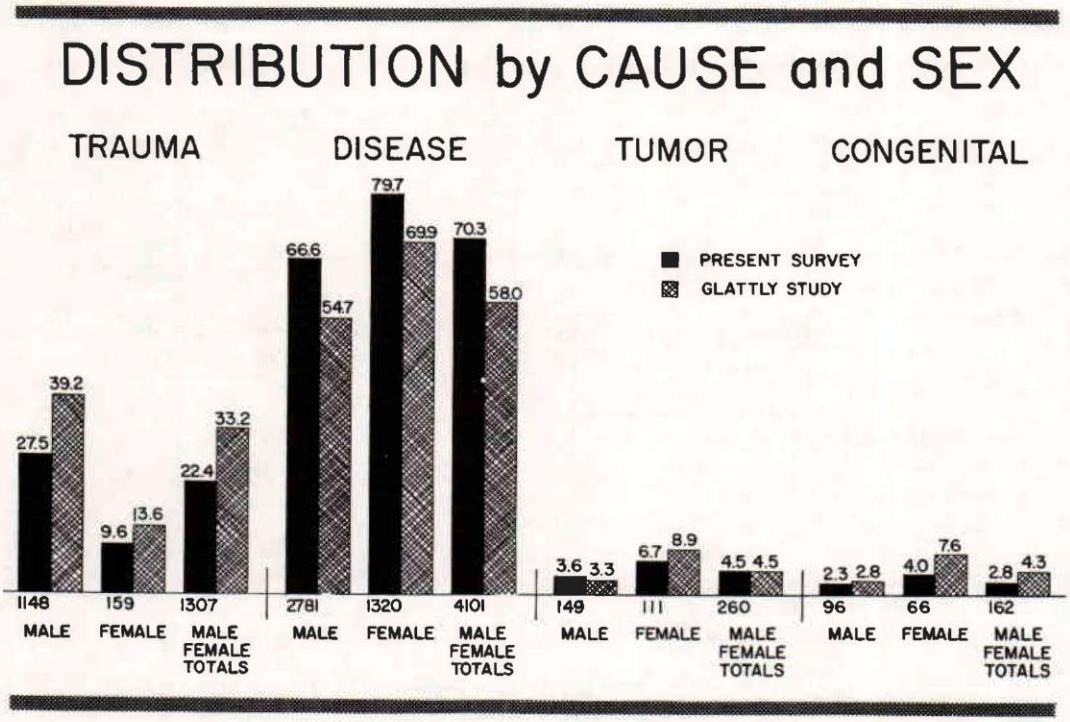
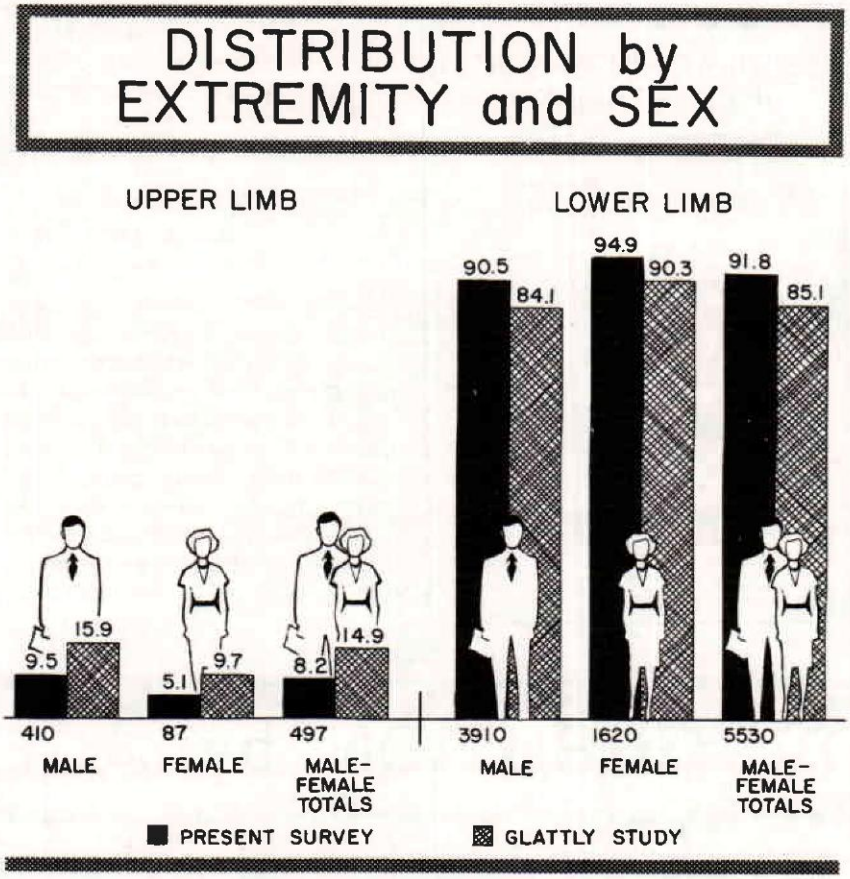


Table 4.



tial decreases in trauma-related amputations in both males and females are apparent. The reverse situation is evident in figures for disease-related amputation. In the total sample the percentage increased from Glattly's 58 percent to 70.3 percent in the present study, percentage increases occurring in both male and female populations. Other cause-of-amputation categories did not appear to show significant changes.

In the 1961-63 study the proportion of lower- to upper-limb amputations in the total sample was roughly 6 to 1 (Table 4). In the present survey the ratio had increased to approximately 11 to 1. This ratio increase was apparent for both males and females. It could be caused by an increase in the number of older patients fitted with lower-limb prostheses rather than a decrease in the incidence of upper-limb amputations.

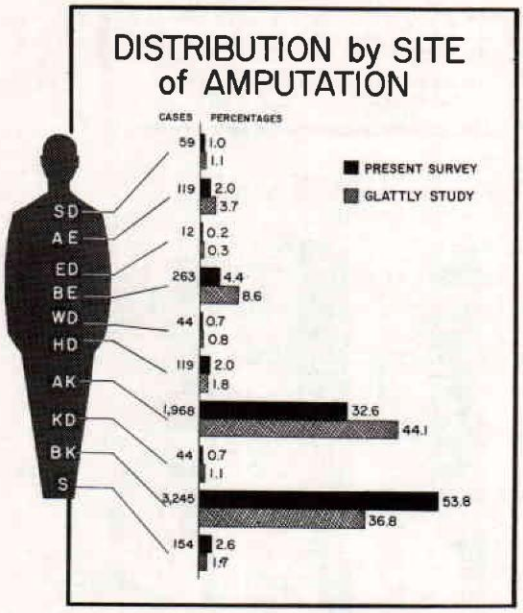
SIDE AND SITE OF AMPUTATION

• *Side*. Glattly found no significant difference in the incidence of left- and right-sided amputations in either the upper or lower limbs. These proportions remained essentially unchanged in the present data (Table 5).

Table 5.
Distribution By Side Of Amputation

	Percent Present Study	*Percent Glattly Study*
Upper Limb		
Left	51.3	49.2
Right	48.7	50.8
Lower Limb		
Left	50.1	49.2
Right	49.9	50.8

Table 6.



• *Site*. The data presented in Table 6 show significant changes in the percentages of above- and below-knee amputations. The present survey shows a decrease to 32.6 percent from Glattly's 44.1 percent in above-knee amputations, and a proportionate increase in below-knee amputations from 36.8 percent to 53.8 percent.

AGE AND CAUSE

Glattly was surprised by the large number of amputees over 70 years of age who were being fitted with prostheses. They numbered 1,749, or 15.4 percent of all reported cases. In the present report the amputees in this category numbered 1,271, or 22 percent of the total number of cases, a significantly higher proportion (Table 7). Moreover, the later data show four more amputees over the age of 91 in a one-year period than there were in the Glattly two-year study (12 versus 8). Both studies revealed that the largest

Table 7.

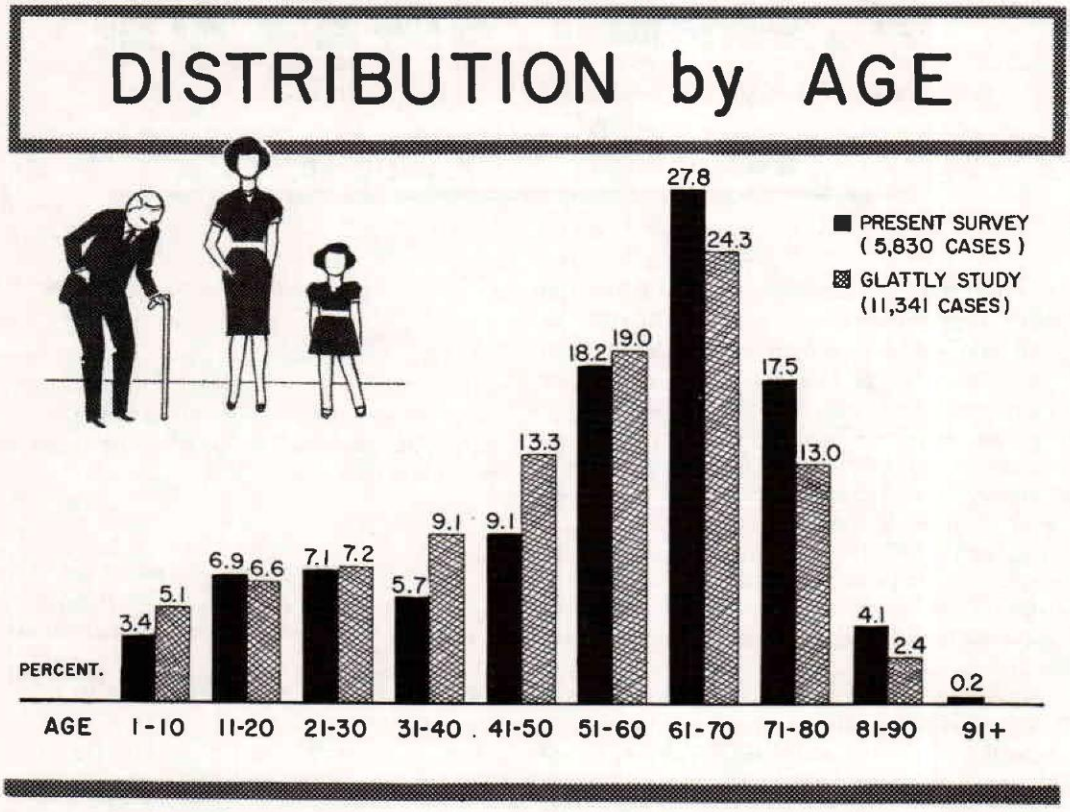
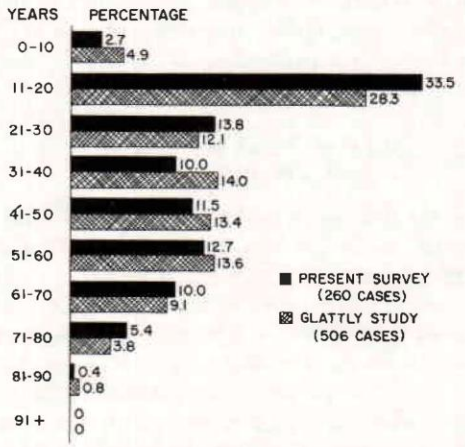


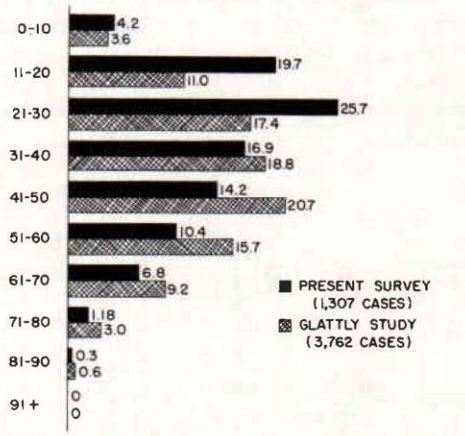
Table 8.

RELATIVE INCIDENCE by AGE

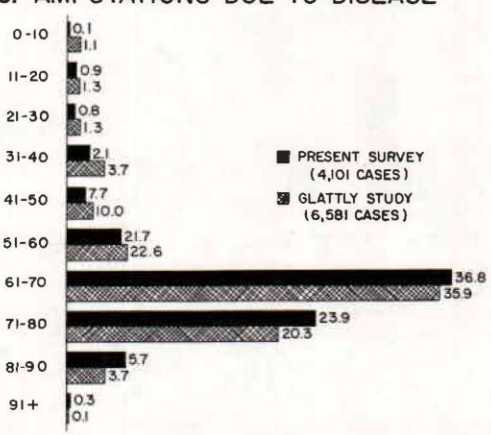
A. AMPUTATIONS DUE TO TUMOR



B. AMPUTATIONS DUE TO TRAUMA



C. AMPUTATIONS DUE TO DISEASE



number of "new" amputees fitted with prostheses were in the 61-70 age group.

• *Tumor.* A relatively high incidence of amputation for malignancy in the second decade of life was noted by Glattly. This common finding was confirmed by the present data (Table 8A).

• *Trauma.* In the Glattly report the largest number of amputations due to trauma occurred in the 41-50 age group. In the current survey the largest number of trauma-related amputations occurred in the 21-30 age group (Table 8B). One might speculate that injuries occurring during the Vietnam war could be largely responsible for trauma-related amputations in the younger age group. However, it seems unlikely that a significant number of such patients could be receiving their first limbs in 1973-74.

• *Disease.* In both studies the largest number of amputations for disease occurred in the 61-70 age group (Table 8C). Ninety-three percent of all amputations in this age group were performed for disease. The figure rises with advancing age — 96.5 percent of amputations for persons over age 71 were for disease.

MULTIPLE AMPUTATIONS

Amputations involving more than one limb that are done at the same time for the same cause are infrequent (Table 9). They represent only 3.3 percent of all amputations in the current study. In Glattly's survey they represented 2.6 percent of all reported cases.

Table 9. Multiple Amputations Occurring At Same Time From Same Cause

	Cases Present Study	Cases Glattly Study
Upper Limb — Same Level	8	32
Upper Limb — Two Levels	2	19
Lower Limb — Same Level	131	96
Lower Limb — Two Levels	38	55
One Upper and One Lower Limb	19	106

POLICY CONSIDERATIONS

The Glattly data provided two items which might influence the policies of State Bureaus of Vocational Rehabilitation:

- *Amputees over 65 years of age who are fitted.* Glattly noted that in six states amputees in this age group exceeded 30 percent of all amputees reported as being fitted in these states. The current study reveals that the 30 percent figure for this group was exceeded in 29 states. In four states the number exceeds 50 percent (Table 10). These data suggest that funds to provide prostheses for the elderly have become more readily available. One could speculate that more are below-knee cases with better chances of success.
- *The percentage of new amputees fitted who are females.* During the period of the Glattly study housewives were not accepted as beneficiaries by certain State Bureaus of Vocational Rehabilitation. In one state females represented only 8 percent of the fitted amputees, but in another they accounted for 36 percent of all new cases. The current study shows that in only two states did females represent fewer than 20 percent of all new amputees fitted (Table 11). Moreover, in 14 states females represented 29 percent or more of the total amputee population, as opposed to only 3 states in this category in the Glattly report. Again, the implication is that funds for fitting female amputees are now available in more states than they were 12 years ago.

BELOW- VS. ABOVE-KNEE AMPUTATIONS

In his discussion of below- and above-knee amputations in patients over 40 years of age, Glattly reported that the vast majority of these individuals had peripheral vascular disease, with or without diabetes. He found "no significant difference in the age distribution of below- and above-knee amputees." No breakdown of his figures showing this distribution is available. Table 12 indicates that in the present CPRD-CPOE-AOPA survey below-knee amputations outnumbered above-knee amputations by a ratio of nearly 2 to 1 for the over-40 age category. However, in the above- and below-knee subsamples, the percentages for each decade were remarkably similar. For instance, of all those pa-

Table 10.

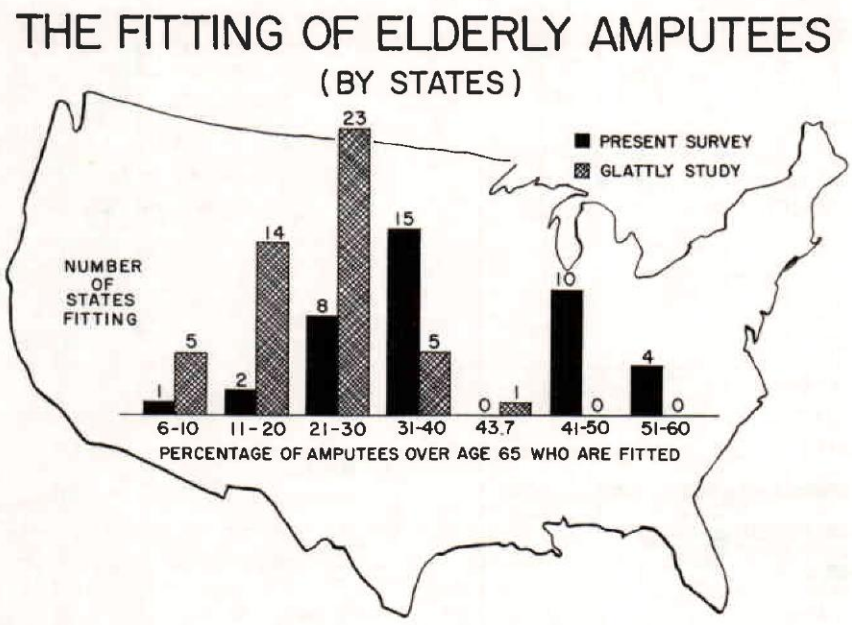
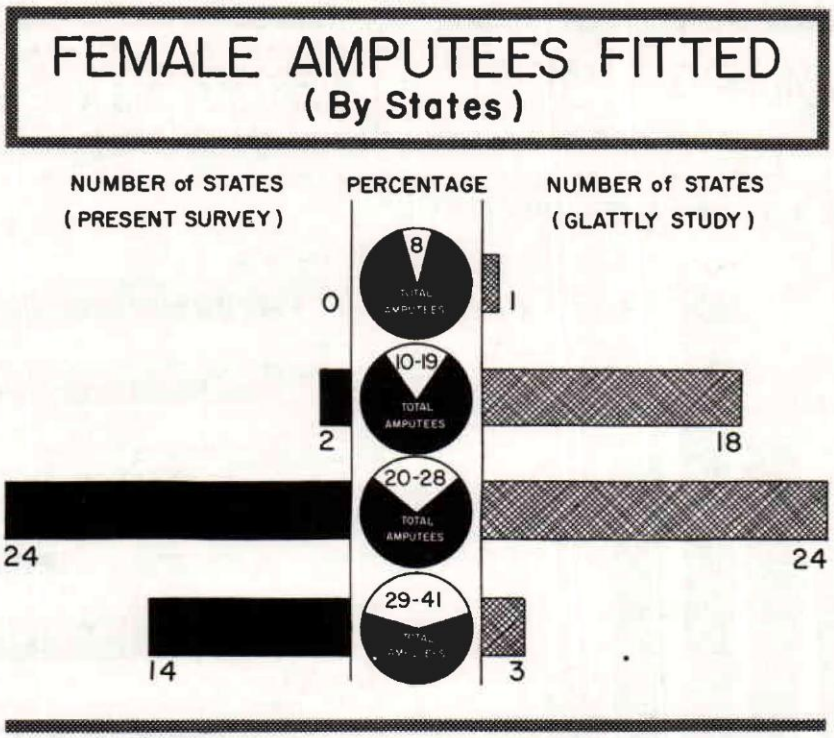


Table 11.



tients receiving above-knee amputations, 9.9 percent fell in the 41-50 year age group; while of all those receiving below-knee amputations, 10.3 percent were in the same age group. This finding suggests that age is not a factor in the decision as to whether the amputation should be above or below the knee.

Glattly cited the then-current textbook warnings against below-knee amputation in cases of gangrene due to vascular disease by reason of the likelihood of a second amputation. However, he reasoned that the relatively large percentage of such amputees who were being successfully fitted at the below-knee level threw doubt upon the validity of this principle. He urged preservation of the knee joint in older individuals, and the current study indicates that more decisions are being made in favor of below- rather than above-knee amputations.

In Table 13 percentages of above- versus below-knee amputations for disease in ten metropolitan areas are shown. Glattly pointed out that, while the patients operated upon were quite similar, 66 percent were amputated at the above-knee level in one area, while in another area only 42 percent were amputated at this level. In the present study, significant changes were found in below- and above-knee rates for the same areas previously reported. In all cities except one (Baltimore), percentages of below-knee amputations for disease increased, with a corresponding decrease in above-knee amputations. Some cities showed quite striking reversals in level selection. San Francisco, for example, showed a 36 to 64 below- to above-knee ratio in the earlier study, but present figures indicate a 74 to 26 below- to above-knee ratio. All cities except one (Philadelphia) showed a higher percentage of below- than above-knee amputations. In four cities (San Francisco, Los Angeles, New York, and Atlanta) below-knee amputations are more than double the reported above-knee amputations. In the Glattly study all but three cities (New York, Atlanta, and Baltimore) reported greater numbers of above- than below-knee amputations for disease.

Table 12.

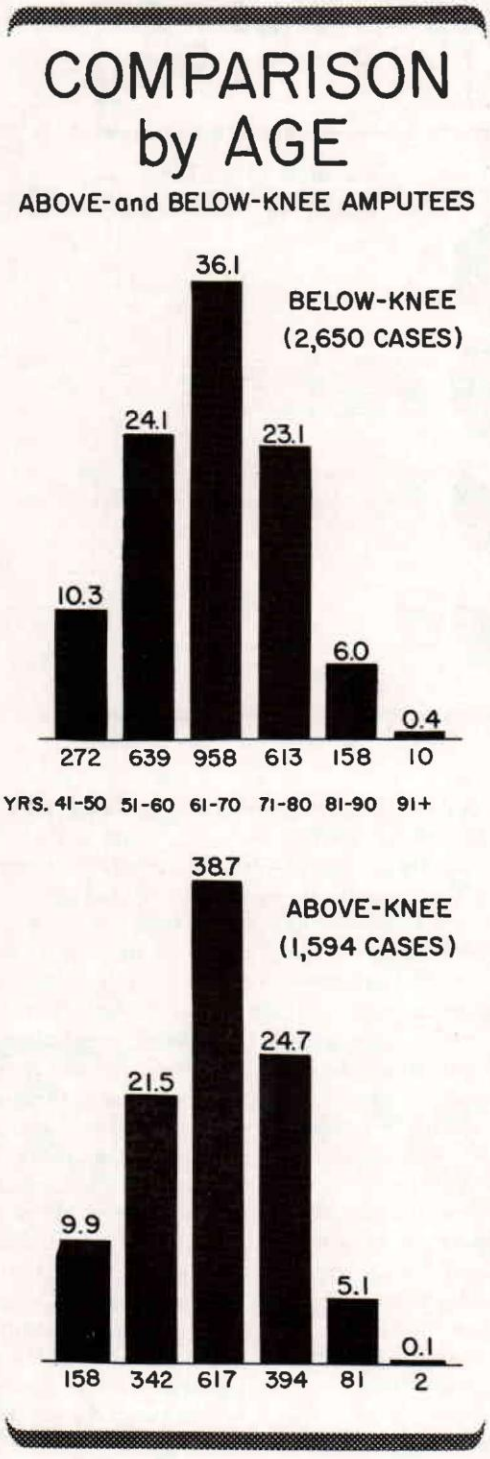
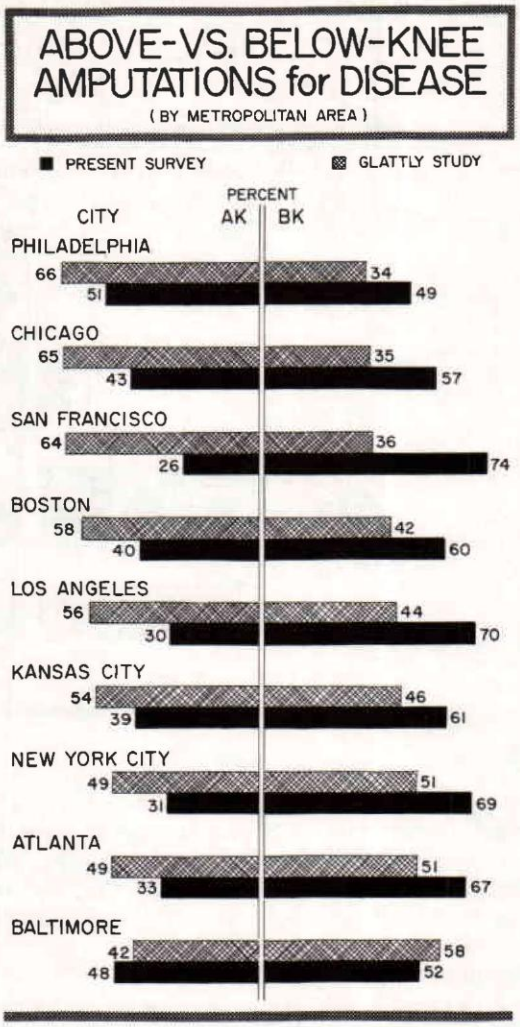


Table 13.



THE SECOND OR THIRD AMPUTATION

Multiple amputations occurring serially in time, reported on data card No. 2 (Fig. 3), made up less than 1 percent of the cases in this study; in Glattly's they represented 1.6 percent of all reported cases. As indicated in the earlier study, the figures do not accurately represent the relative numbers of persons who have had a second or third amputation. Unless such persons were fitted with a prosthesis, they were not included in either study.

For the 56 cases reported on data card No. 2 in this study, the following facts appear significant:

Forty-seven (84 percent) were male amputees.

Forty-one (73 percent) were 50 years of age or over.

Disease was the cause of reamputation in 41 (73 percent) of the cases.

In the 50-and-over age group, disease was the cause of reamputation in 93 percent of the cases.

Trauma accounted for 16 percent; tumor for only 2 percent; and congenital cases, 4 percent.

All but two amputations were of the lower limb. Fifty percent of all lower-limb amputations were at the above-knee level, 30 percent were at the below-knee level.

LITERATURE CITED

1. Glattly, H. W. A statistical study of 12,000 new amputees. *South. Med. J.* **57**:1:1373-1378, November 1964.
2. Kay, H. W., and J. D. Newman. Amputee survey, 1973-74: preliminary findings and comparisons. *Orth. and Pros.* **28**:2:27-32, June 1974.

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Orthotics and Prosthetics, Vol. 29, No. 2, pp. 17-20, June 1975

VACUUM-FORMED SOCKETS IN PROSTHETICS EDUCATION[1]

Bernard C. Simons, C.P.O.,[2]
and Alan J. Dralle, C.P.[3]

The mystery of what is occurring inside a prosthetic socket with reference to pressure on the stump has been cleared up, literally, with the advent of transparent polycarbonate, vacuum-formed sockets as described by Snelson *(3,4,5)*.

During the past several years, various methods have been used to evaluate prosthetic socket fit. However, most of these techniques do not provide definite information to the prosthetist and provide even less to students of prosthetics. The use of clay, talcum powder and dye-impregnated stump socks was and is more of a ritual than a scientific method of evaluation. Such things as asking the patient how the socket feels to him and evaluation of stump sock impressions on the skin and observations of reddened skin areas have proven to be at best subjective criteria for proper, comfortable socket fit. Indeed, edema in the distal stump area causes the same kind of discomfort to the patient as does too firm a contact in the same area. Because of a "hammock" effect, stump sock weave impressions on the skin indicate good total contact even when total contact on the distal stump area is not present.

The amount of flexion present in below-knee sockets can affect the fit because, as flexion is increased, the stump migrates proximally and, in extension, the reverse occurs. The critical phase of gait, in reference to socket fit, appears to be at mid-stance as full weight is borne on the stump. However, anterior distal stump trauma can be caused by excessive piston action as a result of insufficient socket suspension during swing phase and lack of proper gait training in the use of hamstrings as a knee extensor after heel contact (closed kinetic chain).

The cause and effect of poor socket fit on the gait of amputees has been, until the advent of transparent sockets, very difficult to ascertain and could only be accomplished by a prosthetist with years of experience. How then could he convey his expertise in a few weeks time to the student? The need for a system that would eliminate most of the intuition has been apparent for years, as evidenced by various attempts to develop a technique for fabricating transparent sockets. Even though many were successful, the cost in time and materials has proven to be exorbitant.

During a meeting at Moss Rehabilitation Hospital *(1)* and a subsequent meeting held at the facilities of Orthomedics, Inc., in Downey, California, both sponsored by the Committee on Prosthetics Research and Development, it was demonstrated that the use of vacuum-formed polycarbonate sockets (Fig. 1) was feasible and does not require excessive demands on the prosthetist's time *(2)*. In fact, the time used in fabricating and using a vacuum-formed check socket is repaid many times over because fewer problems are experienced in the definitive prosthesis. It is recommended that the check socket not be used in the definitive prosthesis, and thus the prosthetist is encouraged to make the last little modification that ensures a socket acceptable to the patient *(3)*.

In the curriculum at the University of Washington, students are required to vacuum-form polycarbonate check sockets for both lower and upper limbs in fitting their assigned patients. The technique not only allows the students to view the areas of misfit, but also allows the instructor to evaluate the students' performance in casting and modification of the model.

The regimen used for evaluation is in a state of flux, and will evolve into a definite plan as time and experience dictate. At the present time, evaluation is carried out as described below.

[1]This study was supported in part by Grant #16-P-56818 from the Social and Rehabilitation Service, DHEW.

[2]Director, Prosthetics-Orthotics Curriculum, Department of Rehabilitation Medicine, University of Washington, Seattle, Washington 98195.

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When the below-knee patient is bearing weight in a polycarbonate socket supported on a standard fitting stool (Fig. 2) and with the socket flexion angle maintained at 5 deg., it is possible to observe changes in the appearance of the stump-sock weave. In areas of increased pressure, the weave appears to be closer than in those areas of less pressure. A standard corset stay is inserted

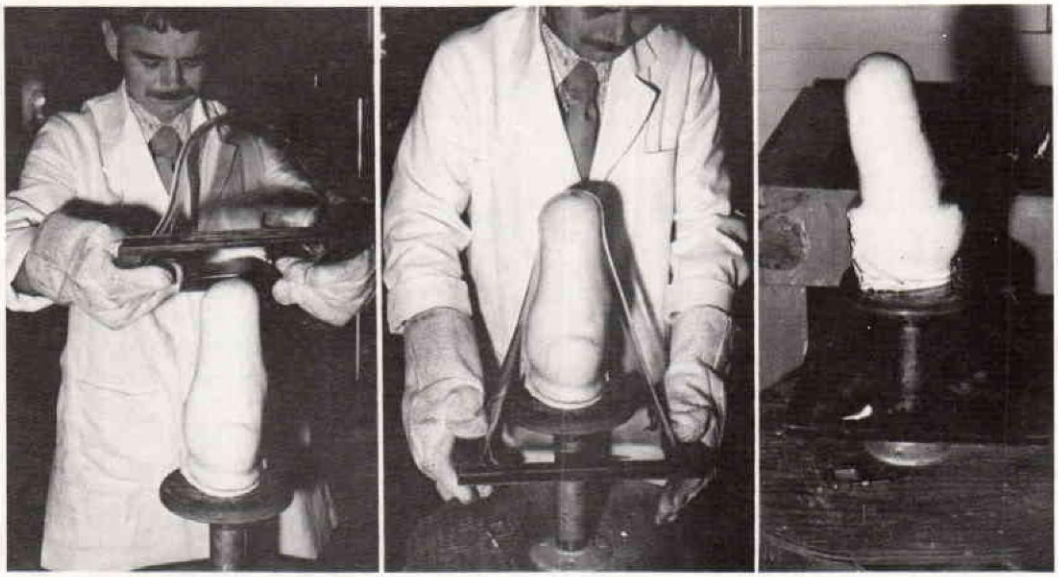

Fig. 1. Forming a transparent socket from sheet polycarbonate with use of vacuum. (*Courtesy Roy Snelson*)

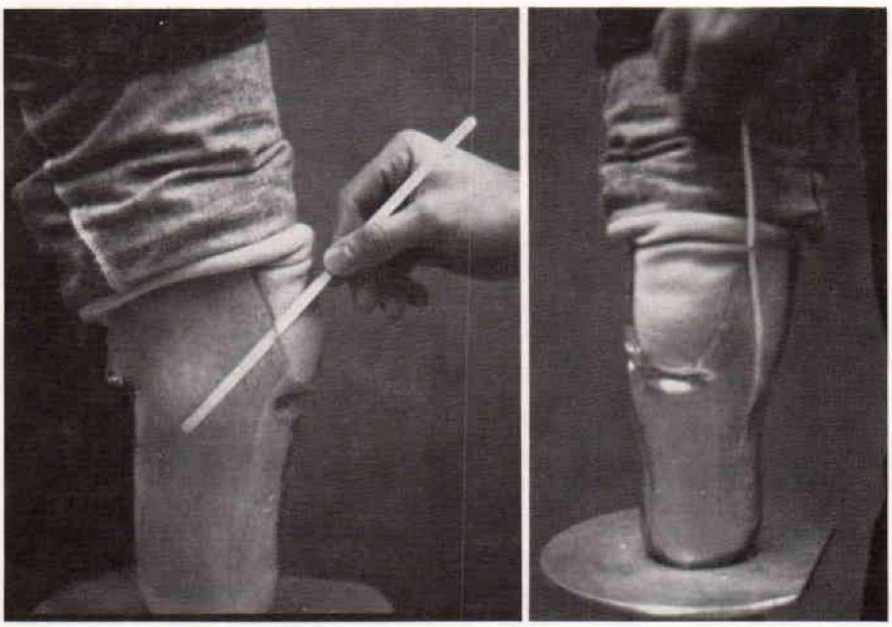

Fig. 2. Use of polycarbonate socket for checking fit. The probe is an ordinary corset stay.

into the socket, and pressure can be felt as a function of the tension on the corset stay as the operator probes in all areas of the socket (Figs. 1 and 2). Weight-bearing areas, as well as areas of relief, can be examined precisely as the exact position of the probe is visible. As potential trouble spots are identified, they are marked with a grease pencil directly on the outer wall of the socket. It is interesting to note that the introduction of clay powder or other substances into a polycarbonate socket will demonstrate the inadequacy of those old techniques although they do indicate gross misfit, especially in the case of excessive relief at the anterior distal tibia.

In the above-knee amputee, the use of a polycarbonate check socket is even more dramatic because changes in overall stump pressure on the skin can be seen (Figs. 3 and 4). Snug areas of contact show a blanched condition and loose areas, or areas not in total contact, redden very quickly, or take on a purple hue. Sometimes both changes occur. Again, marks and notes are placed directly on the outer wall of the clear socket for reference in modification of the new model. The very smooth surface of a polycarbonate socket tends to grip the skin more than a conventional socket; and therefore to assist in removal of the check socket, it should be sprayed with a silicone lubricant.

The equipment used by this University for vacuum-forming is of our own manufacture, and has been very satisfactory for our clinical and teaching needs. The oven used is a double unit obtained from Sears, Roebuck and Co., and is wall mounted. The lower unit is used for drying and storing precut polycarbonate sections and the upper unit for heating to the working temperature.

A standard Hosmer vacuum system is used in connection with a volume storage tank, a one-way check valve and a foot control. The platen stand was fabricated of a 4-ft. length of 1½-in. galvanized pipe and floor flange fittings. Platens are fabricated of ¾ in. plywood with a pipe flange attached for quick change. Squares of polycarbonate (12 in. x 12 in. x ½ in.) are used for below-knee and above-knee check sockets. However, care must be exercised in vacuum forming long above-knee models to prevent the proximal socket section from becoming too thin. By allowing

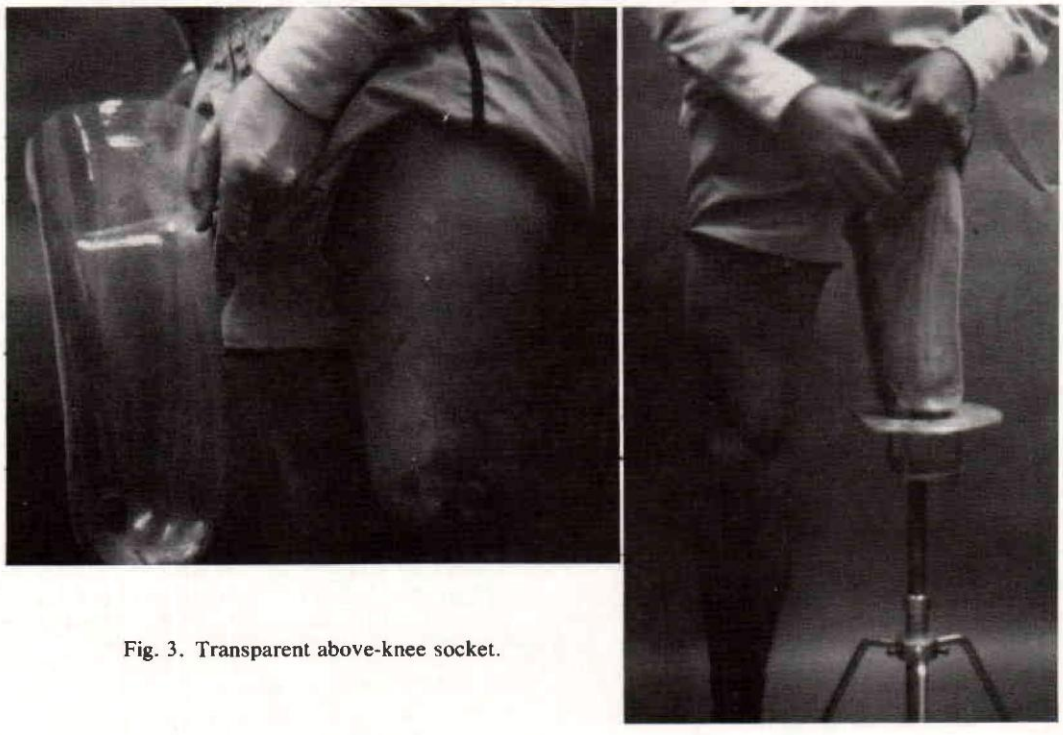

Fig. 3. Transparent above-knee socket.

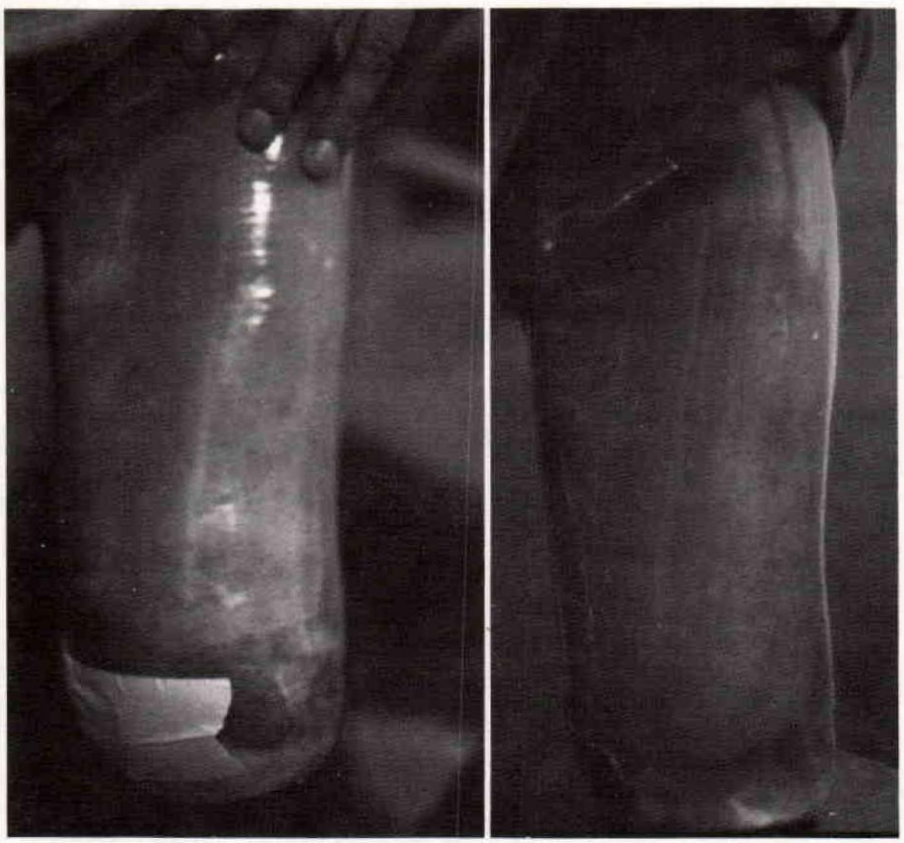

Fig. 4. Closeup views of a transparent above-knee socket.

the plastic to sag a full two-thirds of the total cast length, the proximal portion seems to be thick enough for purposes of socket fit evaluation even under full patient load. In upper-limb sockets, squares of material (6 in. x 6 in. x ½ in.) are adequate for all stump lengths encountered to date.

SUMMARY

The polycarbonate, vacuum-formed check socket is a valuable tool not only for teaching, but also in the clinical management of the amputees, both acquired and congenital. As experience is gained, it will be possible to establish more definite criteria for interpretation of observed conditions.

LITERATURE CITED

1. Committee on Prosthetics Research and Development, *Workshop on Vacuum-Forming Equipment*. Report of a meeting, National Academy of Sciences, Washington, D.C., June 1973.
2. Hamontree, Samuel, and Roy Snelson, The use of check sockets in lower-limb prosthetics. *Orth. and Pros.* 27:4:30-33, December 1973.
3. Mooney, Vert, and Roy Snelson, Fabrication and application of transparent polycarbonate sockets. *Orth. and Pros.* 26:1:1-13, March 1972.
4. Snelson, Roy, Fabrication of vacuum-formed sockets for limb prostheses. *Orth. and Pros.* 21:3:3-13, September 1973.
5. Wilson, A. Bennett, Jr., Vacuum forming of plastics in prosthetics and orthotics. *Orth. and Pros.* 28:1:12-20, March 1974.

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AN EVALUATION OF THREE CASTING TECHNIQUES FOR PATELLAR-TENDON-BEARING PROSTHESES[1]

Michael J. Quigley, C.P.O.[2]
and A. Bennett Wilson, Jr.[3]

Until relatively recently, most sockets for below-knee prostheses were carved from wood (*12,17*), a process that required considerable skill. "Thigh corset" and "side bars" to take most of the weight-bearing load off of the stump were used almost universally.

Plaster-of-Paris impressions to define the stump and, thus, socket configurations were used from time to time (*11*), but it was not until 1959 with the introduction of the so-called patellar-tendon-bearing prosthesis by Radcliffe and Foort (*7,13,18*) that "casting" or impression of the limb remnant became routine in below-knee prosthetics. This procedure calls for wrapping the limb remnant with plaster-of-Paris bandages, using the npression to cast a positive model of the limb emnant (Fig. 1). In order to arrive at a socket that will provide tolerable weight-bearing loads, certain modifications have to be made to the positive model before it can be used to form a plastic socket over it.

Modification of the positive model, in light of our present knowledge, requires a good deal of skill, and many approaches have been made in order to reduce the skill required.

One approach has been to add build-ups of felt or other material to the limb remnant itself so that a positive model from the female mold or wrap will not have to be altered to provide an adequate socket. Fillauer first suggested this (*11*), and Traub and Zettl, who called it the "pre-modified method," found the technique to be useful in fitting patients immediately after surgery (*19*) (Figs. 2 and 3).

In 1971, Fillauer (*6*) described a technique that utilizes plaster splints to form a pretibial shell that defines the anterior structures of the below-knee leg remnant, followed by a circumferential wrap to enclose the soft posterior tissues (Figs. 4, 5, and 6). He claims an improved definition of the bony structures with this technique. In 1972, Gleave (*8*) also described a technique utilizing splints placed anteriorly over an elastic prosthetics sock, followed by a circumferential wrap.

The original UC-BL technique, the two-part procedure described by Fillauer (hereafter referred to as the two-part technique), and variations of the pre-modification technique are used widely today.

Educational programs largely teach the method that the chief instructors prefer, their choice being based on their own personal experiences and feedback from other clinicians. At the Workshop on Below-Knee and Above-Knee Prostheses sponsored by the Committee on Prosthetics Research and Development in January 1973 (*4*), New York University requested that CPRD conduct an evaluation of the three commonly used casting techniques. Other members of the University Council on Orthotics-Prosthetics Education (UCOPE) concurred.

Although many studies have been conducted to evaluate socket fit by using pressure transducers (*1,5,15*), radiographic techniques (*16*), and dye-impregnated prosthetics socks (*2,3*), none has attempted to relate the casting technique to the socket fit.

The staff of the Amputee and Problem Fracture Service of Rancho Los Amigos Hospital, Downey, California, were asked to assist in the evaluation, since that group had the capability for measuring pressure and temperature, and had

[1]This report was prepared by Michael J. Quigley and A. Bennett Wilson, Jr., on behalf of the Subcommittee on Evaluation, Committee on Prosthetics Research and Development, National Academy of Sciences. The work was carried out under the provisions of Contract SRS 72-7 between the Social and Rehabilitation Service, Department of Health, Education, and Welfare and the National Academy of Sciences.

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[3]Executive Director, Committee on Prosthetics Research and Development, National Academy of Sciences, Washington, D.C. 20418.

pioneered the use of transparent check sockets (*10,14*). Besides, Rancho Los Amigos Hospital receives support from the Social and Rehabilitation Service of the Department of Health, Education, and Welfare to conduct clinical evaluations of prosthetics and orthotics techniques. The staff at Rancho who conducted the evaluation consisted of Vert Mooney, M.D., Roy Snelson, C.P.O., Richard Voner, C.P.O., John Rogers, M.S., and Donald Colwell, C.P.

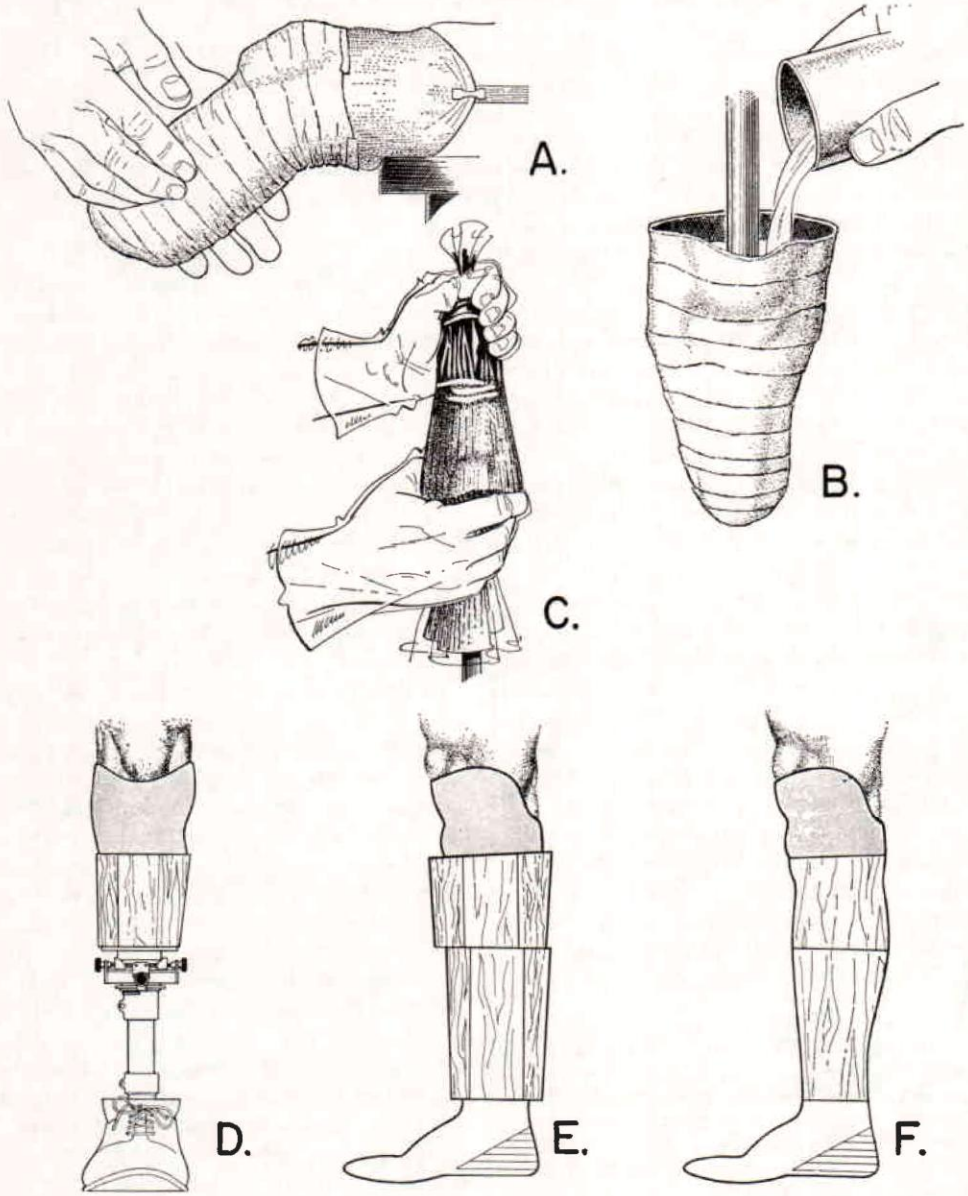

Fig. 1. Some of the major steps involved in the fabrication and fitting of the standard patellar-tendon-bearing prosthesis: *A*. Wrapping the limb remnant with plaster-of-Paris bandage to obtain a female, or negative cast. *B*. Pouring plaster-of-Paris solution into female cast to produce a male model. *C*. Making a plastic-laminate socket of the male model. Not shown are modifications that need to be made to the male model to insure a socket shaped to provide tolerable distribution of loads between the socket and the limb remnant. *D*. Socket mounted on adjustable leg for trial fitting and alignment. *E*. Replacement of adjustable unit with wooden shank piece. *F*. Leg shaped ready for finishing.

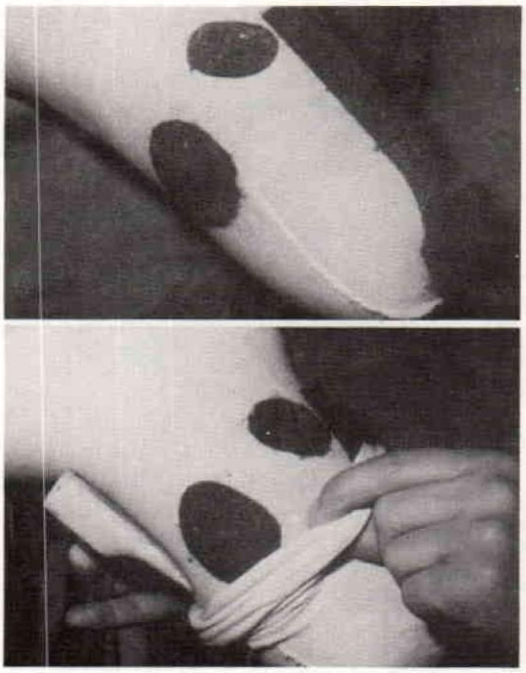

Fig. 2. *Top*—Application of felt pads over first cast sock in the premodified casting technique. *Bottom*—Application of hamstring relief pad and second cast sock.

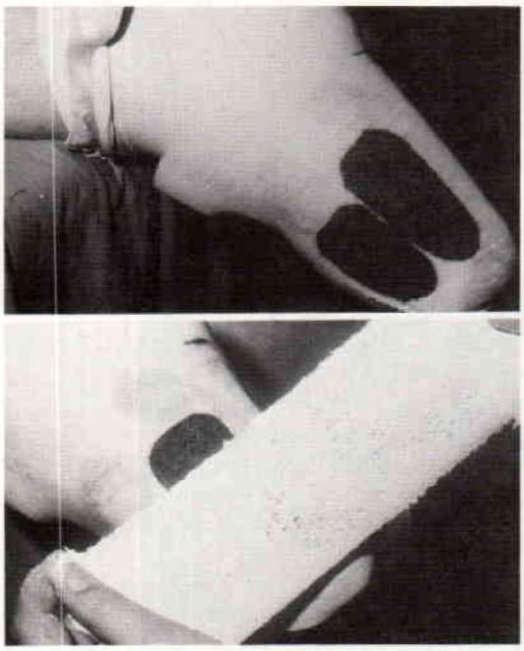

Fig. 3. *Top*—Application of felt pads over second cast sock in the premodification casting technique. *Bottom*—Application of plaster-of-Paris bandage.

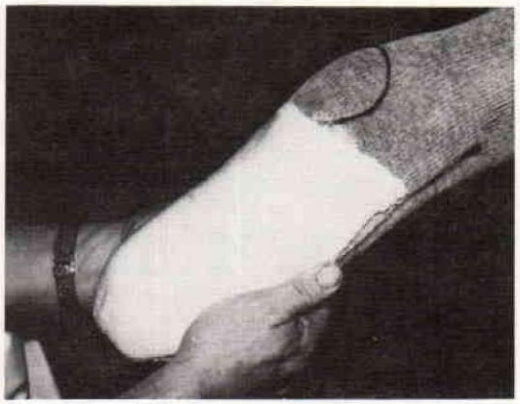

Fig. 4. Formation of the pretibial shell in the Fillauer two-step procedure.

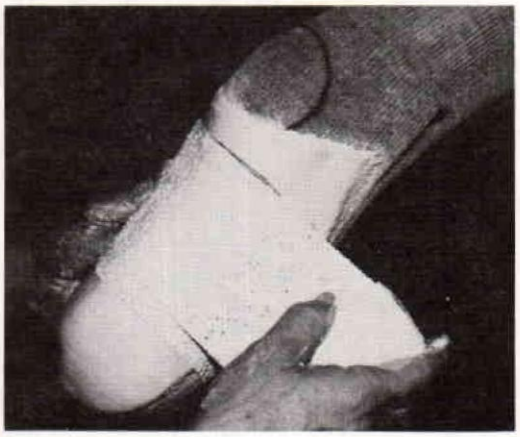

Fig. 5. Application of the circumferential wrap below the level of the patella in the Fillauer two-step procedure.

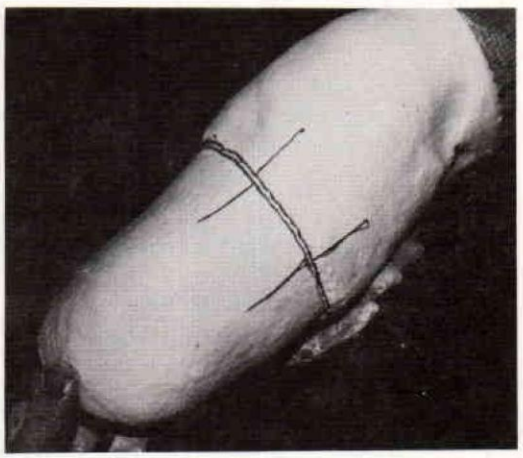

Fig. 6. Application of the supracondylar shell in the Fillauer two-step procedure.

METHOD

A method for evaluating the two-part technique, the pre-modified technique, and the standard technique was devised by Maurice LeBlanc, C.P., then Staff Engineer, CPRD. The method was modified and then approved by CPRD's Subcommittee on Evaluation. Each of six patients was provided with three prostheses each containing a socket formed by one of the three methods (Fig. 7). Thus, a total of 18 prostheses was involved. Casts and modifications of the male model were to be made by Carlton Fillauer, C.P.O., Leigh Wilson, C.P., formerly of the UCB staff, and Joseph Zettl, C.P.

The following assessment techniques were to be used:

1. Comparison of length, width and circumference of unmodified and modified models.
2. Comparison of medial tibial flare contour of modified model to template made on patient's limb.
3. Comparison of volume of model before and after modification.
4. Observations made when a transparent socket was used.
5. Patient comments concerning relative comfort and fit.
6. Observations normally used by a prosthetist.
7. Temperature differentials on a patient's limb after wearing socket and walking a specified distance.
8. Two-week trial wear period of each prosthesis by the patients.

All patients were to use the same type of artificial foot (SACH) and the same type of suspension (cuff). Shoes for each patient were transferred from prosthesis to prosthesis, and hard sockets were used.

The time required for casting and modification, the "teachability" of each technique, and the practicality of each technique were to be assessed by the staff of Rancho Los Amigos Hospital.

On August 15 and 16, 1973, Leigh Wilson, C.P., who was associated with the development of the UC-BL casting technique, took the casts of six patients at Rancho, and modified the positive molds. Joseph Zettl, C.P., the co-developer of a pre-modification technique, and Carlton Fillauer, C.P.O., developer of the two-part technique, also came to Rancho on consecutive two-day visits to take casts of the same patients and to modify the positive models. Transparent check sockets (*10, 14*) of Lexan were formed over the modified positive models (Fig. 8).

Some characteristics of the subjects are given in Table 1.

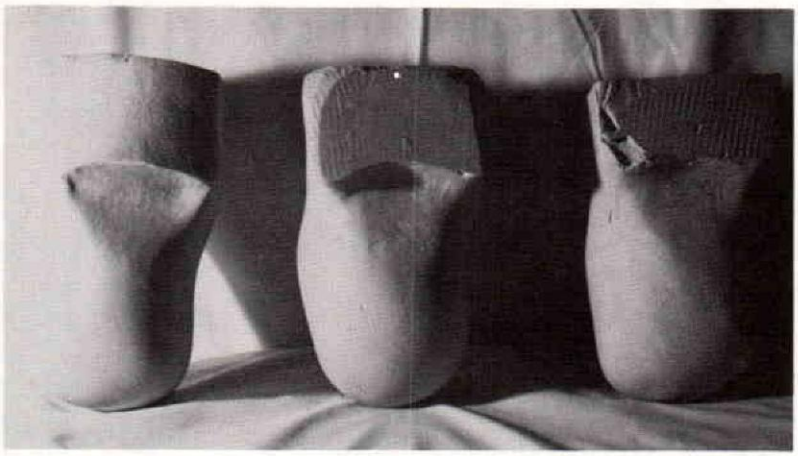

Fig. 7. Posterior views of three molds of the same patient modified using three different modification techniques.

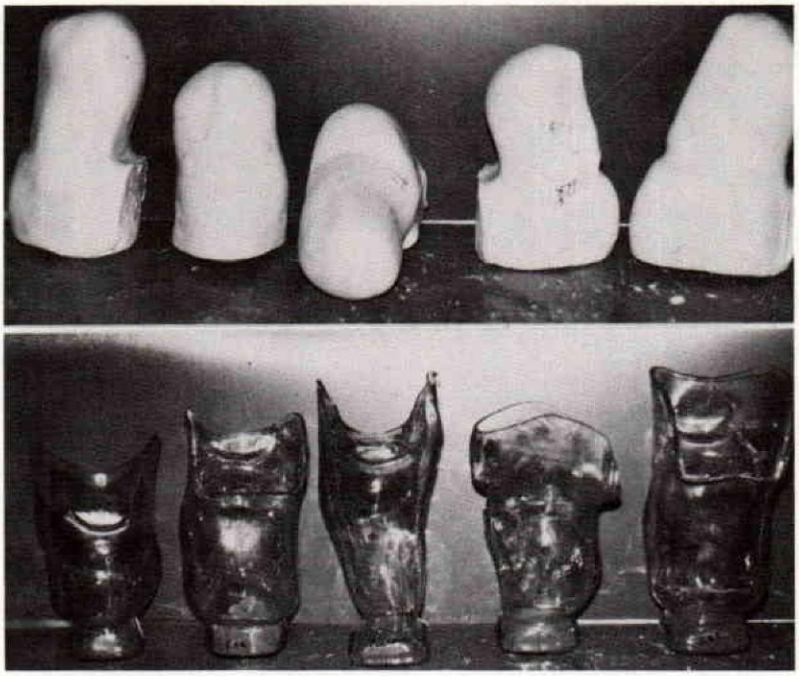

Fig. 8. *Top*—Modified positive molds for five patients. *Bottom*—Polycarbonate check sockets with distal extensions for attachment to the pylon.

Table 1. Characteristics Of Subjects Used In The Study

Subject	Age	Date of Amputation	Reason for Amputation
N.B.	55	8/71	Diabetic/gangrene
D.B.	32	6/71	Osteo./trauma
N.J.	66	1971	Diabetic/gangrene
W.M.	72	1971	Circulation prob./ gangrene
L.M.	67	1968	Diabetic/osteo.
A.P.	65	1967	Diabetic/gangrene

Volume measurements of each socket were made and the sockets were attached to an endoskeletal shank[4] and SACH foot, and statically aligned. Socket modifications and fitting problems were recorded by the prosthetist during the fitting procedure. Holes were drilled in the transparent check sockets when necessary in order to palpate the limb in areas where either excessive or inadequate pressure was suspected. This information was recorded and used later to modify the positive mold after the check socket was filled (Figs. 9, 10, 11, and 12).

Patients were then scheduled for four visits each to have skin stress measurements made, using the temperature differential technique. Following the completion of these visits the patients were provided with polyester laminate sockets and requested to use them for two-week trial wear periods.

During the twelve-month course of the evaluation, each patient made approximately eleven visits to the Amputee and Problem Fracture Service. Three of these visits were for casting and initial evaluation, one for initial fitting (Fig. 9), four for temperature differential measurements, and three during the trial wear periods.

[4]Otto Bock Modular System.

Fig. 9. Patient ambulating during dynamic alignment.

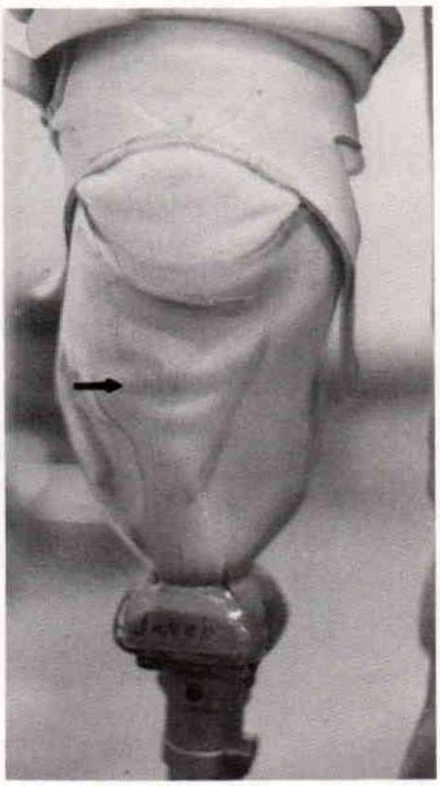

Fig. 10. Excessive relief over the proximal tibia is seen as looseness and wrinkling of the prosthetics sock.

RESULTS

VOLUME MEASUREMENTS

The volume of each check socket was measured by filling the sockets with water to the mid-patellar-tendon level and then pouring the water into a measuring beaker. The volumes were then compared to the volumes recorded for the unmodified model. As can be seen from Table 2, the volumes of the models taken by standard and pre-modification techniques decreased an average of 3.2 and 3.3 percent respectively, while the volume of the models made using the two-part technique decreased by an average of 6.1 percent. In addition, the models made using the two-part technique were an average of 40-50 milliliters (ml) less than the other techniques. The change in volume of the model taken with the premodification technique could be expected to be small, since most modifications are made in the initial casting procedure. In fact, the volume decrease indicates that additional modifications had been made after casting.

Comparing the original unmodified models, the models taken with the two-part technique were an average of 9.1 percent smaller than those taken with the standard technique, and 5.5 percent smaller than those taken with the pre-modification technique. After modification the volume of the model modified by the two-part technique was 11 percent smaller than the standard technique and 8.5 percent smaller than the pre-modification technique.

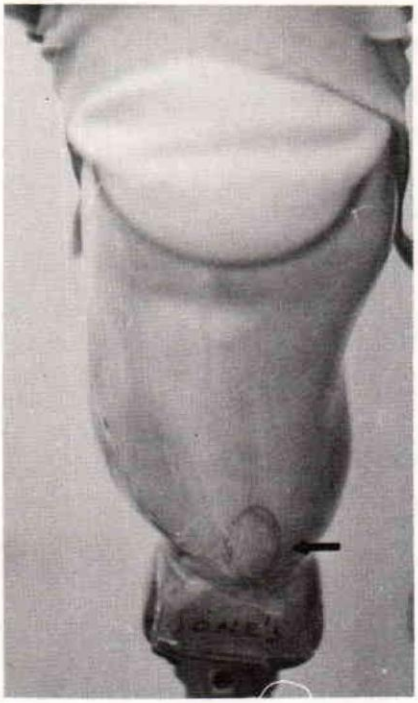

Fig. 11. Discomfort at the medial tibial flare is caused by an uneven socket contour. The weave of the prosthetics sock can be "read" like a contour map to identify potential problem areas.

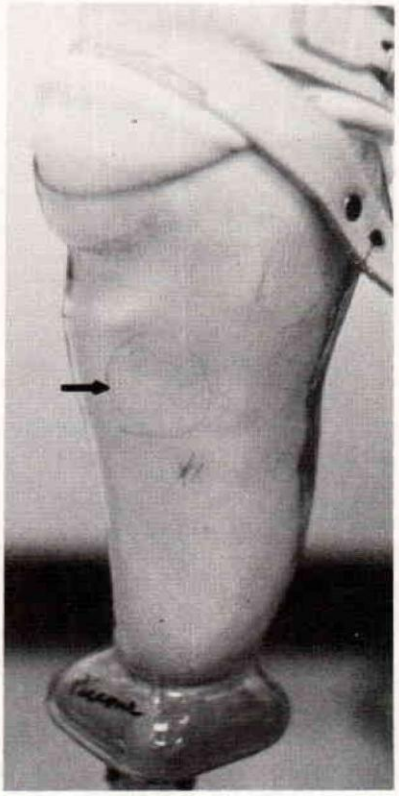

Fig. 12. Pressure over the distal tibia is seen as a localized area of compression of the prosthetics sock.

Table 2. Volumes Of Sockets From Three Casting Techniques Before And After Cast Modification
In Milliliters*

	UNMODIFIED MOLD			MODIFIED MOLD			DECREASE IN VOLUME (ACTUAL)			DECREASE IN VOLUME (%)		
Patient	Standard	Pre-Mod.	2-Part	Standard	Pre-Mod.	2-Part	Standard	Pre-Mod.	2-Part	Standard	Pre-Mod.	2-Part
N.B.	1180	1160	1070	1120	1120	970	60	40	100	5.1%	3.5%	9.2%
D.B.	1050	950	880	1020	880	850	30	70	30	2.8%	7.4%	3.5%
N.J.	760	770	730	740	760	680	20	10	50	2.6%	1.3%	6.9%
W.M.	770	710	710	720	710	680	50	0	30	6.5%	.0%	4.2%
L.M.	670	660	630	660	650	600	10	10	30	1.5%	1.5%	4.8%
A.P.	790	780	720	790	740	675	0	40	45	0%	5.1%	6.2%

*One milliliter = .001 liter
One liter = 1.057 quarts liquid

LENGTH, WIDTH, AND CIRCUMFERENCE MEASUREMENTS

No correlation could be found betwen A-P, M-L and length measurements and the volume differences, even though relatively large differences were found. The difference in A-P measurements taken by two prosthetists on one patient was ½ in., M-L differences of ⅜ in. occurred twice, and length measurements varied up to 9/16 in. The only consistency in measurement techniques was that the A-P and length measurements taken for the pre-modification techniques were generally the largest, and the M-L measurements for the two-part technique were always the largest.

USE OF PROSTHETICS SOCKS

The use of prosthetics socks is related to the volume measurements in general, but not directly. The assumption is made that the greater the number of plies needed, the larger the socket is in relation to the patient's limb. Prosthetics socks are often used to fill or pad sockets when the patient's limb shrinks or cushioning is needed for a specific area. Patients fitted with sockets made using the pre-modification technique used an average of 8.5-ply socks. Four of these patients used 10-ply socks, one used a 6-ply, and one used a 5-ply sock. However, sockets made from the standard technique had the highest volumes in all but one case.

The average ply of prosthetics socks used by patients in the standard technique category was 5.2, although the average volume of the sockets made by this technique was 34 ml greater than those made following the pre-modification technique. In four out of the six patients, however, the A-P was greater on the pre-modification socket than on the standard.

Patients fitted with sockets made with the two-part technique used an average of 2.8-ply prosthetics socks. The average volume of the sockets was 99 ml less than the standard technique and 67 ml less than the pre-modification technique, so a relationship between volume and the number of ply used could be made in this case.

No consistent direct relationship between volume of sockets and prosthetics sock use can be made from this study. In one case, the same patient with a 675 ml volume socket used a 3-ply sock, with a 740 ml volume socket used 10-ply, and with a 790 ml volume socket used a 5-ply sock.

MEASUREMENT OF TEMPERATURE DIFFERENTIALS

The Tissue Trauma Group at Rancho Los Amigos Hospital has been measuring temperature rises in skin subjected to either constant or intermittent pressure. The group has begun its work as a result of the findings of Paul Brand (*3*). Dr. Brand states that "perhaps the best index of commencing tissue damage is commencing hyperemia."

John Rogers, Director of the Tissue Trauma Group, measured the difference in temperature between points on the patient's residual limb and the temperature at the elbow crease after the patient walked a specified distance. This temperature difference was taken for the patient's original prosthesis and for the prostheses used in the evaluation. A comparison was then made of the differences.

Differential temperatures were measured at each patient's patellar tendon, popliteal fossa, distal tibia, fibular head, medial flare, medial femoral condyle, anterior tibia and gastrocnemius. Patients were requested to walk a specified distance (600 yd), but distances varied according to physical tolerance and the fit of the prosthesis. Patients were not forced to walk the full distance on uncomfortable prostheses in order to avoid any tissue breakdown that may result. Distances walked ranged from 150 to 600 yd. Trauma was not sufficient to cause tissue breakdown in any patient.

The following observations are made from the temperature differential measurements:

1. The average frequency of temperature "rebound" was approximately one cycle every 45 minutes. Temperature "rebound" is the tendency for the temperature of traumatized skin to return towards normal periodically and then rise again towards the original level.

2. Differential temperatures taken 90 minutes after trauma was discontinued were consistently different than when the patients were using their regular prostheses. This is demonstrated in Figure 13, where it can be seen that temperatures of

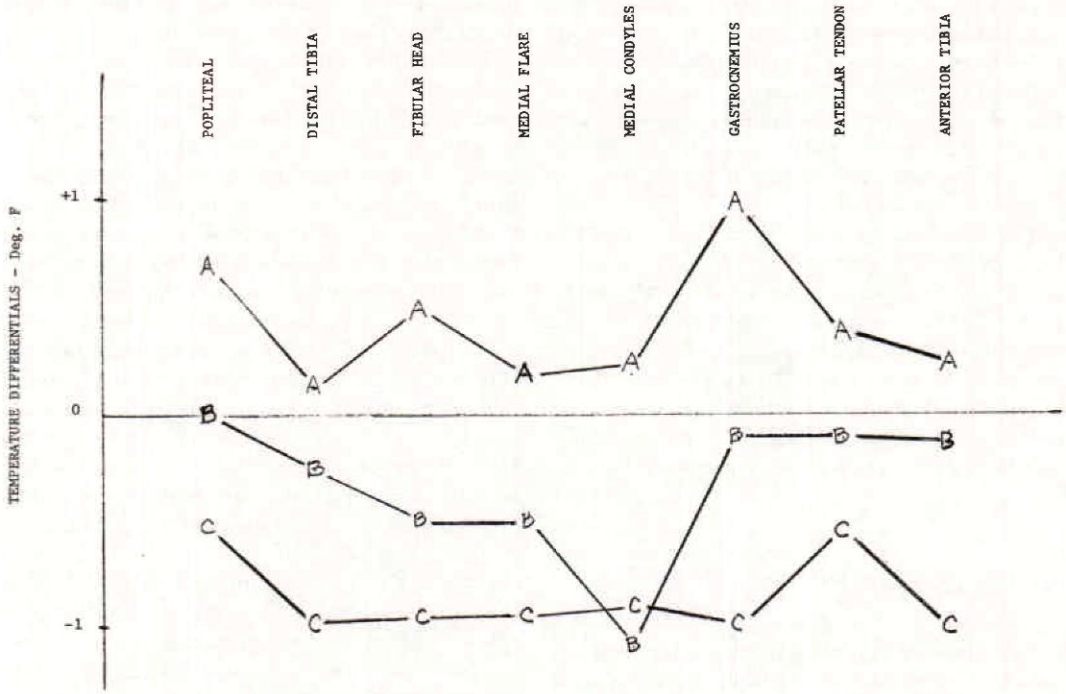

Fig. 13. Differences in temperature on various points of the stump between the use of experimental prostheses and their own. All temperatures were taken after 90 minutes of walking. The zero or base line represents the temperature after use of the regular prosthesis. *A*—Premodification Technique; *B*—Two-Part Technique; *C*—Standard University of California-Berkeley Technique.

patients using pre-modification technique sockets were warmer than after wearing their own prosthesis, and patients using the standard and two-part technique sockets were cooler. Average temperatures of patients using the pre-modification technique would have been higher, had not one patient been consistently much cooler than the others. The medial femoral condyle measurement on patients using the two-part technique sockets was noticeably cooler than their normal prosthesis. Measurements of the sockets indicated that the M-L dimension was widest on all sockets made with the two-part technique.

OBSERVATIONS BY PROSTHETISTS

Patients were fitted with hard sockets made of Lexan (polycarbonate), cuff suspension, Bock endoskeletal pylons, and SACH feet. The use of transparent check sockets aided the evaluation of socket fits.

In general, sockets made by the two-part technique were too tight initially; one patient was not able to get in the socket at all until the socket was relieved. After weight-bearing for about five minutes, the other patients did settle into the sockets. By the end of the alignment procedure, four of the patients were able to comfortably wear a 3-ply wool sock or a Daw sheath with 2-ply cotton socks. Thé most common socket reliefs needed for pressure were over the distal tibia (four patients). This pressure can be seen through the transparent check socket as an area of increased compression of the sock. Increasing the radius at the medial and lateral posterior walls was the second most common relief needed (three patients). Areas of excessive buildup were not noticed on any of the sockets.

The pre-modification technique sockets had the best fit initially for two patients and the worst fit for one patient. Patients generally used a 5-ply

sock at the initial fitting. Additional socket relief was needed for only one patient, but excessive reliefs were noted over the tibial tubercle area on many of the patients. Excessive reliefs are seen through the clear check socket as a looseness or wrinkling of the prosthetics sock (Fig. 10). Patients usually progressed to 8-10 ply by the time alignment was complete.

The standard technique sockets provided the best fits initially. Patients used a 3-ply sock and worked up to a 5-ply by the end of the alignment period. Three patients needed relief over the femoral condyles, and in each case the M-L measurements over the femoral condyles was ⅛ to ¼ in. smaller than the other two sockets. On the remaining three sockets the M-L measurement was the same as the pre-modification technique.

PATIENTS' REACTIONS

Patients were requested to use each prosthesis for a two-week trial wear period. Between each trial wear period the patient wore his own prosthesis for at least one week.

The transparent check sockets were replaced by polyester-laminate sockets since prior work at Rancho Los Amigos Hospital demonstrated that the polycarbonate sockets can crack under certain conditions.

Results from the trial wear period merely indicate that the patients were able to tolerate the prostheses for two weeks. In no case was there a tissue breakdown. Two patients could not wear the prosthesis all day and reverted to their original prosthesis. The comment most often heard was: "This prosthesis is good, but I still like my old one better."

DISCUSSION

The evaluation attempted to define specific advantages or disadvantages of each casting technique by relating the technique to the patients' outcome. No relationship could be found. The reasons for this were defined at the final meeting of the participants in August 1974.

The attempt to eliminate variables actually introduced variables. In retrospect, the requirement that all patients use the same type of foot, suspension, pylon, and hard socket introduced more variables than it eliminated. In addition, some patients used Greissinger "Five-Way" feet. After the evaluation the patients using Greissinger feet had them transferred to their evaluation prostheses in order to observe the difference. In every case, and not surprisingly, the patient stated the prosthesis was more comfortable with the foot he was used to. Probably, only the socket should be changed in such an evaluation so that it is the only variable to be considered. However, this procedure is questionable because worn feet can cause problems in alignment, and the use of inserts, whether old or new, introduces intangible factors.

Objectivity is nearly impossible to achieve. Despite measuring techniques such as x-rays, volume studies, temperature studies, etc., there is a point when someone must decide if the fit is acceptable. When the patient has sensation, the feedback from the patient is a strong factor that aids the prosthetist's decision concerning the adequacy of the fit.

Follow-up by the same prosthetist who originally made the cast of the patient was not possible. The three prosthetists came from different areas of the country so they were only able to cast the patients and modify the models. Fittings were performed by a disinterested prosthetist who was not totally familiar with the three techniques, although his experience as a prosthetist is extensive.

The socket volume measurements and the number of ply of prosthetics socks used did not always reflect the experience of the practitioners, as only heavy cast socks were available for casting in one instance, when the practitioner preferred to use light cast socks.

Logistical problems added complications, as patients would not always keep appointments or medical problems would interrupt the schedules. The amount of time needed from casting to the final meeting was 12 months, which reflects the unpredictable scheduling and coordination problems that were encountered.

CONCLUSIONS AND RECOMMENDATIONS

It is difficult, if not impossible, to relate patient outcome to one aspect of prosthetics fabrication. Future studies should consider all of the aspects of patient management. Fabrication techniques are only one small segment. Counseling, therapy, training, timing and understanding are the aspects of patient management that affect the patient outcome more than the physical design of the prosthesis. After all, many patients are mobile and well adjusted in wheelchairs. This study showed large volume and dimensional differences in the sockets, but the patient outcome was not affected by these differences.

The two-part technique reproduced the contours of the tibia more closely than the other techniques, was relatively easy to use, and consistently resulted in a mold with less volume than the other techniques. Therefore, it is recommended that this technique be used by teaching programs in prosthetics and orthotics. The use of transparent check sockets to evaluate socket fit is also encouraged because problem areas can be identified with a greater degree of accuracy.

This project illustrates the great difficulty in evaluating, objectively and subjectively, prosthetic devices and techniques. In nearly every instance the number of factors involved in successful use of an artificial limb is so great and so many of these factors are interdependent that it soon becomes impractical to eliminate the variables involved.

In this case it was considered best to provide each patient with a SACH foot in order to eliminate at least one variable. In retrospect, it may have been better to use the same type of foot each subject was accustomed to.

The volumetric and linear measurements recorded here are probably the most accurate ever made in a study of this type. Yet, they are not of much help in determining proper or adequate fit. They do reveal, though, once again that considerable variation in socket configuration is acceptable to the patient, but we are yet unable to determine these tolerances. Further work in this area is encouraged.

The temperature studies failed to yield any useful information although the potential usefulness of skin-temperature measurements is great. It is felt that thermograph pictures of the entire limb remnant would have given useful information but a suitable machine was not available. Certainly the use of thermography (*9*) as a means of evaluating the socket-stump relationship should be studied carefully, especially in conjunction with transparent sockets.

The difficulties found in evaluation of fitting techniques reflect both the complexity of socket fit and prosthesis alignment and our ignorance of just what constitutes "correct" fitting and alignment. Even though a great deal of progress has been made during the past 25 years in the development of rational approaches to fitting and alignment of artificial limbs, there remains the need for a great deal of art in the provision of a satisfactory prosthesis.

LITERATURE CITED

1. Appoldt, Francis A., Leon Bennett, and Renato Contini, The results of slip measurements in above-knee suction sockets. *Bull. Pros. Res.* **BPR 10-10**: 106-112, Fall 1968.

2. Brand, Paul W., and James D. Ebner, A pain substitute—pressure assessment in the insensitive limb. *Am. J. Occup. Ther.* **23**:6:1-8, Nov.-Dec. 1969.

3. Brand, Paul W., T. D. Sabin, and J. F. Burke, *Sensory Denervation—A Study of its Causes and its Prevention in Leprosy and of the Management of Insensitive Limbs*. Final Report, SRS Project No. RC-40-7, U.S. Public Health Service Hospital, Carville, Louisiana, 1966-1970.

4. Committee on Prosthetics Research and Development, *Below-Knee and Above-Knee Prostheses*. A report of a workshop, January 27-29, 1973, National Academy of Sciences, Washington, D.C.

5. Committee on Prosthetics Research and Development, *The Effect of Pressure on Soft Tissues*. Report of a workshop, September 21-22, 1971, National Academy of Sciences, Washington, D.C.

6. Fillauer, Carlton, A patellar-tendon-bearing socket with a detachable medial brim. *Orth. and Pros.* **25**:4:26-34, December 1971.

7. Foort, James, The patellar-tendon-bearing below-knee prosthesis for below-knee amputees, a review of technique and criteria. *Artif. Limbs* **9**:1:4-13, Spring 1965.

8. Gleave, J.A.E., *Moulds and Casts for Orthopaedic and Prosthetic Appliances*. Charles C Thomas, Springfield, Illinois, 1972.

9. Goller, Herbert, D. W. Lewis, and R. E. McLaughlin, Thermographic studies of human skin subjected to localized pressure. *Am. J. Roentgenol. Radium Ther. Nucl. Med.* **113**:4:749-754, December 1971.

10. Mooney, Vert, and Roy Snelson, Fabrication and application of transparent polycarbonate sockets, *Orth. and Pros.* **26**:1:1-13, March 1972.

11. Murphy, Eugene F., The fitting of below-knee prostheses. Chapter 22, in *Human Limbs and Their Substitutes*, McGraw-Hill Book Company, Inc., New York, 1954; reissued by Hafner Press, New York, 1968.

12. Murphy, Eugene F., Lower-extremity components. Chapter 5, in *Orthopaedic Appliances Atlas*, Volume 2, J. W. Edwards, Ann Arbor, Michgan, 1960.

13. Radcliffe, C. W., and J. Foort, *The Patellar-Tendon-Bearing Below-Knee Prosthesis*. Biomechanics Laboratory, University of California, San Francisco-Berkeley, 1961.

14. Snelson, Roy, Use of transparent sockets in limb prosthetics. *Orth. and Pros.* **27**:3:3-13, September 1973.

15. Sonck, W. A., J. L. Cockrell, and G. H. Koepke, Effect of liner materials on interface pressures in below-knee prostheses. *Arch. Phys. Med. Rehabil.* **51**:11:666-669, November 1970.

16. Taft, C.B., Radiographic evaluation of stump-socket fit. *Artif. Limbs* **13**:2:36-40, Autumn 1969.

17. Thomas, Atha, and Chester C. Haddan, *Amputation Prosthesis*. J. B. Lippincott Company, Philadelphia, Pennsylvania, 1945.

18. Witteck, Frank A., *Evaluation of Thirteen Below-Knee Amputees Fitted with Patellar Tendon Bearing, Cuff Suspension Prostheses*. Veterans Administration Prosthetics Center, New York, October 1959.

19. Zettl, Joseph H., and Joseph E. Traub, Premodified casting for the patellar-tendon-bearing prosthesis. *Artif. Limbs* **15**:1:1-14, Spring 1971.

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POLYPROPYLENE SPIRAL ANKLE-FOOT ORTHOSES[1]

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Warren Frisina, B. E.[2]

This paper describes a specific technique for moulding polypropylene in a spiral configuration with excellent control over dimensions and surface finish. Because the concept, technique, and indications for spiral ankle-foot orthoses have been described elsewhere (*1,2*) they will not be repeated in this article.

EQUIPMENT AND MATERIALS

- Vacuum pump[3] capable of drawing at least 25 in. of mercury within a few seconds under load to be described. A vacuum gage should be attached to the pump.
- Oven large enough to accept spiral blank.
- PVA (polyvinylalcohol) bag, approximately 25 cm wide and long enough to extend approximately 20 cm beyond cast when it is slipped over.
- Polypropylene spiral blanks cut from sheet stock 5 mm thick, and finished to 5½ cm wide.
- Soft felt patterns 3 to 6 mm thick that duplicate the shape of the plastic blanks, but are 12 mm wider than the blanks on all edges.
- Insulated gloves.
- Thin stockinet to fit snugly over cast.
- Pressure-sensitive tape.
- One pair of supports for plastic blanks for use in oven to permit even heating and fine oven timing by allowing observation of the amount of sag (Fig. 1). Supports are topped with nylon rods sprayed with silicone or fine talcum ("baby") powder to ensure free motion of blank when sagging occurs.
- Retaining band—a stiff elastic band with Velcro sewn on to hold calf band on cast temporarily and hold footplate in place while winding the spiral.

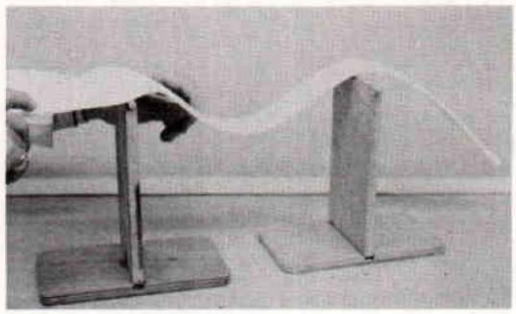

Fig. 1. Supports required for polypropylene parts when heated in an oven. These are made of plywood.

PROCEDURE

Obtain the modified cast. A hollow pipe should be imbedded so that it extends approximately 30 cm beyond the proximal end of the cast.

Drill a 3 to 4 mm hole *through* pipe approximately 12 mm proximal to the junction of the cast and the pipe.

Clamp the pipe in the vise at a point approximately 12 cm from the cast.

Cover the hole drilled through the pipe with approximately 5 layers of stockinet.

Cover the cast with 1 layer of stockinet and fasten it with tape to the pipe proximal to the drilled hole.

[1]This study was supported, in part, by the Social and Rehabilitation Service, Department of Health, Education, and Welfare, under the designation of New York University as a Rehabilitation Research and Training Center.

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[3]Pump preferably larger than the model BLVGH from Pneumotive, Monroe, Louisiana, that was used in this work.

Connect the end of the pipe to the pump with a flexible hose.

Sprinkle both faces of polypropylene with fine talcum ("baby") powder, or spray with silicone.

Place the polypropylene calf band blank in an oven that has been preheated to 165° C., and support by uprights as shown in Figure 1. Leave for approximately 10 minutes. Continue to observe until a sagging of 5 cm occurs when the uprights are 20 cm apart. The polypropylene must be free to slide on the supports during sagging.

Turn on the vacuum pump.

Place the softened plastic on the cast. Wrap the plastic with the felt pattern, making sure that the pattern overlaps the plastic on all edges. Hold the plastic and the pattern in place with the retaining band. Figure 2 shows this with the spiral portion.

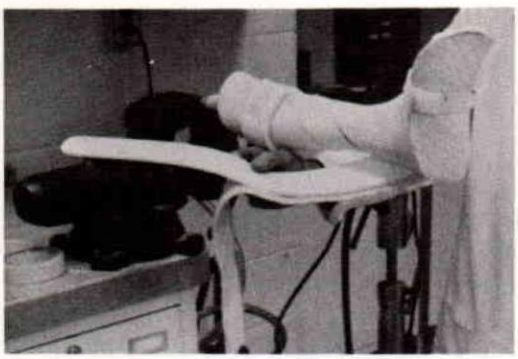

Fig. 2. Application of felt patterns needed to apply uniform loading over the softened polypropylene.

Slip the PVA bag over the cast and seal off by hand against the pipe proximal to the drilled hole (Fig. 3). If the plastic has shifted position or the PVA bag has been drawn under the polypropylene, the "hand" seal is easily released to disperse vacuum and correct the condition. When the positioning is satisfactory, the bag is sealed more permanently to the pipe with plastic tape. Pressure should be maintained for at least 10 minutes.

Remove the retaining band and felt, but leave the calf band on the cast.

Repeat the procedure with the spiral blank. The spiral blank should sag 8 cm when supports are placed 28 cm apart (Fig. 1). To facilitate positioning of the spiral, place the footplate first, cover with the felt pattern, and hold the footplate and cover in place with the retaining band. Wrap the remainder of the spiral around the cast, being certain that folds in the plastic do not occur because of an improperly positioned footplate. Hold the end of the spiral piece against the calf band *by hand* while slipping the bag over the assembly. Do not fix the upper part of the spiral because this encourages folds to occur when vacuum is applied.

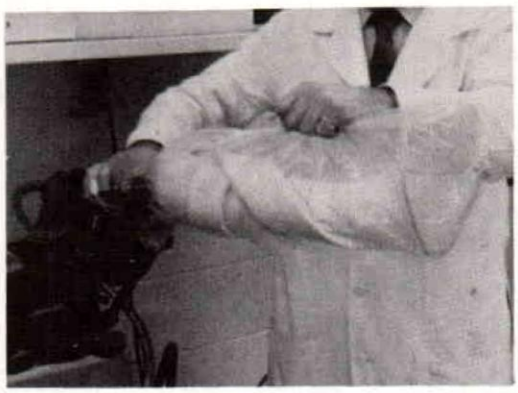

Fig. 3. Application of PVA bag over assembly, just prior to application of suction.

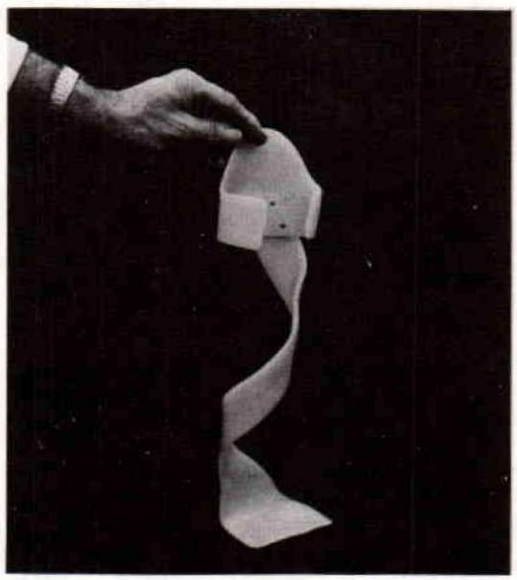

Fig. 4. Finished spiral AFO made of polypropylene.

Just before the vacuum is to be released (after a minimum of 10 minutes), ensure that the polypropylene has stabilized by wrapping the proximal and distal portions of the spiral with an elastic bandage and allow it to stand for a few hours.

Join the spiral to the calf band with rivets. The finished orthosis is shown in Figure 4.

PVA bags can be reused many times. However, if they become excessively dry they will crack and allow the vacuum to disperse. To avoid this the bag could be wrapped in a dampened towel prior to use.

When more support is required than can be supplied by material 5 mm thick, either or both the width and thickness can be increased. More heating time will probably be required and the footplate will need grinding when the thickness is increased.

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PROXIMAL FEMORAL FOCAL DEFICIENCY AND ITS TREATMENT[1]

Thomas V. Rossi, M.D.[2] and
Leon Kruger, M.D.[2]

Proximal femoral focal deficiency (PFFD) is a relatively rare disorder involving the proximal femur and frequently the acetabulum. It occurs unilaterally more commonly than bilaterally. The problems seen in patients with PFFD are discrepancy in leg length, instability of the hip, contractures of the hip and knee, unequal level of the knee, short stature, and associated anomalies. The associated anomalies increase the problems of treatment and prognosis significantly.

Proximal femoral focal deficiency has been discussed at length in the proceedings of a symposium edited by Aitken (*2,4,8,10*). The present paper discusses the authors' experience with 38 patients, and suggests a classification of PFFD based on treatment considerations. Attempts are made to answer four questions:

- When is amputation or turnplasty (Van Nes procedure) indicated?
- When is knee fusion indicated?
- When is valgus osteotomy indicated?
- When is surgery contraindicated?

Indications for hip stabilization are not discussed because the authors' experience in this area is limited to two patients.

The classification systems of Aitken (*1, 2*) and Amstutz (*4*), which are based primarily on x-ray data, are the best currently available. Aitken has divided PFFD into four types (A, B, C, and D). In both Type A and Type B a femoral head and an adequate acetabulum are present. In Type A, there is either a bony or cartilaginous connection between the head and neck fragments and the shaft at maturity, whereas in Type B there is no such connection. In Type A, often there is a subtrochanteric pseudoarthrosis. X-rays of patients in Types C and D show no femoral head or acetabulum. These two types are differentiated by the presence of an ossified tuft at the proximal end of the shaft in Type C patients. The four types are depicted in Figure 1.

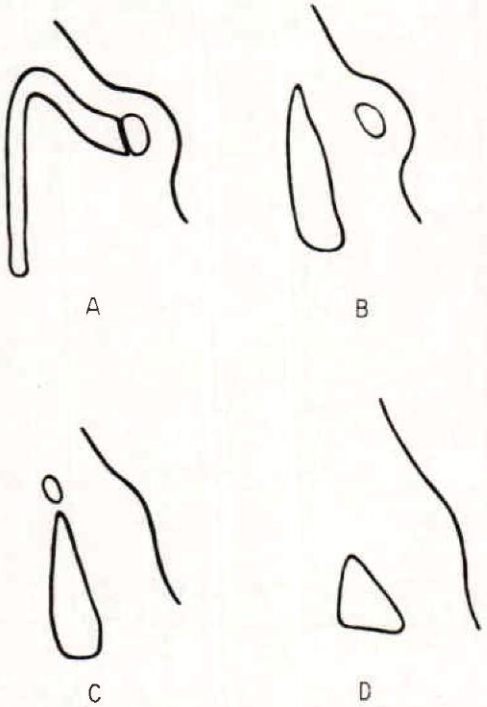

Fig. 1. Diagrammatic representation of four types of proximal femoral focal deficiency as proposed by Aitken (10).

Amstutz's method of classification is similar to Aitken's but includes coxa vara with bowing and further differentiation into subtypes. His five morphological types identified at birth are subtyped usually by five years of age. The different types and subtypes are presented in Figure 2.

[1]Presented at the annual meeting of Chiefs of Child Amputee Clinics sponsored by the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, National Academy of Sciences, held in Springfield, Massachusetts, May 24-25, 1972.

[2]Shriners Hospital for Crippled Children, 516 Carew Street, Springfield, Massachusetts 01104.

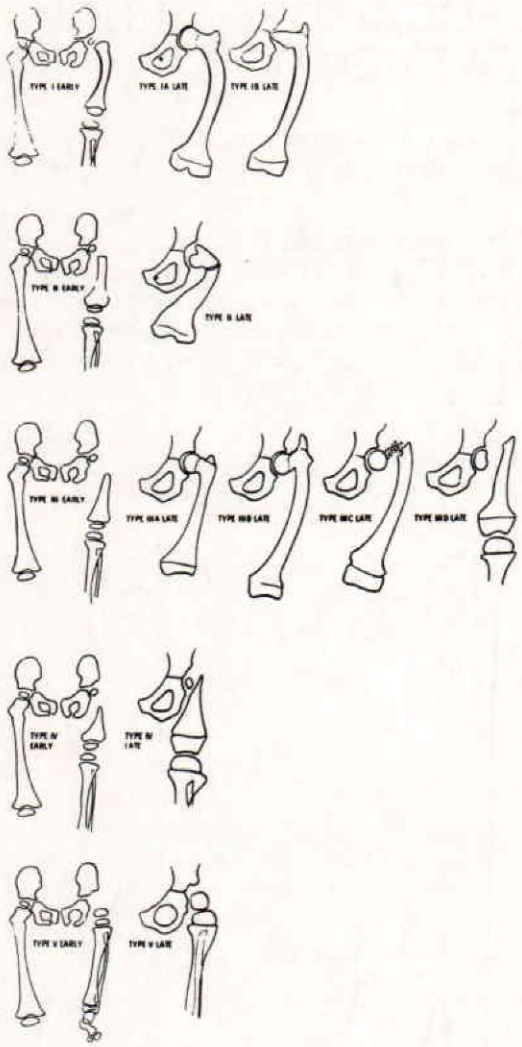

Fig. 2. Diagrammatic representation of five early PFFD types and developmental variations as proposed by Amstutz (4).

THE PRESENT SERIES

Patients treated at the Shriners Hospital for Crippled Children, Springfield, Massachusetts, from 1925 to the present comprise the series of PFFD cases reported here.

All patients coded in the hospital records with a diagnosis of PFFD, femoral hypoplasia, proximal phocomelia, and coxa vara were reviewed (Table 1). The classification systems of Aitken and Amstutz as described in the National Academy of Sciences Symposium report (*2*) were used in this study. Aitken's classification system was the principal one used because of its greater simplicity in arranging the various groups of patients. We also used Amstutz's Type I, coxa vara with bowing, because of the inequality of knee length and knee levels seen with patients in this category. Aitken does not include this disorder under PFFD. In our experience, Amstutz's classification with its multiple subtypes was difficult to use and was not found helpful for our purposes. Five hips were included which were similar but not clearly Aitken Type D, PFFD by x-ray. Four patients had an elongated proximal tibial epiphysis without a distinct femoral remnant (Fig. 20). These cases probably represent proximal phocomelia. The fifth patient had a similar globular proximal tibial epiphysis, and had a normal head and neck well-seated in a normal acetabulum as well, but there was no femoral shaft and no bony connection between the neck and tibial remnant. All five of these hips were clinically and functionally indistinguishable from the Aitken Type D deformities.

Table 1. Present Series of PFFD

Total No. Patients	38
Total No. Hips	50
Unilateral PFFD	**Patients**
Group A. Short Femoral Segments	6
B. Medium Femoral Segment	12
C. Long Femoral Segment	7
D. Patient with contralateral amelia	1
	26
Bilateral PFFD	**Patients**
Bilateral Asymmetrical	5
Bilateral Symmetrical	7
	12

A total of 50 hips in 38 patients are included in this series. There were 26 patients with unilateral involvement and 12 patients with bilateral involvement. The 12 patients affected bilaterally were further subdivided into bilateral symmetrical and bilateral asymmetrical categories. The criteria for differentiating the two groups were clinical leg-length measurements. Differences discernible and measurable in the roentgenographs were not used. The patient's functional status based on total leg-lengths and not his x-ray diagnosis was the primary concern. If both legs were equal functionally regardless of differences in the segments he was classified as a bilateral symmetrical PFFD. If he had significant leg-length discrepancies (3 inches or greater) from any cause, i.e., fibular hemimelia, proximal migration of the femoral remnant, or other deformity, he was classified as asymmetrical bilateral PFFD and his treatment was based on this consideration.

Table 2. Associated Congenital Anomalies

	Patients	
Upper-Limb Anomalies		
Without Lower-Limb Involvement	2	5 %
With Lower-Limb Anomalies	7	17 %
	9	22 %
Total Lower-Limb Anomalies	29	76 %
Fibular Hemimelia		
Unilateral	14	37 %
Bilateral	5	13 %
	19	50 %
Other Anomalies	9	22 %
Total No. of Patients With Anomalies of the Limbs	31	81 %

ASSOCIATED ANOMALIES

The data from this series confirmed the repeatedly reported findings of previous investigators (*5,8,10*), namely, other congenital anomalies are frequently associated with PFFD. Thirty-one of the 38 patients in the present series had other limb abnormalities (Table 2). The most frequently associated anomaly was fibular hemimelia which was found in 50% of the patients. Fourteen had ipsilateral fibular hemimelia and 5 had bilateral involvement.

CLASSIFICATION AND TREATMENT

After careful study of the 38 patients, we concluded that while Aitken and Amstutz classifications are soundly based on the embryology and morphology of the condition, they do not indicate a therapeutic approach to the individual patient. On the basis of our experience, therefore, a new method of classification is suggested (Table 3). We submit that the basic division in these patients is between individuals with unilateral and bilateral PFFD. We would further subdivide the bilateral group into symmetrical and asymmetrical categories.

We suggest that the unilateral group be subclassified according to the length of the remaining femoral segment. In order to express this in a meaningful manner we have used the technique of proportional measurement. The proportion, or percentage, is determined by dividing the length of the involved femur by the length of the normal femur and multiplying by 100:

$$\frac{\text{length of involved femur}}{\text{length of normal femur}} \times 100 = \%$$

The measurements are made from the triradiate cartilage to the most distal border of the femur as viewed on the x-ray plate (Fig. 3). If the involved femur has migrated proximally so that it is superior to the triradiate cartilage we ignore the portion above our landmark. In an occasional patient the femoral remnant will be in an almost horizontal position due to hip and knee flexion deformities. It is then necessary to measure the entire length of the femoral remnant instead of using the triradiate cartilage as a fixed proximal point.

In the case of unilateral PFFD we believe that there are three therapeutic groups characterized by a short, medium, or long femoral segment. The short femoral segments measure less than 20% of the normal side. Those measuring 20 to 70% of the normal side were considered to be medium femoral segments, and those greater than 70% were designated as long femoral segments. While it was found that there was a tendency for the ratio or percentage of femoral length to change with time, in no case was this change great enough to put a patient into a different treatment group. Amstutz has stated that proportionality of growth was present in all patients by age five (*4*).

UNILATERAL PFFD

Unilateral PFFD affects the largest group of patients. Of the 26 unilateral patients in our series, 19 underwent a total of 35 surgical procedures on the involved extremities. The two most common operations were amputation, which was performed 12 times, and valgus osteotomy in 7 patients (9 procedures). The next most common procedures were knee fusion in 4 patients, and contralateral epiphyseal stapling or epiphysiodesis in 3 patients. Other procedures involving at least one patient were rotation-plasty, osteosynthesis of the femoral neck, acetabuloplasty, toe amputation, and open reduction and fusion of the hip with subfusion osteotomy. Seven patients did not receive any surgical treatment. Two of these were seen very early in the series, 2 were lost to follow-up, and 2 are yet too young for surgery. In the 7 patients for whom surgery was not indicated the leg-length discrepancy was no more than 1½ in., and function and cosmesis were satisfactory otherwise.

Twenty-three unilaterally involved patients had a leg-length discrepancy of more than 1½ in. One patient had contralateral amelia, and 2 had coxa vara with bowing (Amstutz Type I PFFD) and leg-length discrepancies of less than 3 in. Twenty patients had leg-length discrepancies of 4½ in. or greater at the time of amputation or when last seen. Twelve of these patients had an amputation. The youngest patient had 4¾ in. of shortening at the age of one year and the oldest had 4½ in. of shortening at the age of 13 years. Of the remaining 8 patients with more than 4½ in. of leg-length discrepancy who did not have amputations, one had a turnplasty procedure, 2 were lost to follow-up, and the remaining 5 were doing well with either an extension prosthesis or a platform orthosis. Treatment of these 5 patients was carried out prior to 1955. On the basis of study of this group of patients we feel that patients in the short and medium femoral length groups will eventually come to amputation and above-knee-type prostheses.

Twenty-five patients (the twenty-sixth patient had contralateral amelia) were divided into three treatment groups according to femoral percentages as described (Table 3).

Table 3. Treatment Classification

I. Bilateral PFFD
   A. *Bilateral Symmetrical*-Articulated Extension Prosthesis or Extension Braces. Amputation not indicated.
   B. *Bilateral Asymmetrical*-Treatment To Be Individualized

II. Unilateral PFFD
   Short Femoral Segment Less Than 20% Femoral Ratio
   1. Foot Disarticulation & A-K Prosthesis
   2. Van Nes Rotation Plasty & B-K Prosthesis
   3. Articulated Extension Prosthesis

   Medium Femoral Segment 20%-70% Femoral Ratio
   1. Knee Fusion, Amputation and A-K Prosthesis
   2. Knee Fusion, Rotation Plasty B-K Prosthesis
   3. Amputation and B-K Prosthesis
   4. Extension Prosthesis or Brace

   Long Femoral Segment Greater Than 70% Femoral Ratio (coxa vara with bowing)
   1. Treat as routine leg-length discrepancy
   2. Coxa Vara
      A. Observed over several years
      B. Valgus osteotomy probably only indicated near maturity
      C. Valgus osteotomy is contraindicated in the presence of acetabular dysplasia

Short Femoral Segments

Case History

Case 1, L.C. (Figs. 3 and 4), a white male, had a right proximal femoral focal deficiency, Aitken's Class D deformity, and bilateral upper-limb terminal transverse hemimelia. He had a right transtibial amputation at the age of nine years at which time the leg-length discrepancy was 11 in. His right ankle was at the level of the normal knee. Postoperatively, he was fitted with a nonstandard above-knee prosthesis which provided ischial weightbearing. As a result, this patient, who had previously worn an extension prosthesis obtained an improvement in appearance and gait and an increase in hip stability. With modern concepts of amputation surgery, a foot disarticulation rather than a below-knee amputation might have been performed.

The treatment recommendations for the patients with the short femoral segments would be;

1. Foot disarticulation and ischial weightbearing above-knee prosthesis.
2. Van Nes turnplasty procedure and modified below-knee prosthesis.
3. No surgery and an articulated extension prosthesis.

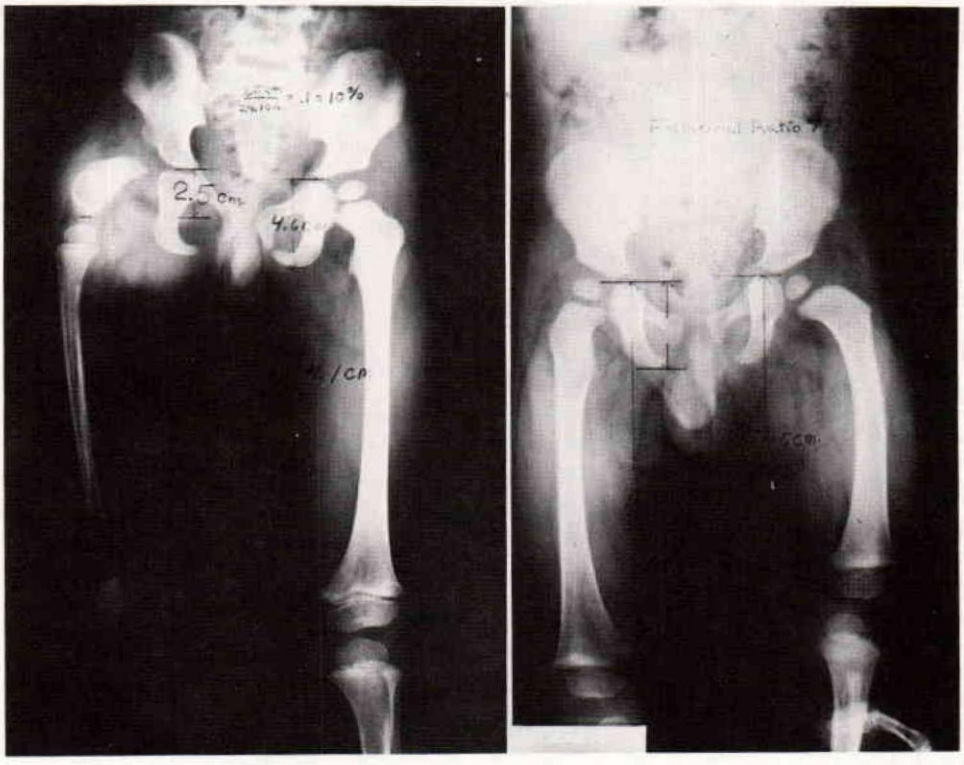

Fig. 3. The measurements of femoral length from triradiate cartilage to the end of the distal femoral epiphysis are demonstrated. The figure on the left shows a patient with an Aitken Class D deformity with a femoral segment less than twenty percent of the normal side. This patient in fact has a femoral segment ten percent of the normal side and represents what we would classify a short femoral segment. Note that the ankle on the affected side is above the normal knee level. In the right photograph notice again the measurement of the femoral length, and note that this patient demonstrates a left coxa vara with bowing with a femoral segment seventy-seven percent of the normal side. This represents a long femoral segment.

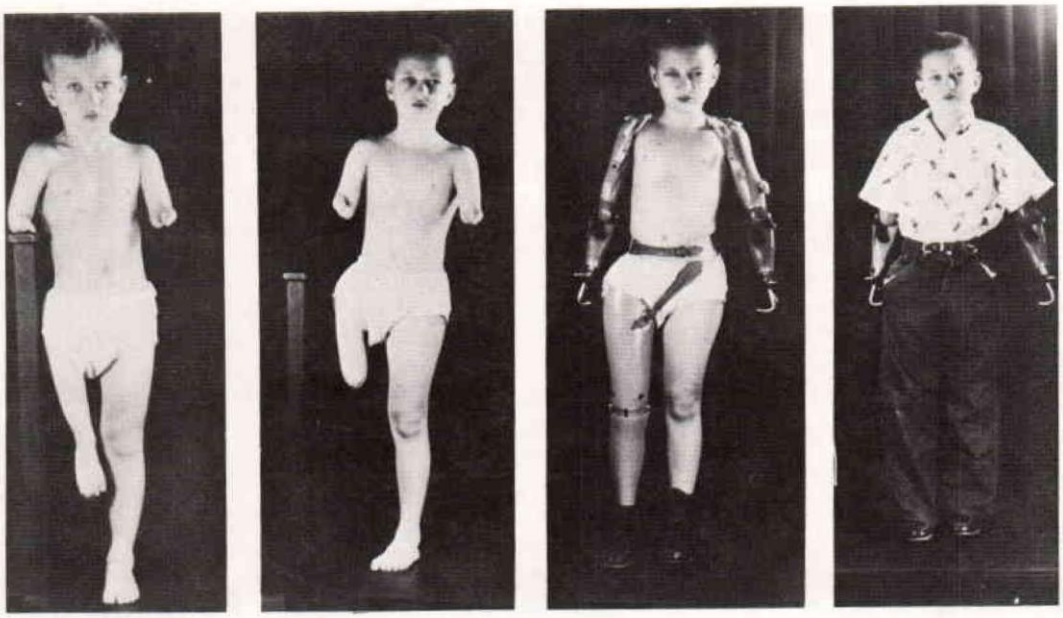

Fig. 4. Case 1; L.C. This six-year old boy presents with bilateral upper-limb transverse hemimelia had a right PFFD. His foot on the affected side is at the normal knee level (Fig. 3). At age nine the patient underwent transtibial amputation. The patient has been fitted with an A-K prosthesis with modified UCB quadrilateral socket and Silesian-type suspension. He is fully active and has gained hip stability through ischial bearing (11).

Medium Femoral Segments

There were 12 unilateral proximal femoral focal deficiency patients whose femoral segment ranged from 20 to 70% of the normal femur. The average shortening in this group was 6½ in., with the foot lying both at the level of the opposite knee and, in approximately half of the patients, between the contralateral knee and ankle. Hip- and knee-flexion deformities are the rule unless the patient is seen very early in life and properly splinted or braced. Efforts at fitting these patients without surgery are rewarded by ambulation, but progressive knee- and hip-flexion deformities may occur. The longer the femoral segment, the easier it is to control knee flexion. In those patients with shorter femoral segments, 20-40%, the ship's ventilator or stovepipe type of socket is satisfactory, but good gait is difficult to achieve when hip- and knee-flextion deformities are present. The weightbearing line of the prosthesis will be anterior to (in front of) the body's weight line, and ischial weightbearing will be difficult to achieve. The result is an exaggeration of the hip limp which the proximal femoral focal deficiency patients always demonstrate.

Perhaps the best way to correct this problem is by fusion of the knee in full extension. This provides a single-segment lever *(9)* to correct hip flexion and, when the distal limb is ablated, good ischial weightbearing is permitted through the prosthesis, thus diminishing the hip lurch. Knee fusion can be accomplished without damage to the distal femoral and proximal tibial epiphysis (Fig. 5). We have performed knee fusion as early as age five.

Only four of our patients had knee fusion while nine had amputations and one had a Van Nes rotation-plasty. The four patients with knee fusion had femoral segment ratios varying between 25 and 40%. On the basis of the results of these four, we feel that most patients in the group of patients with medium femoral segments do best with knee fusion and ablation. The functional and cosmetic appearance is superior to other known treatment regimes.

The amputation level for this group of patients depends upon the relationship of the involved foot to the normal knee. A transtibial amputation should be performed when the involved foot is below the normal knee. Ankle disarticulation is possible in those patients with a foot lying at or slightly above the normal knee. The object is to fit the patient with an AK prosthesis so that the prosthetic and normal knees are at the same level. We find that consultation with the prosthetist is of great benefit in making the final decision on level of amputation.

It is well to recall that in children the ideal ablation procedure is disarticulation, a procedure which permits end bearing by the resulting stump. This of course is valuable for proprioceptive feedback. It is also preferable because spiking as found in transtibial amputations, is prevented. When disarticulation leaves a stump that is excessively long, epiphysiodesis or bone shortening procedures should be considered in lieu of transtibial amputation.

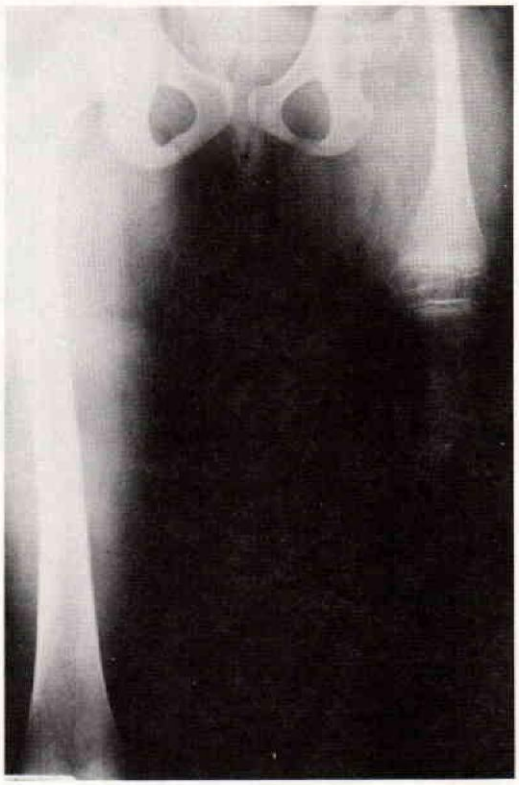

Fig. 5. Case 2; J.G. This boy age six with right PFFD had seven inches of shortening with an ankle level two inches below the normal knee. He had a poor gait with the extension prosthesis. At age seven he underwent a turnplasty procedure and received a B-K prosthesis. Note that the ankle level is still below the knee level. Ischial weightbearing will improve hip stability. Knee fusion in the future will simplify the prosthetic problem.

Case Histories

The following cases illustrate the above points:

Case 2, J.G. (Figs. 5 and 6), a white male, with a left Aitken Class C proximal femoral focal deficiency, had associated upper-limb deficits. Present were terminal longitudinal adactylia bilateral of the fourth and fifth rays, and dislocation of the left radial head and syndactylism of the second and third fingers of the left hand. He had progressive shortening from 2½ in. at age eight months to 7 in. at age seven years. When he was seven years of age a left Van Nes turnplasty procedure was performed. At the time of surgery the left ankle was 2 in. below the contralateral knee level. At the present time, he is wearing a modified below-knee prosthesis with his own ankle joint functioning as a knee joint. Now, one-and-one-half years postoperatively, there has been no sign of spontaneous derotation of the turnplasty procedure, *(5,7,8)*, and the ankle continues to provide good function as a knee joint.

The Van Nes procedure is an alternative to amputation and is probably indicated only when the ankle level of the affected limb can be expected to be at the knee level of the sound limb when maturity is reached. Some shortening, of course, can be gained at the time of osteotomy by removal of bone. We have considered this procedure as appropriate primarily for the male patient because the cosmetic appearance of the prosthesis is only fair and the appearance of the limb with the prosthesis off is poor. It is interesting to note that, when Van Nes *(12)* described his procedure in 1950, all three of the patients discussed were female and all three had knee fusion performed. In one patient, the rotation plasty was done through the knee.

Case 3, L.S. (Figs. 7, 8, and 9), a white female with a left proximal femoral focal deficiency, Aitken Class A, had 7½ in. of shortening at the age of eight years with the foot midway between the

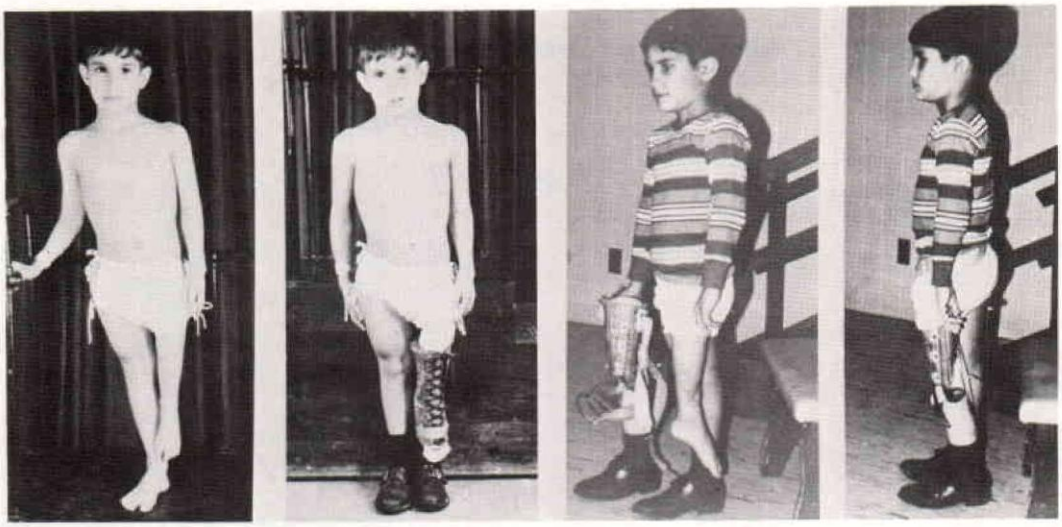

Fig. 6. Case 2; J.G. Left PFFD Aitken Class C. Note that because of severe hip and knee flexion deformity it is necessary to measure the femoral length from the proximal end of the femoral remnant and not from the triradiate cartilage. The femoral segment was twenty-two percent of the normal side.

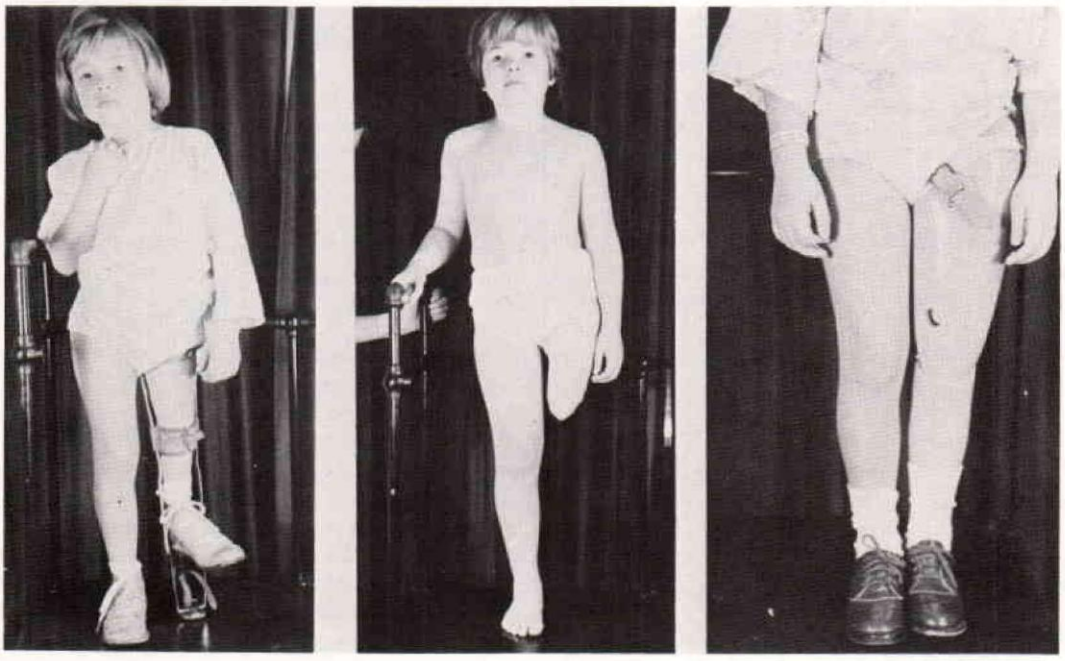

Fig. 7. Case 3; L.S. This eight-year-old girl with a left PFFD had eight inches of shortening. Note ankle level midway between normal knee and ankle. At age eight she underwent a transtibial amputation, knee fusion and fitting with A-K prosthesis with a quadrilateral socket. Her hip stability, gait and cosmetic appearance were markedly improved.

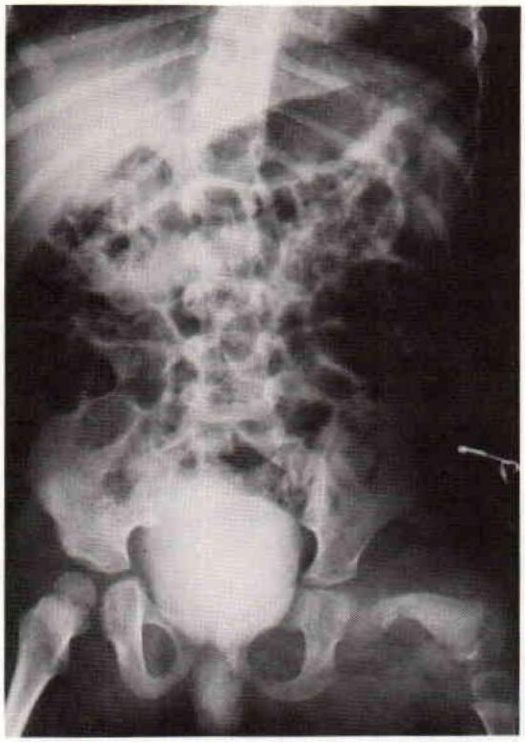

Fig. 8. Case 3; L.S. Note left PFFD Aitken Class C deformity. The femoral ratio was approximately forty percent.

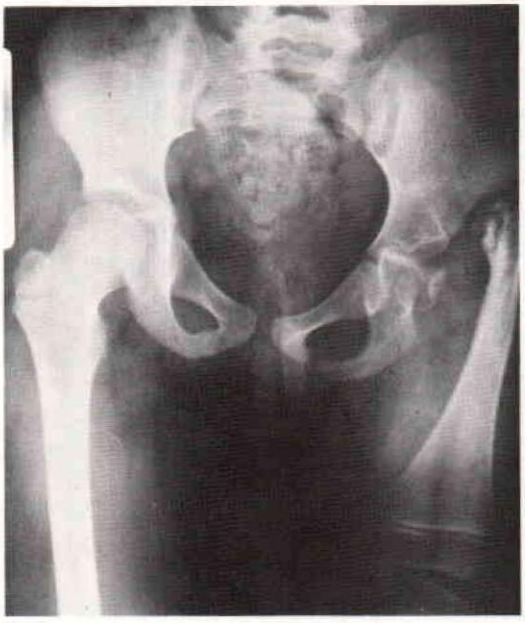

Fig. 9. Case 3; L.S. The knee is shown fused in extension without damage to either of the epiphyses.

knee and ankle on the normal side. In 1967, she underwent a transtibial amputation followed two years later by removal of a bone spike and fusion of the knee in extension without interference with the epiphysis. She was fitted with an ischial-bearing above-knee prosthesis with an excellent cosmetic and functional result. Her femoral ratio was 44 percent.

The treatment recommendations for this group of patients are:

1. Knee fusion with appropriate amputation and AK prosthesis.
2. A Van Nes rotation plasty with knee fusion and BK prosthesis.
3. Foot disarticulation and BK prosthesis.
4. Extension prosthesis or brace without surgery.

Long Femoral Segments

The seven patients with femoral ratios greater than 70 percent (Fig. 3) had an average leg-length discrepancy of 2½ in. All patients in this group fell into the Amstutz Type 1, or coxa vara with bowing deformity. Only one amputation was performed. This was done on a patient who had an associated fibular hemimelia. The amputation was at age one year, when the child had a leg-length discrepancy of 4¾ in. He has done very well with a below-knee prosthesis. Three patients in this group have undergone either epiphyseal stapling or epiphysiodesis of the normal side. One achieved leg-length equality at maturity and the other two have shown no change of their leg-length discrepancies. This entity differs from the two groups previously discussed. Patients in this group usually do not have leg-length discrepancies of such magnitude as to require amputation unless associated anomalies are present. Knee levels are frequently unequal but never to such a degree as to require knee fusion. The primary problem in this group of patients has been the coxa vara and its treatment. Nine valgus osteotomies were performed on seven patients. Two of these patients were also included in the group with bilateral asymmetrical proximal femoral focal deficiency, one side being Amstutz Type 1.

The earliest initial valgus osteotomy was done at age three years and the latest initial operation

was at age seven. In two patients valgus osteotomies were repeated three years after the initial procedure. The neck-shaft angle ranged from 75 deg. in the youngest to 90 deg. in the oldest patient. The acetabular index at the time of surgery in all patients except three was approximately 20° which was very close to the opposite or normal acetabular index. All patients with acetabular indexes of close to 20° at the time of surgery had no significant change. The remaining three patients had acetabular indexes of 33, 30, and 35°, respectively, at the time of surgery. All of these patients had an increase in the acetabular index.

The results of valgus osteotomy in these patients was generally unsatisfactory (Table 4). In four patients the results were rated as poor because of markedly short necks and frequently flattened femoral heads with limited motion (Figs. 10 and 11). Three patients had subluxation. One patient progressed from subluxation to eventual dislocation of the femoral head (Fig. 12). One patient rated as having a good result maintained a well-seated head without increase of the acetabular index and with improvement of the neck-shaft angle from 75° to 115°. The remaining patient is

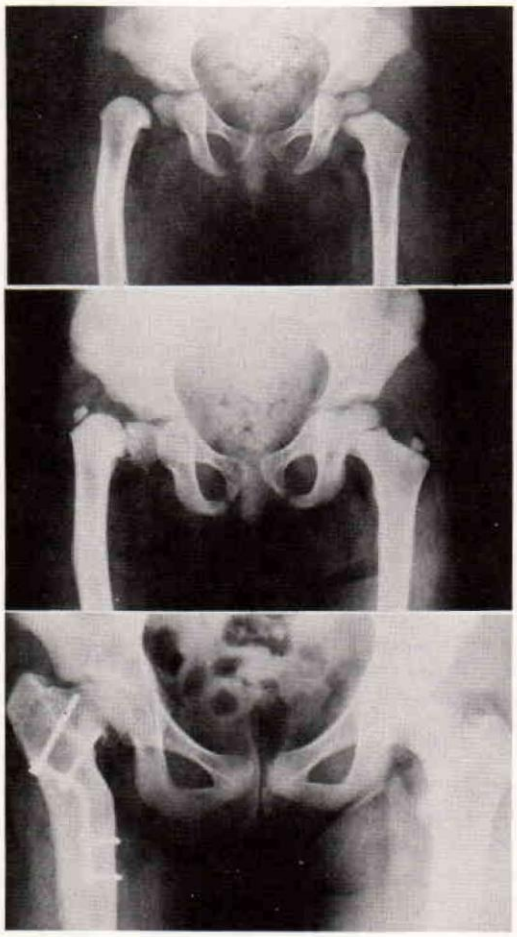

Fig. 10. Case 5; C.M. *Top*, age two with right coxa vara with bowing. Note normal acetabular index. At age five years, *middle*, there is slight increase of coxa vara with short neck, base of neck vertical defect, and no definite proximal femoral epiphysis. At age twelve years, *bottom*, she has had a valgus osteotomy twice, at age five and seven. Note short neck, small head, well seated in the acetabulum.

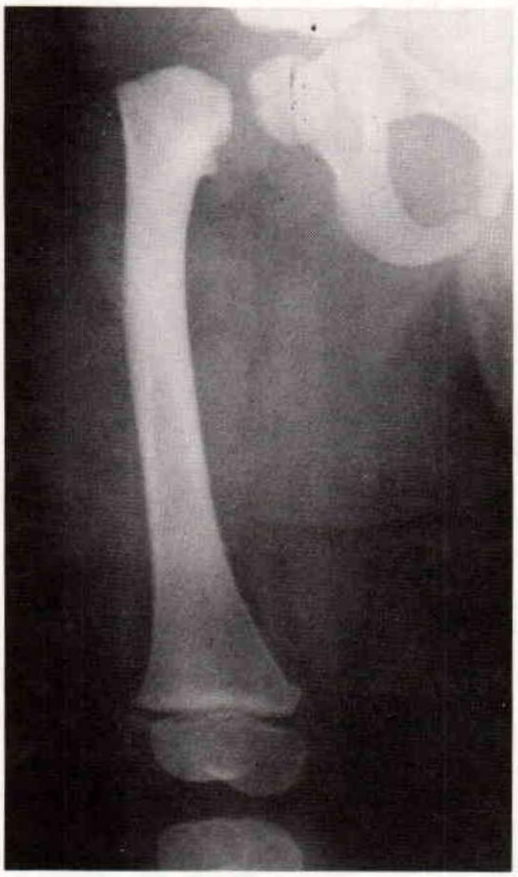

Fig. 11a. Case 6; P.O. Note right coxa vara with bowing. At age three note the short laterally bowed femur with thickened medial cortex and coxa vara. There is a mid-neck vertical lucency and a normal acetabular index in the absence of a definite proximal femoral epiphysis.

one year post-valgus osteotomy and the result to date is considered good, with a neck-shaft angle of 120° and a rounded and well-seated femoral head.

In this series, 14 hips in twelve patients had coxa vara with bowing, but to date no hip has been followed long enough without surgery for the natural course of this deformity to be deter-

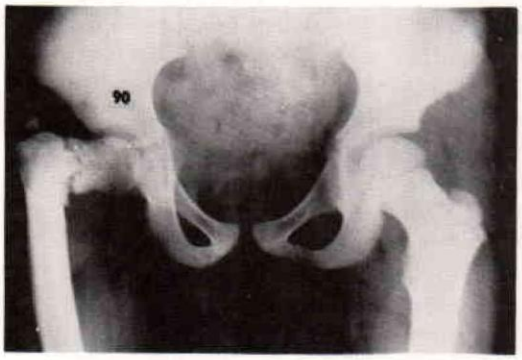

Fig. 11b. Case 6 at age seven. Note slight decrease in the neck-shaft angle and the base of neck defect.

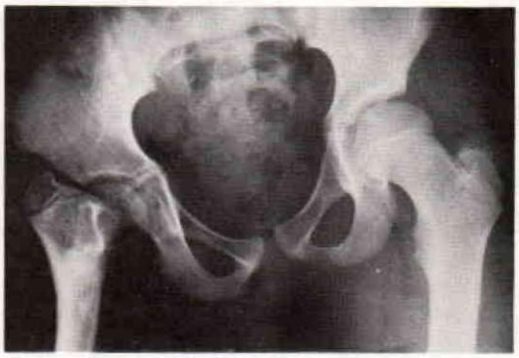

Fig. 11d. Case 6 at age thirteen. Note the very short neck and small but rounded well-seated head.

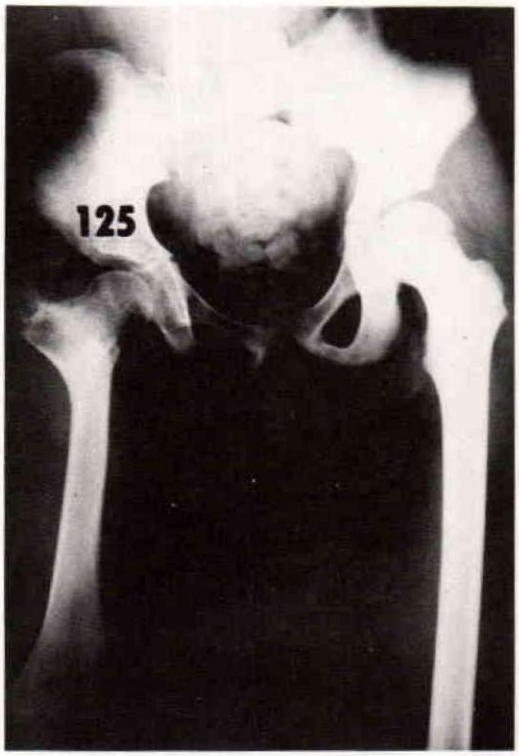

Fig. 11c. Case 6 at age nine. A successful valgus osteotomy has been performed with a resulting neck-shaft angle of 125 deg. Note the small head and neck, absence of a proximal femoral epiphysis, and closure of mid-neck lucency.

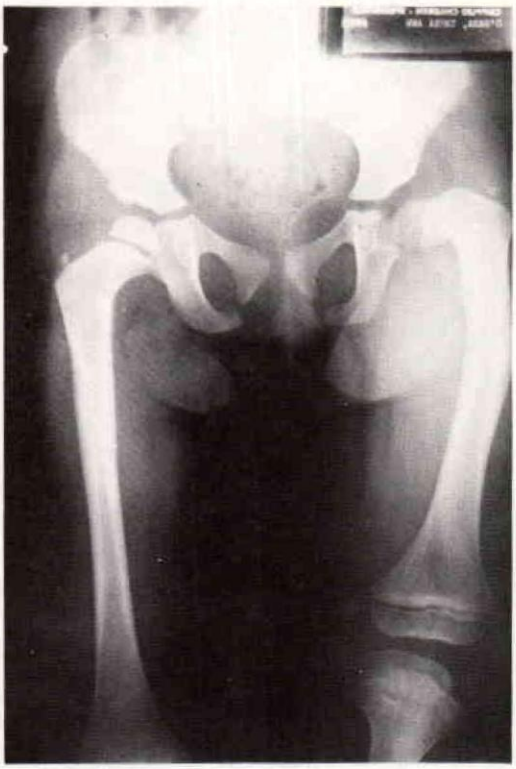

Fig. 12a. Case 7, T.O., at age five prior to valgus osteotomy for her coxa vara with bowing deformity. Note the shallow acetabulum (33°) and the vertical lucency which is beginning to close.

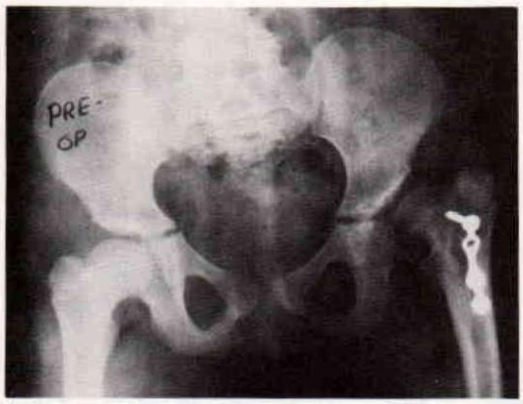

Fig. 12b. Case 7, at age nine, four years after valgus osteotomy. Note the marked acetabular dysplasia, subluxed femoral head and very short femoral neck. This patient progressed to frank dislocation.

mined. The treatment which is indicated for this group of patients is equalization of leg-length discrepancy. Amputation may be indicated only when leg-length discrepancies are exaggerated by associated anomalies. Knee fusion is not indicated. This retrospective study suggests that these patients do not benefit from valgus osteotomy. If it is indicated it should not be performed until maturity has been attained. Valgus osteotomy is contraindicated in any patient with an acetabular index greater than 30°.

BILATERAL SYMMETRICAL PPFD

In the seven patients with bilateral symmetrical proximal femoral focal deficiency included in this

Table 4. Valgus Osteotomy In Patients With Coxa Vara With Bowing

Name	Age At Operation or Last X-ray	Classification of Contralateral Hip	Acetabular Index Involved/ Uninvolved	Angle of Inclination prior to surgery	No. Of Valgus Osteotomies	Results
P.O.	7 yrs.	Normal	20°/23°	90°	1	Poor-angle of inclination 105° with short neck
	12 yrs.					
R.H.	3 yrs.	Normal	20/20°	75°	1	Good-head round well seated, slight shortening of neck, neck shaft angle greater than 120°
	10 yrs.		20/20°			
C.M.	4 yrs.7 mos.	Normal	21°/20°	80°	2	Poor-very short neck increase of acetabular index
	18 yrs.		32°/20°			
T.O.	5 yrs.	Normal	32°/23°	85°	1 acetabuloplasty	Progressive subluxation & acetabular dysplasia
	11 yrs.		46°/20°		very poor	
M.G.	5 yrs.& 8 yrs.	Aitken Class C	30°/ ?°	90°	2	Poor-short head & neck, early subluxation
	12 yrs.		35°/ ?°			
F.F.	5 yrs.	Normal	20°/16°	85°	1	Good to date-Angle of inclination 120°
	6 yrs.		20°/16°			Good result to date with short neck
R.P.	6 yrs.	Aitken Class D	35°/ ?°	85°	1	Poor-Angle of inclination 70°
	11 yrs.		45°/ ?			Conical head, early subluxation

series, there was an extremely high incidence of associated anomalies, frequently multiple. Only one patient of the seven *did not* have an associated congenital anomaly.

The treatment of this group of patients was nonsurgical except for two. One patient, S.M. (Figs. 13 and 14), had a right ankle fusion. A second patient (T.B.) had a posterior release of the left ankle. *No patient in this group had an amputation.*

When they have upper limbs for balance assistance, patients in this group ambulate in spite of the severity of the lower-limb anomalies. We have fitted them with articulated limbs, without amputation, and they have done well. Our oldest patient is now thirty-two years of age and has been wearing articulated extension prostheses for eighteen years. We do not know whether or not she will be able to wear them at age forty or at age fifty. Therefore no amputation is anticipated.

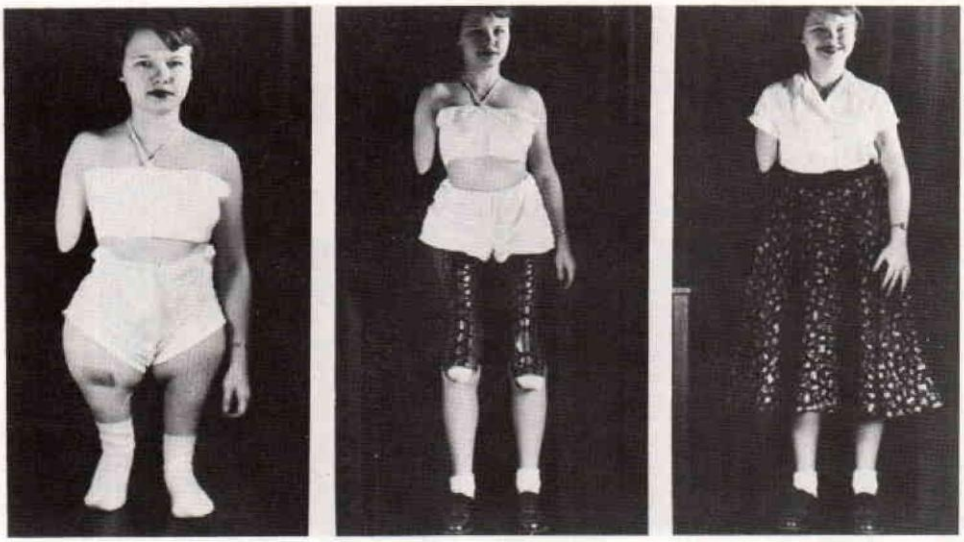

Fig. 13. Case 8, S.M., with bilateral symmetrical PFFD, is shown with and without her articulated extension prostheses. There is marked improvement of cosmetic appearance and increase in height from 3 ft. 6 in. to 5 ft. 1½ in. S.M. wears the prostheses full time, yet retains the ability to ambulate independently.

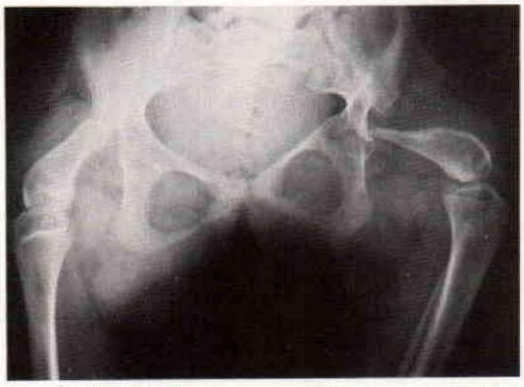

Fig. 14. X-ray of Case 8 showing bilateral symmetrical PFFD Aitken Class C deformities.

This philosophy is shared by Hall *(8)*, Aitken *(2)* and others. For those few patients in whom increasing deformities preclude continued ambulation without prosthesis, amputation is to be considered in order to provide the potential for prosthetic fitting. Of three patients with associated bilateral fibular hemimelia, two ambulate independently or with extension prostheses. The third patient is the only one with significantly limited ambulation (T.B.). He has bilateral proximal femoral focal deficiency, bilateral fibular hemimelia, and bilateral upper-limb amelia. It is the upper amelia and lack of balance assistance from arms that have precluded significant ambulation.

One patient was lost to follow-up at age seven. Five of the six remaining patients were walking independently albeit with a waddling gait when last seen. Two of the five patients use articulated extension prostheses and a third patient has been fitted with nonarticulated stubbies. At the age of twelve, the sixth patient (T.B.) can take no more than 12 steps without assistance.

Case Histories

Case 8, S.M. (Figs. 13 and 14), first seen at age fourteen, in 1953, was noted to have symmetrical bilateral proximal femoral focal deficiency of the Aitken Class C type with right intercalary paraxial fibular hemimelia and right terminal transverse distal humeral hemimelia plus a valgus deformity of the right foot with ½ in. shortening on the right side. Following fusion of her right ankle, she was fitted with articulated extension prostheses which increased her overall height from 3 ft. 6 in. to 5 ft. 1½ in. After one year she was able to manage her prostheses without external support. At the age of thirty-two she has two normal children that she takes care of, and for the past eighteen years has worn her prostheses from the time she arises in the morning until she goes to bed at night.

Both hips are unstable and she has a 30° fixed-flexion deformity of the right knee and a 90° fixed-flexion deformity of the left knee. She walks with a waddling gait, both with and without her prostheses. This patient, as do all patients with unstable hips and weak musculature, ex-

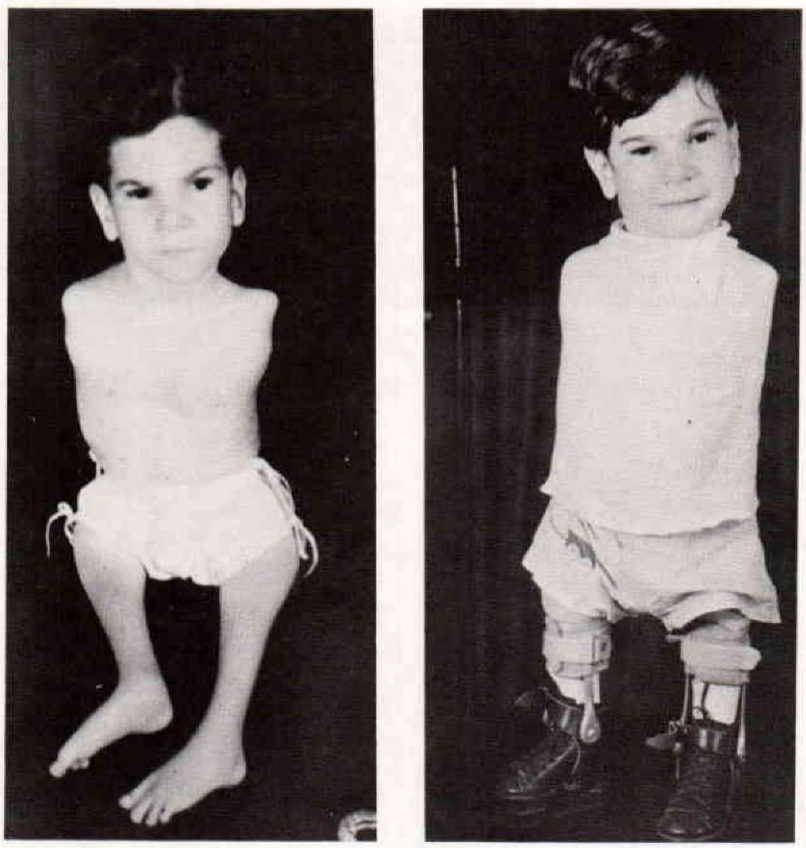

Fig. 15. Case 9, T.B., with bilateral symmetrical PFFD and upper-limb anomalies, is shown in and out of braces. He is only able to take a few steps independently. The lack of upper limbs markedly decreased the potential for ambulation. The patient has associated scoliosis.

pends a great deal of energy in using the articulated extension prostheses. Balance is an added difficulty. Despite the extended period she has worn her prostheses it is difficult to say whether she will continue to wear them in another ten, twenty or thirty years.

Case 9, T.B. (Figs. 15 and 16), is a white male born with bilateral Aitken Class C proximal femoral focal deficiencies and bilateral terminal paraxial fibular hemimelia, bilateral upper-limb amelia, right congenital torticollis resolved, and a slowly increasing right convex dorsolumbar scoliosis. The only surgical procedure was a left tendon Achilles lengthening and a posterior release for an equinovalgus deformity of the foot. He has 1½ in. of apparent shortening on the right side. Independent ambulation is limited to twelve

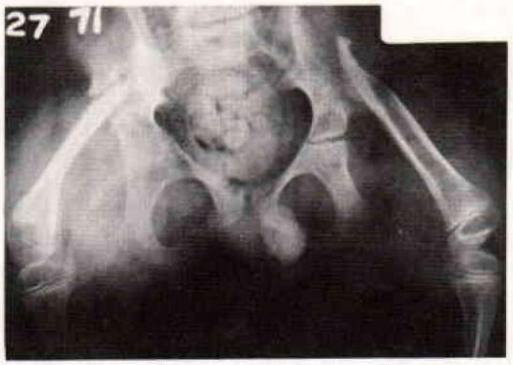

Fig. 16. X-ray of Case 9, with bilateral symmetrical PFFD Aitken Class C deformities. Note the burrowing of the right femoral remnant into the ilium. He has pain on weightbearing and no passive or active motion on the right.

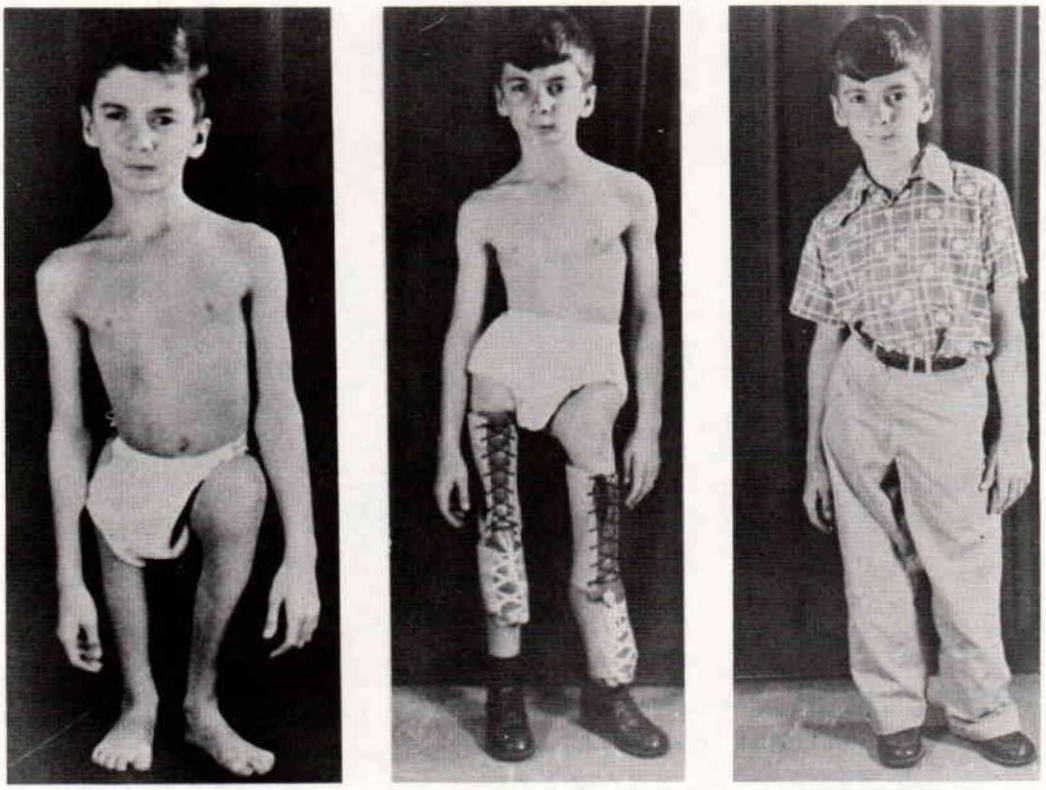

Fig. 17. Case 10, N.T. This patient with bilateral asymmetrical PFFD has both markedly short stature and progressive leg length discrepancy. At the time of this photo he was ten and a half years old with 3½ in. of shortening on the right and was 3 ft. 5 in. in height. Extension prostheses increased his height to 4 ft. 5½ in. He wears his prostheses in public, but for play and at home he removes them (11).

steps. This boy, who is of normal intelligence, relies on a CAPP electric cart to get about. Although his lower-limb involvement is no more severe than some of our other patients, he is markedly hampered by a balance problem owing to the absence of upper limbs.

BILATERAL ASYMMETRICAL PFFD

Five patients in the present series had bilateral asymmetrical proximal femoral focal deficiency. All had leg-length discrepancies of 3½ in. or more. Three of these patients had amputations and were fitted with prostheses to provide equalization of leg lengths. One had a surgical fusion of the knee on the short side and valgus osteotomy of the contralateral side where coxa vara with bowing was present. A second also had an associated valgus osteotomy of a coxa vara deformity. Two patients were treated non-surgically, the older being given an articulated extension prosthesis on the short side and an extension prosthesis on the long side. The fifth is currently only six months old.

These five patients do not represent a homogeneous entity; rather they tend to show characteristics of both unilateral and bilateral symmetrical proximal femoral focal deficiencies. M.V. (Case 11) and N.T. (Case 10) with their markedly shortened stature are very similar to the bilateral symmetrical proximal femoral focal deficiencies, yet they also have problems of leg-length discrepancy. They also had the problem of bilateral hip instability found in the bilateral symmetrical proximal femoral focal deficiencies. Three illustrative case reports follow.

Case Histories

Case 10, N.T. (Figs. 17 and 18), with bilateral asymmetrical proximal femoral focal deficiency (right Aitken Class D and left Aitken Class C deformities) had a non-segmentation of the right knee, associated scoliosis, and a hypoplastic mandible. His upper limbs were normal. He had a leg-length discrepancy which increased from 3½ in. on the right at age ten, to 4½ in. at age sixteen, at which time his height was 4 ft. 2 in. without prostheses. With bilateral extension prostheses this patient was the same height as his peers during school hours, but at home and after school he removed the prostheses and played without external support or other devices.

This case illustrates that while surgery might have been desirable because of significant leg-length discrepancy, it is not always necessary. A patient's short stature can be compensated for while his ability to get about without external aids is maintained.

Case 11, M.V. (Figs. 19 and 20), had bilateral asymmetrical proximal femoral focal deficiency (right proximal phocomelia and left Aitken Class

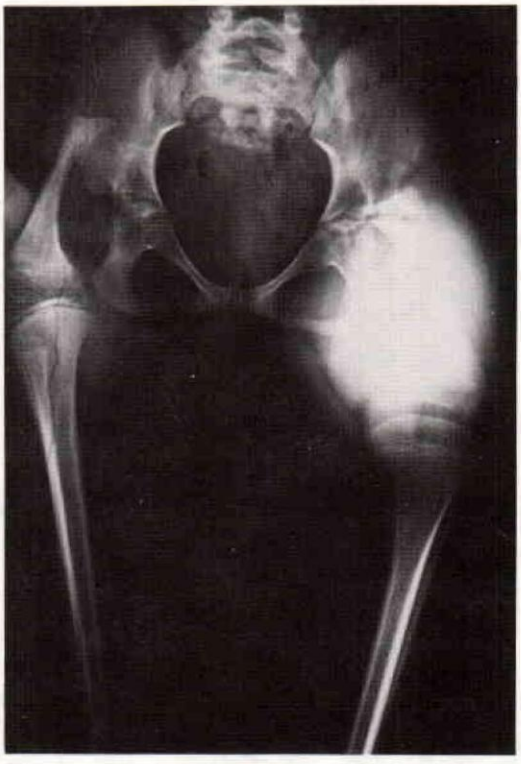

Fig. 18. Case 10; N.T. X-ray shows bilateral PFFD with a right Aitken Class D and left Aitken Class C deformities. Note proximal migration of right femoral remnant and non-segmentation of the knee which caused a functional leg length discrepancy of three and a half inches. Because of the functional and progressive discrepancy of over three inches we classified N.T. as a bilateral asymmetrical PFFD.

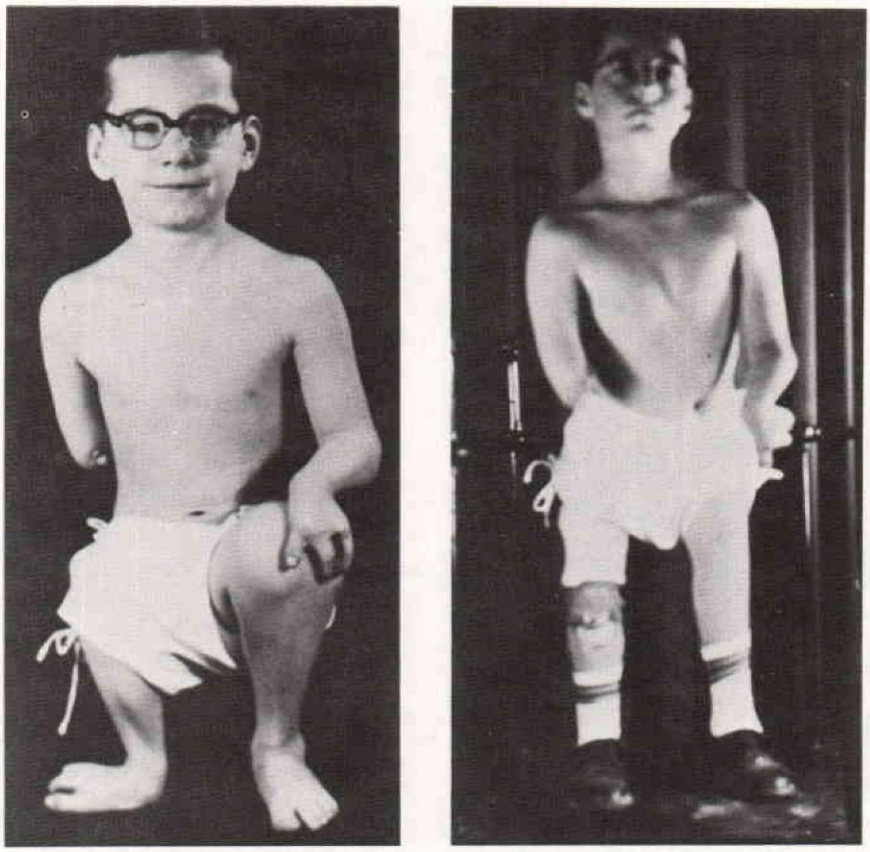

Fig. 19. Case 11, M.V. This boy has bilateral asymmetrical PFFD. At age seven he was 3 ft. 4 in. tall and had 4½ in. of shortening on the right side, but could walk independently (Fig. 10 top). At age thirteen he was five years post right Boyd amputation (Fig. 3, right). His height was 3 ft. 9½ in. with a right Syme's-type prosthesis. M. V. was fitted with a right A-K prosthesis and a left articulated extension prosthesis with increase in height to the level of his peers, but, for reasons of poor balance and marked effort, he returned exclusively to a right Syme's-type prosthesis.

C deformity). He also had an associated right terminal paraxial fibular hemimelia. The leg-length discrepancy of the right limb progressed from 3 in. at age five to 5½ in. at age eight and a half, at which time a right Boyd amputation was performed, and a Syme's-type prosthesis was fitted.

At the age of thirteen years, M.V. was given a right above-knee prosthesis and a left extension prosthesis because of his short stature, then 3 ft. 9½ in. He used these devices for approximately 2½ years during school hours, but returned exclusively to his Syme's prosthesis. At the age of fifteen he elected to use the Syme's prosthesis alone, because of the difficulty with balance and the physical effort involved in walking with the longer devices. He also had associated limb deficiencies, of a right upper terminal transverse hemimelia and a left upper terminal longitudinal incomplete paraxial ulna hemimelia.

M.V. was fully active with a right Syme's prosthesis and still had the ability to use his end-bearing stump. His height of 4 ft. 2½ in. at the age of fifteen, lack of knee motion, and instability of the hip resulted in only fair cosmesis and function. This patient's ability to use his extension prosthesis because of lack of balance and the marked effort involved point out not only the

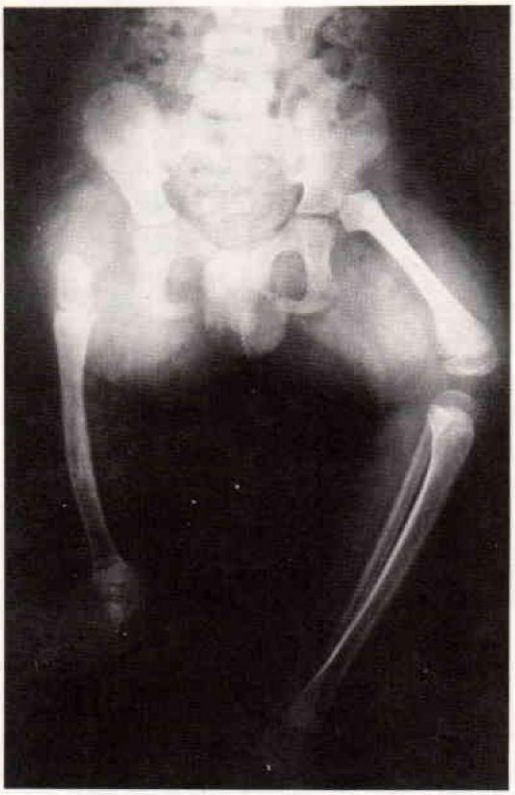

Fig. 20. Case 11; M.V. This x-ray illustrates bilateral asymmetrical PFFD with what is probably a proximal phocomelia on the right with associated fibular hemimelia. The left side was classified as Aitken Class C because of the lack of an acetabulum and definite femoral head.

importance of the upper limbs in ambulation but also the possible tragedy of bilateral amputation. M.V. was left with the option of being short but being able to walk independently. This option is not open to the patient with a bilateral amputation.

Case 12, M.G. (Figs. 21 and 22), a white male, had a left Aitken Class C proximal femoral focal deficiency and a right Amstutz Type I coxa vara with bowing deformity. He had 3½ in. of shortening on the left side at age four and a half years, and without a lift or prosthesis he walked with a severe limp. At the age of five and a half years he had a right subtrochanteric valgus osteotomy followed by a left Boyd-type amputation. He was fitted with a Syme's-type prosthesis and ambulated well but with marked inequality of knee levels and considerable instability of the left hip. At the age of eight years the right subtrochanteric valgus osteotomy was repeated. At the age of eleven years his left knee was fused and a transtibial amputation was performed above the level of the contralateral knee. He was fitted with a prosthesis incorporating a modified quadrilateral socket and hydraulic knee. He is now twelve years old, 4 ft. 9 in. high, and wears on the left side an above-knee prosthesis with ischial weightbearing. His gait is considered to be excellent.

This case illustrates several points. This child had a marked leg-length discrepancy, which was 3½ in. at age four with marked inequality of knee levels. Amputation improved his gait significantly but no improvement in inequality of knee levels or hip stability was achieved. Although this patient no longer has an end-bearing stump he wears a total-contact, ischial weightbearing socket which gives him increased hip stability and improved gait. M.G. also had contralateral coxa vara with bowing with moderate acetabular dysplasia and a conically shaped femoral head. This is the type that Amstutz would probably classify as a Type I B, and which he feels would do poorly with valgus osteotomy (*4*). As we can see from the x-rays, (Fig. 22) this child has undergone two valgus osteotomies without improvement. The head and neck are short and conical, the trochanter is above the hip joint and almost impinging on the ilium, and the acetabulum is dysplastic.

DISCUSSION

In this retrospective study of 38 patients with proximal femoral focal deficiency, we have proposed a new method of classification based on treatment considerations. For children with unilateral proximal femoral focal deficiency, classification would be on the basis of the femoral length ratios. It has been shown that while leg-length discrepancies almost always increase in patients with unilateral involvement, the growth ratios are constant. After five years of age, all patients show proportional growth (*4*). A patient with an ankle level opposite the normal knee at

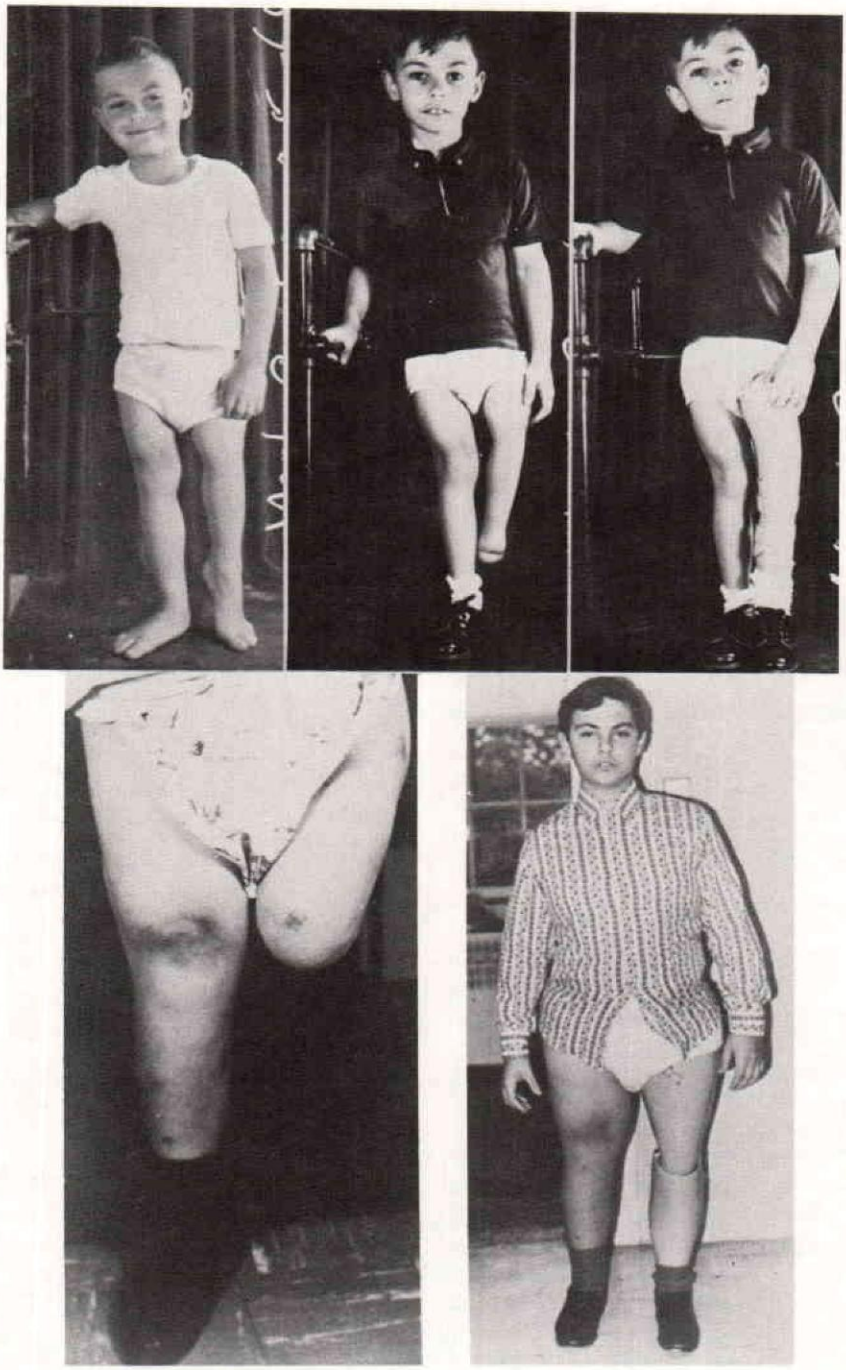

Fig. 21. Case 12; M.G. *Top left*, this boy with bilateral asymmetrical PFFD had 3½ in. of shortening at age four and a half years. *Top, center,* and *right,* at age 5½ years he had a left Boyd amputation, and was fitted with an A-K prosthesis. Note the poor cosmetic appearance due to marked inequality of knee levels. His gait was poor because of the inequality of knee levels and hip instability. Bottom photographs, at age eleven he underwent a left knee fusion and B-K amputation. Now he has an A-K prosthesis with ischial weightbearing and hydraulic knee. His cosmetic appearance and gait are considered to be excellent.

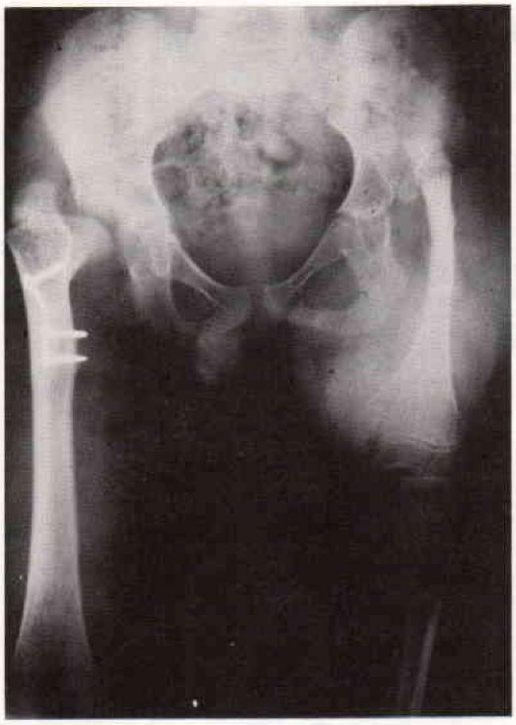

Fig. 22. Case 12, M.G. At age seven his x-ray shows a left Aitken Class C deformity. On the right the patient is post valgus osteotomy for a coxa vara with bowing. Note the very short and conical head, acetabular dysplasia and probably early subluxation; also note the marked inequality of knee levels.

age 2-5 years will probably have a similar relationship at maturity unless there is marked migration of the femoral remnant, or increase in hip- and knee-flexion deformities.

Those with short femoral segments will either have a small nubbin of femur lying completely above the ischium or lower edge of the pelvis, or have a form of femoral phocomelia or proximal phocomelia. The patients with medium femoral segments almost all had knee levels below the ischium. This led us to calculate the ratios of the distance from triradiate cartilage to ischium, and compare this to the length of normal femora in twenty five patients (Fig. 3). The age range was from 2 months to 12 years and the ratios were all from 18-24%. Thus, a patient who has a unilateral proximal femoral focal deficiency with a knee level below the ischium on the involved side will usually have a femoral segment ratio of twenty percent or greater of the normal side.

Hip instability will be a problem in these patients. The above-knee prosthesis with ischial weightbearing will markedly improve hip stability. Patients treated with rotation-plasty and below-knee prostheses will also need added support to achieve hip stability. Bevan-Thomas *(6)* has suggested a pelvic corset and lateral hinge connected to the prosthesis, and an ischial weightbearing socket. We would emphasize the latter.

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We wish to express our appreciation for the kind assistance of Mr. Hector Kay in the preparation of this paper.

REFERENCES

1. Aitken, George T., Amputation as a treatment for certain lower-extremity congenital abnormalities. *J. Bone and Joint Surg.*, 41-A:7:1267-1285, October 1959.

2. Aitken, George T., Proximal femoral focal deficiency—Definition, classification, and management, pp. 1-6, in *Proximal Femoral Focal Deficiency: A Congenital Anomaly*. National Academy of Sciences Publication No. 1734, 1969.

3. Amstutz, Harlan C., and Philip D. Wilson, Jr., Dysgenesis of the proximal femur (coxa vara) and its surgical management. *J. Bone and Joint Surg.*, 44-A:1:1-24, January 1962.

4. Amstutz, Harlan C., The morphology, natural history, and treatment of proximal femoral deficiencies, pp. 50-57, in *Proximal Femoral Focal Deficiency: A Congenital Anomaly*. National Academy of Sciences Publication No. 1734, 1969.

5. Babb, F. S., R. K. Ghormley, and C. C. Chatterton, Congenital coxa vara. *J. Bone and Joint Surg.*, 31A:115-131, January 1949.

6. Bevan-Thomas, W. H., and E. A. Millar, A review of proximal focal femoral deficiencies. *J. Bone and Joint Surg.*, 49-A:7:1376-1388, October 1967.

7. Hall, John E., Rotation of congenitally hypoplastic lower limbs to use the ankle joint as a knee. A preliminary report. *Inter-Clin. Inform. Bull.*, 6:2:3-9, November 1966.

8. Hall, John E., and Dietrich Bochman, The surgical and prosthetic management of proximal femoral focal deficiency, pp. 77-81, in *Proximal Femoral Focal*

Deficiency: A Congenital Anomaly. National Academy of Sciences Publication No. 1734, 1969.

9. King, R. E., Proving a single skeletal lever in proximal femoral focal deficiency. A preliminary case report. *Inter-Clin. Inform. Bull.*, 6:2:23-28, November 1966.

10. King, Richard E., Some concepts of proximal femoral focal deficiency, pp. 23-27, in *Proximal Femoral Focal Deficiency: A Congenital Anomaly*. National Academy of Sciences Publication No. 1734, 1969.

11. Kruger, Leon M. Classification and prosthetic management of limb-deficient children. *Inter-Clin. Inform. Bull.*, 7:12:1-25, September 1968.

12. Van Nes, C. P., Rotation-plasty for congenital defects of the femur. *J. Bone and Joint Surg.*, 32-B:1:12-16, February 1950.

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WOUND DRESSINGS: SOFT, RIGID, OR SEMIRIGID?

A Review by
Hector W. Kay[1]

In the sequence of events comprising lower-limb amputation and prosthetic restoration a number of discrete steps are readily identified:

1) the amputation itself, including the surgery, wound closure, and provision for drainage;
2) the application of a dressing of some type over the fresh surgical wound;
3) postsurgical management—which may include one or more of such considerations as exercise and other therapy modalities, provision of a temporary prosthesis, removal of sutures, and mobilization and/or ambulation of the patient;
4) provision of the definitive prosthesis and additional prosthetics training, if necessary.

The details of some of these procedures, as well as their timing, may vary in conventional amputee management, immediate postsurgical procedures, and early postsurgical procedures. This brief review focuses on the second of these considerations—the postoperative dressing applied over the wound.

THE SOFT DRESSING

In traditional amputation management the dressing typically applied to the fresh surgical wound has been "soft," i.e., comprised essentially of gauze pads and a gauze bandage. Again typically, this type of dressing has been maintained, with changes, until the wound has healed. Subsequent management might include exercise and other modalities for the residual limb, and the application of a "shrinker" sock, "Ace" bandage, or other elastic materials to prepare the stump for prosthetics fitting.

Thus the use of a "soft" dressing is ordinarily associated with "delayed" prosthetics fitting and, in the ischemic patient, with above-knee amputation. However, this is not necessarily so. Gay and Heard *(7)* have reported a high level of healing success (80-plus percent) in a series of below-knee amputations in which "soft" dressings were used in conjunction with long posterior flaps.

RIGID DRESSINGS

With the advent of "immediate postoperative fitting procedures," *(1-3,11,17-18,21-23)* considerable emphasis was placed on the application of a rigid plaster-of-Paris cast immediately after amputation. This cast, carefully applied to provide "total contact" or "total tissue support," was considered to have two prime functions:

1) The limitation of fluid accumulation (stump edema) with consequent reduction in pain and accelerated wound healing; and
2) The provision of a foundation on which, either immediately or soon, the patient could stand and bear at least part of his weight, or even ambulate, by means of a simple pylon prosthesis attached to the cast. In this way fitting of the definitive prosthesis could be expedited.

The report of a survey published in the April 1975 issue of *Newsletter . . . Amputee Clinics (6)* indicates that the use of the rigid dressing is still viewed quite positively in regard to the first of these functions, even when the second is not utilized. Details concerning various methods of applying rigid postoperative casts may be found in the references.

According to some users, rigid dressings can present difficulties as well as benefits. A summary of the pros and cons advanced by various practitioners might read as follows:

[1]Assistant Executive Director, Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education, Division of Medical Sciences, Assembly of Life Sciences, National Research Council.

ADVANTAGES

- The dimensions of the plaster cast will be the limiting factor in any increase in tissue volume.
- Stump movements, and changes in pressure across the interface associated with standing and walking, will promote beneficial reductions in stump volume.
- These pressure changes may improve blood circulation in the tissues, thus expediting wound healing.
- Psychological benefits accrue to patients through the achievement of early walking.

DISADVANTAGES

- The correct application of the postoperative cast requires specific skills, particularly if felt pads or other modifying materials are incorporated.
- If the cast is not applied correctly or if there are subsequent changes in stump dimensions, localized high-pressure areas may develop.
- Some surgeons find unacceptable the lack of easy access to the stump for inspection. Moreover, once the cast has set, changes in the environment to meet changing tissue conditions can usually only be effected by replacement of the entire cast.
- Some surgeons are inadequately trained or do not wish to take the time to apply the postoperative cast themselves in the operating room, their assistants lack the skill, and prosthetists are unwelcome or unavailable.
- Plaster casts provide limited protection against bacterial infection and little or no control of temperature and relative humidity in the immediate environment of the stump.

SEMIRIGID DRESSINGS

In attempts to obtain the benefits of rigid dressings without the attendant difficulties, a number of wound-encasement substitutes for postoperative procedures have been tried recently. It is these substitutes that we are referring to as "semirigid" dressings. Two lines of approach are discernible, Unna paste and the air splint.

UNNA PASTE

Although we understand that Unna paste has been available and in use for about 50 years, its values have been stressed most recently and most strongly by Ghiulamila and his co-workers *(8,9,13)*. Originally the paste was prepared by combining one part zinc oxide, two parts gelatin, three parts water, and four parts glycerin, and heating the mixture in a double boiler until it became smooth. The warm paste was brushed over succeeding layers of gauze applied to the limb remnant. Now, however, bandages impregnated with a similar paste (Dome Paste Bandage) are available commercially. Once applied, this bandage acts as a liner which is soft but inextensible, thus maintaining the shape of the stump. Over it a temporary prosthesis can be fitted.

A brief abstract of the technique of application as described by Dr. Ghiulamila for below-knee amputations follows. Interested readers are referred to the complete text of the referenced publications.

After the skin is closed in the operating room, the suture line is covered with one layer of nonadherent gauze or Telfa. For below-knee amputations the stump is wrapped with Unna paste and bandage applied directly over the skin from the distal end to the junction of the middle and proximal thirds of the thigh. Typically, two Dome Paste Bandages 2 in. wide by 10 yd. long are used. The wrap must be applied with a complete absence of folds.

After the first bandage has been applied, protective felt pads are placed over the medial and lateral sides of the stump and the patella, as is done in the rigid casting by the Seattle method *(24)*. The felt pads adhere easily and firmly to the first layer of Unna bandage while the second layer is wrapped in the same manner (Figs. 1-A through 1-F).

For above-knee amputations three bandages are needed to wrap the stump and include the pelvis in a spica.

Application of the Prosthesis

Since the semirigid bandage will not permit any swelling or change in stump shape, the prosthesis may be fitted immediately in the recovery room.

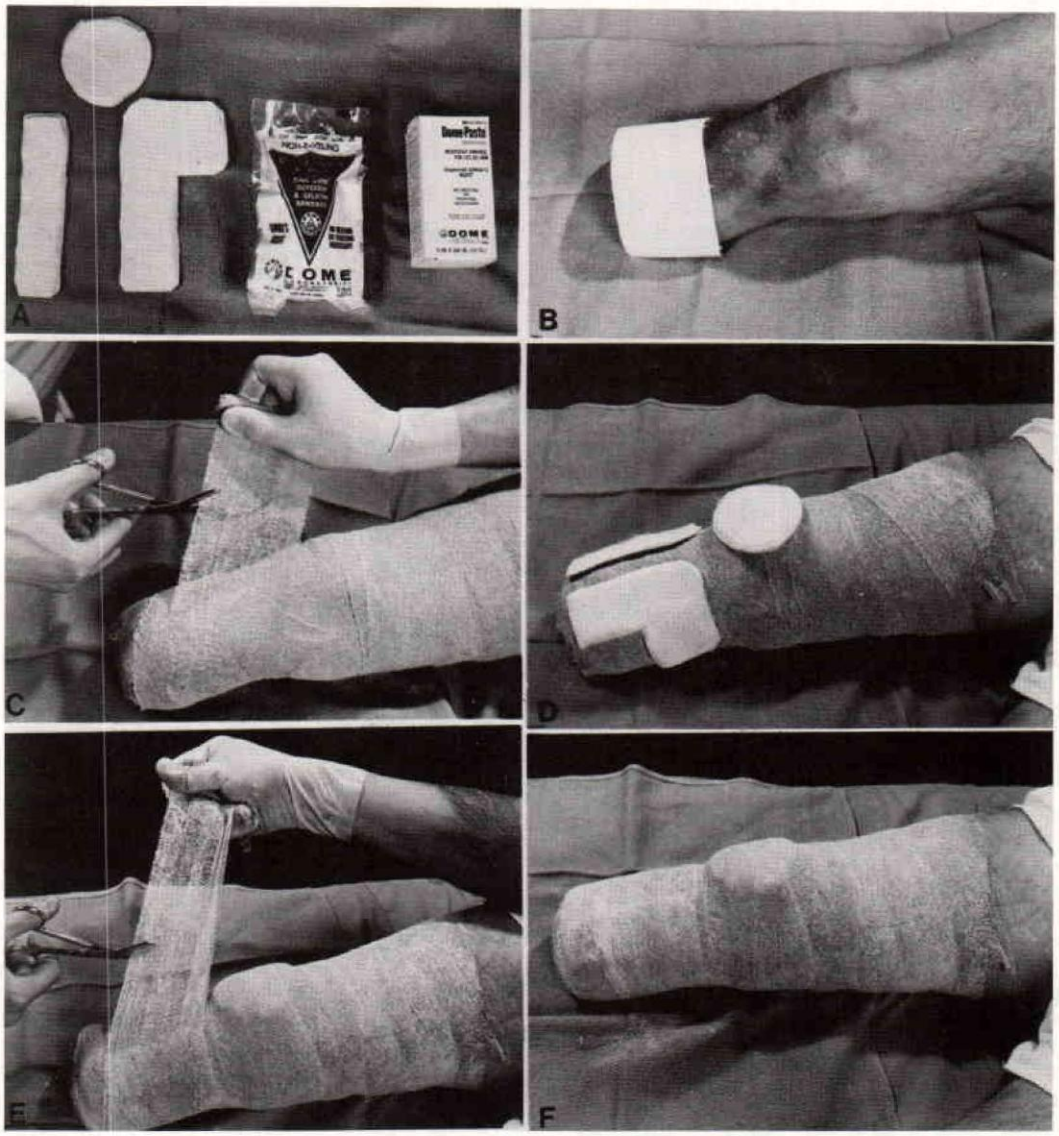

Fig. 1-A. Material: two Unna paste bandages and felt pads.
B. Gauze dressing is placed over the incision.
C. One Unna paste bandage is applied to the skin over the stump and cut to avoid any folds.
D. Felt pads are positioned to protect the skin at pressure points.
E. Second Unna paste bandage is applied to hold the felt pads in place, avoiding any irregularity.
F. Completed semirigid dressing.

However, in these circumstances the moist bandage must be covered with talcum powder and stockinette. Or the prostheses may be fitted on the following day or subsequently. Under these circumstances the bandages are left to dry and the knees maintained in the extended position so as to avoid creating any folds in the bandage. In the cases cited by Dr. Ghiulamila, the prosthetist fitted the amputee 24 to 48 hours after amputation, thus was not involved in the operating

schedule. The type of prosthesis fitted was a temporary patellar-tendon-bearing device with a Polysar socket *(21,23)* for below-knee amputations (Fig. 2). A prefabricated quadrilateral socket adapted to a modular unit with a manual-locking knee is used for above-knee amputations (Fig. 3).

Fig. 2. Patient with vascular insufficiency 3 days post right BK amputation. Unna paste bandage with felt pads and temporary prosthesis with a Polysar socket and SACH foot. The patient had previously a left BK amputation treated with the same technique.

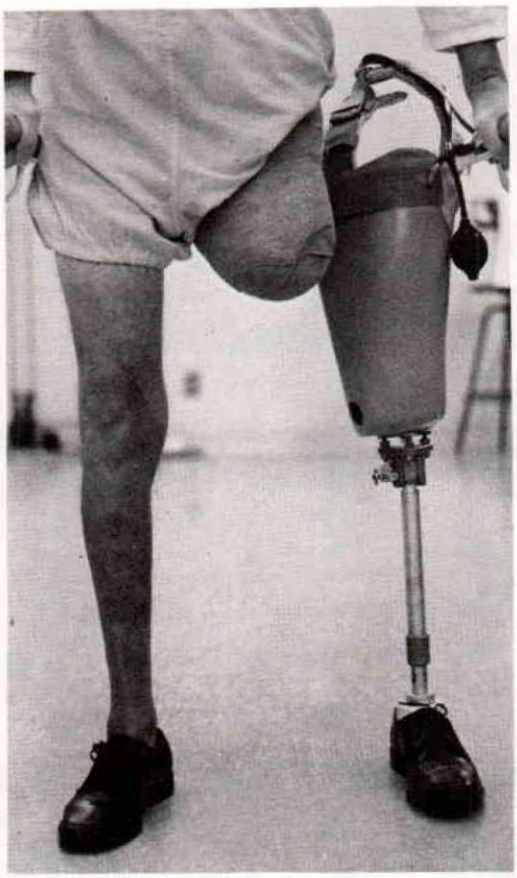

Fig. 3. Patient with left AK amputation 10 days post surgery. Unna paste bandage and temporary prosthesis with prefabricated socket, inflatable bladder, and modular unit (Cosmevo).

With the Unna paste bandage serving as a liner in the temporary prosthesis, according to Dr. Ghiulamila, the patient can begin standing between parallel bars with progressive weight-bearing instituted almost immediately.

For removal of the drain or inspection of the suture line, the tip of the bandage can be cut with scissors. After removal or inspection, the borders of the cut end can be taped in place. For removal of sutures, or if bleeding occurs, it is recommended that the bandage be completely replaced.

AIR SPLINTS

Little

The use of a plastic air splint as a compressive and weight-bearing component in a temporary prosthesis first came to our attention in the writings of J. M. Little *(14,15,16)*. The device described can be used both as an immediate and as a temporary prosthesis. It is said to be easy to use, requiring little training on the part of rehabilitation personnel. Essentially the temporary prosthesis consists of a plastic pneumatic bag and a rigid aluminum frame to which a SACH foot is attached by means of a telescopic fitting (Fig. 4).

Fig. 4. Two parts of a temporary prosthesis, showing plastic air splint and aluminum frame. The length of the prosthesis and the direction of the SACH foot can be adjusted.

A simple modification allows the prosthesis to be used by above- as well as below-knee amputees.

After the amputation has been completed a light dressing of one layer of rolled cotton-wool is held in place by one or two bandages. No drains are used. The specifically designed air splint (A. & L. Company, Sydney, Australia[2]) is placed around the stump and its length adjusted to match the sound limb (Fig. 5). The splint is then inflated to a pressure of 25 mm Hg and left in place for 48 hours. The pressure is checked several times each day. At the end of 48 hours the splint is

[2]The frame and foot for the temporary prosthesis is also supplied by this company.

[3]Jobst-Jet Air Splint, obtainable from Jobst Institute, Inc., 653 Miami Street, P.O. Box 653, Toledo, Ohio 43694; Park Davis ReadiSplint, obtainable from Park Davis and Company, 205 Flanders Road, Westborough, Massachusetts 01581.

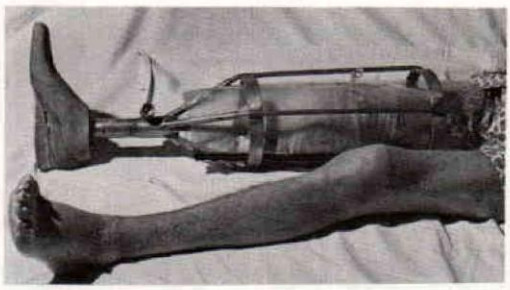

Fig. 5. Prosthesis in place on amputation stump, which has been placed so that its lower end is at the level of the lower ring of the aluminum frame.

removed and the stump dressing is reinforced with another layer of cotton-wool and additional bandages. On the following day the splint is reapplied *(sic)*. The patient is then assisted from the bed into a walking frame. For increased comfort the splint pressure may be increased to approximately 30 mm Hg to prevent vascular pooling. Supported by the walking frame the patient learns to make touchdown contact with the ground. Subsequently, limited walking is allowed in the frame (Fig. 6).

Full weight-bearing is possible with the present splint design. Balance training can begin within the first days after amputation; however, since the splint functions essentially as a pylon, proper gait training is not really possible.

Kerstein

Kerstein *(12)* agrees in principle with the values of early ambulation facilitated by a rigid dressing. However, he stresses the difficulties attendant upon the lack of a fully-trained and available team and ready access to the postoperative wound.

As an alternative, Dr. Kerstein proposes the use of a "long-leg" air splint[3] following below-knee amputation. The splints he uses were originally designed for immobilization of the lower limb following fracture (Fig. 7). Low cost, ease of application, and ability to view the wound are cited as appealing factors.

As described by Dr. Kerstein, the application technique appears to combine the air splint with basic rigid-dressing procedures, as follows:

1) Following completion of the amputation procedures a sterile dressing is applied to the site. Fluffed gauze or lamb's wool is

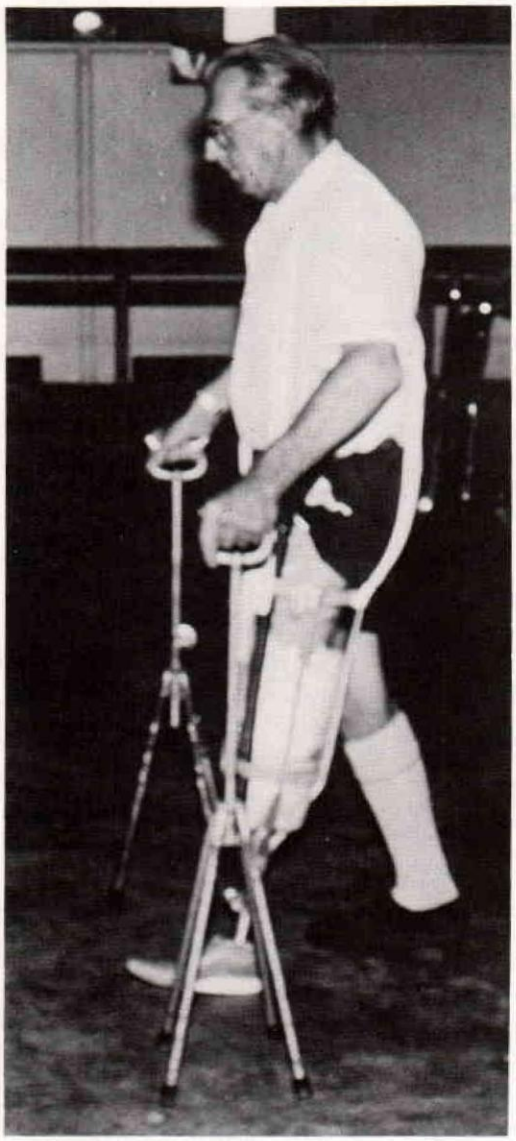

Fig. 6. Weight-bearing on prosthesis.

placed over the operative wound, and a sterile Orlon lycra stump sock is rolled over the dressing. As in the Seattle-type technique, the sock is carefully applied so as to avoid damage to suture lines and is held under firm tension with the primary pull applied on the anteroproximal aspect of the thigh.

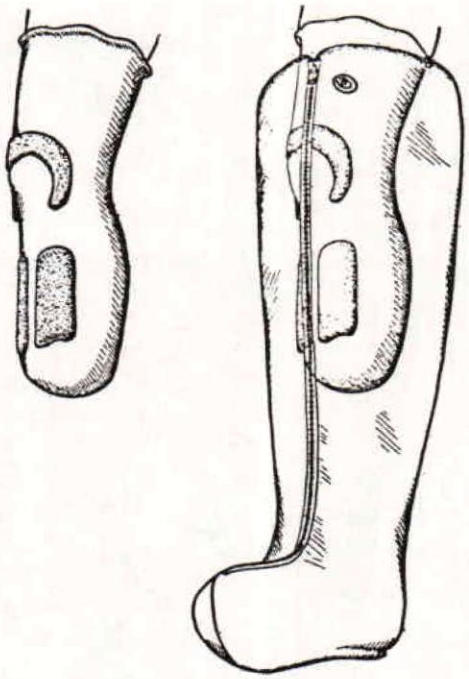

Fig. 7. *Left,* schematic drawing of below-knee amputation with application of an Orlon lycra stump sock and felt pads as reliefs on either side of tibia and above the patella. *Right,* application of pneumatic inflatable splint, inflated, over below-knee stump, with ability to view dressing.

2) Felt or polyurethane relief pads may be applied to the appropriate areas to relieve pressure. Again as in the Seattle procedure, these pads are applied medially and laterally to the tibial crest, and a horseshoe-shaped pad is applied in the suprapatellar region.
3) The "long-leg" air splint is applied and inflated to a pressure of 25 mm Hg, or until resistance is noted on oral insufflation. The air splint is adjusted to the length of the opposite leg and extends to mid-thigh. It is of clear plastic and incorporates the design of a leg and foot. A zipper on the interior surface facilitates application. The below-knee stump is literally encompassed in a double wall of plastic. The stump sock aids in the absorption of perspiration.

At the time of his report Dr. Kerstein had utilized the air splint on 11 male patients with satisfactory results.

Sher

Sher *(20)* describes the use of an air splint that appears to be very similar to the one discussed by Kerstein. In Sher's technique, however, neither felt pads nor an objectively measured pressure are used (Fig. 8).

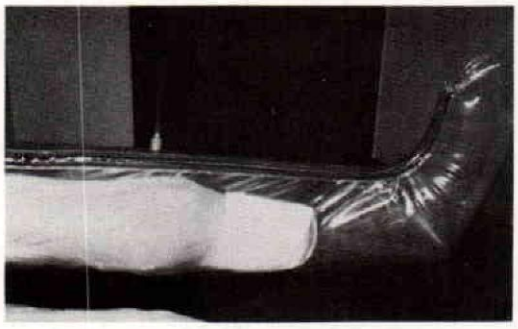

Fig. 8. Air splint applied to amputation stump. Note molding of lining to stump.

A CONTROLLED ENVIRONMENT

A provisional report recently received from R. G. Redhead *(4,19)* describes an ongoing "Post-Operative Wound Management" project at the Biomechanical Research and Development Unit (BRADU), Roehampton, England. The objective of this project was to develop a postoperative wound "dressing" that would require no skill to apply; that would permit the surgeon to have an accurate control of such parameters as pressure on the wound and surrounding tissues, and the temperature and relative humidity of the environment immediately adjacent to the enclosed limb; and that would ensure that the conditions around the wound were bacteriologically sterile at all times.

It was required that the dressing permit visual observation of the wound and indirect palpation through the covering of the dressing without jeopardizing the sterility of the wound environment.

The BRADU system of wound treatment incorporates a control console (Figs. 9-A and 9-B)

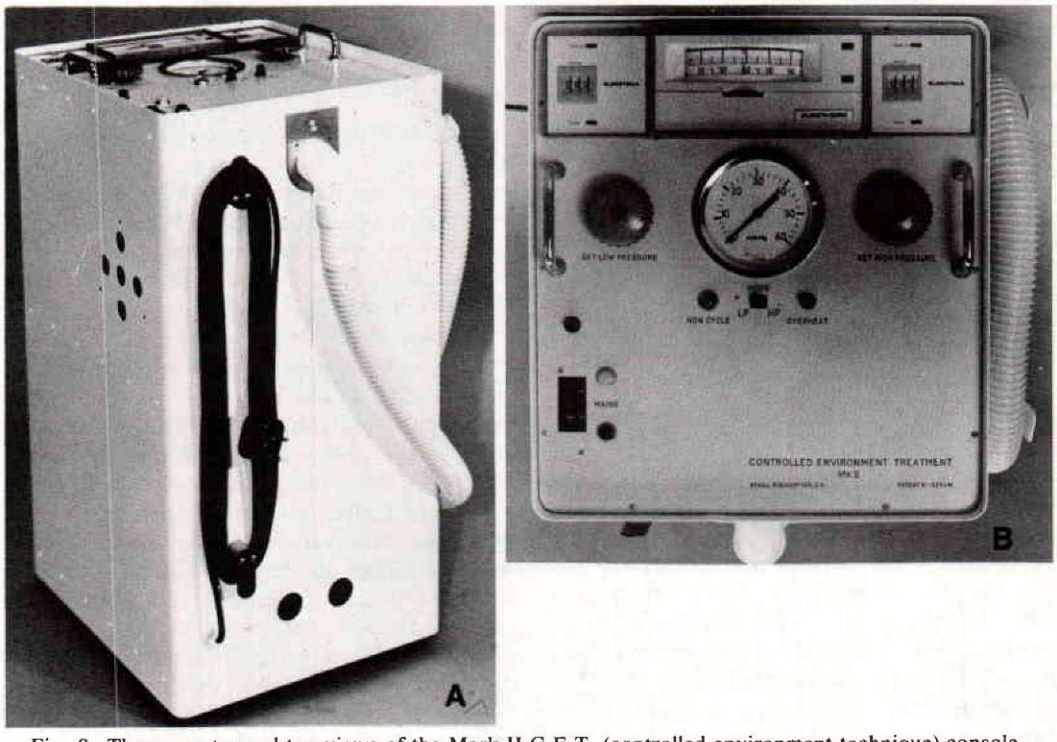

Fig. 9. Three-quarter and top views of the Mark II C.E.T. (controlled-environment technique) console.

containing a multistage centrifugal air compressor, from which the air passes via pressure-control valves and pressure-cycle timing devices to a bacteriological filter. From the filter the now sterile air passes over a thermostatically controlled heating element which raises the air temperature to the required level and also reduces the relative humidity. From there the air passes to the "dressing bag" through a length of flexible hose.

The dressing bags are made of clear flexible PVC in a variety of sizes at present suitable for use on the upper limbs following injury or surgery involving the hand and distal forearm, and for use on the lower limbs following below-knee or through-knee amputations (Fig. 10). The bags incorporate a pleated-type air seal at their proximal end. The seal maintains the raised air pressure within the dressing, without exerting a "tourniquet" effect on the limb, yet allows the escape of some air to provide ventilation for humidity and temperature control of the wound environment.

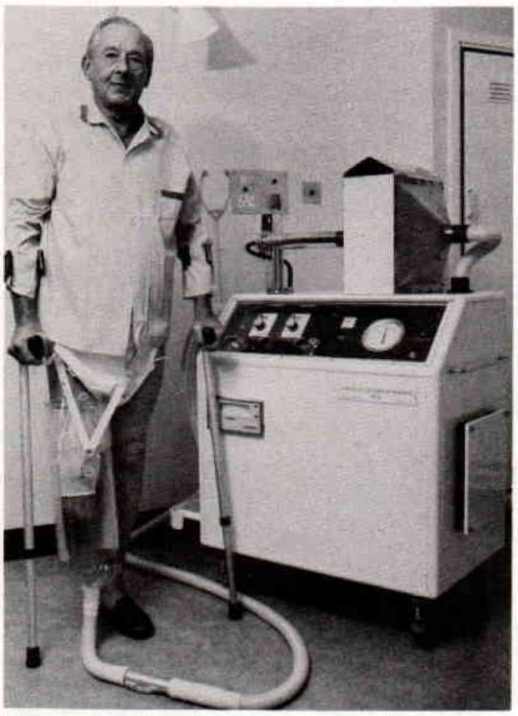

Fig. 10. A patient, 5 days after amputation, standing beside a Mark 1B C.E.T. console.

The dressing bag is kept in place on the patient by means of a lightweight webbing harness.

As soon as possible after the amputation has been completed, the limb is placed in the dressing bag and the controlled environment treatment program started. Of particular interest to this reviewer was a provision in the program for alternating "high" and "low" (air) pressures applied to the stump. These pressures and their durations varied with the time lapse after operation.

No values, actual or potential, are claimed for these pressure variations. Nevertheless, one cannot help being struck by the similarity, in principle at least, to the word reported recently by Hardt *(10)*. The abstract of Hardt's report states: "In New Zealand rabbits, pulses of pressure (70 mm of mercury at two-second intervals) applied by a pneumatic tourniquet placed about the leg and connected to an animal respirator consistently increased femoral nutrient vein blood flow 16 to 150 percent when the pulses were superimposed on an ambient pressure of 5 mm of mercury, while the same pulses superimposed on an ambient pressure of 20 mm of mercury consistently reduced blood flow 25 to 59 percent."

CONCLUSIONS

There appears to be general (but not universal) agreement as to the values of rigid plaster-of-Paris dressing applied to an amputation stump immediately following surgery. Control of edema, a lessening of pain, and faster healing of the wound are claimed whether postsurgical ambulation is "immediate," "early," or "delayed."

To obtain these benefits other materials which are said to require less skill in application than plaster of Paris have been tried with increasing frequency. The techniques involving these alternate materials appear quite promising. According to its proponents, the procedures involving Unna paste have yielded consistently satisfactory results, while those using air splints appear particularly promising from the point of view of simplicity. These devices apparently can be used with or without extensive wound dressings, with or without modifying materials such as felt pads; and the air pressure exerted on the limb remnant can be controlled. An additional facet of great interest is the possibility that controlled fluctua-

tions in the circumambient pressure may increase blood circulation and expedite healing. In fact, it begins to appear that air splints might be used in two distinct but possibly connected applications:

1) Solely in the promotion of healing. Here the condition might be that the patient is at rest, i.e., in bed or in a chair. Pulses of higher pressure (70 mm Hg at two-second intervals) might then be superimposed on a basically low ambient pressure (5 mm Hg) *a la* Hardt and Redhead. Edema would presumably be controlled and blood circulation enhanced.
2) As a means of getting the patient upright in order to practice balancing, partial weight-bearing, etc. Here the pressure in the splint would apparently need to be in the range of 25-30 mm Hg. Edema would be controlled in this application also, but presumably the stimulus to circulation would be less.

The possibility of changing from one set of pressure conditions to the other as circumstance might indicate is intriguing.

In concluding this review it is appropriate to underscore a point made by Victor Cummings *(5)*. He remarks that a widespread but false assumption is that the rigid dressing is applied primarily as a prelude to early weight-bearing, early ambulation, early prosthetics rehabilitation, and hence early discharge from hospital. These factors, while of value if they can be achieved, should be considered "fringe benefits" rather than prime purposes. According to Dr. Cummings, the prime aim in applying a rigid dressing immediately after surgery is *to enhance healing of the amputation stump.*

LITERATURE CITED

1. Berlemont, M., R. Weber, and J. P. Willot, Ten years of experience with immediate application of prosthetic devices to amputees of the lower extremities on the operating table. *Pros. International*, 3:8, 1969.

2. Böhler, L., Die Technik der Knochenbruchbehandlung, 12-13 Auflage. W. Maudrich, Wien, Austria, Vol. I, p. 125, 1953.

3. Burgess, E. M., R. L. Romano, and J. H. Zettl, Management of lower extremity amputations. Prosthetic and Sensory Aids Service, Veterans Administration, TR 10-6, August 1969.

4. Controlled environment post operative wound management equipment. Biomechanical Research Development Unit (BRADU), Dept. of Health and Social Security, Roehampton, England, January 1974.

5. Cummings, V., Immediate rigid dressing for amputees—advantages and misconceptions. *New York State J. of Med.*, 74:980-983, June 1974.

6. Gauging the progress: A survey of IPSF and EPSF procedures. *Newsletter . . . Amputee Clinics*, VII: 2: 4-6, 8-12, April 1975.

7. Gay, R., and G. Heard, Long posterior flap below-knee amputation for obliterative vascular disease of the lower limb. *I. J. Med. Science*, Vol. 141, No. 1-3, January, February, March 1972.

8. Ghiulamila, R. I., Immediate post-surgical fitting of the lower extremity amputee with semi-rigid dressing and temporary prosthesis. Proceedings, Internationaler Kongress Für Prothesentechnik und Funktionell Rehabilitation, Wien, Austria, March 24, 1973.

9. Ghiulamila, R. I., Semirigid dressing for post-operative fitting of below-knee prosthesis. *Arch. Phys. Med. and Rehab.*, Vol. 53, April 1972.

10. Hardt, A., Effects of external limb compression on bone blood flow in rabbits. *J. Bone and Joint Surg.*, 56-A:7:1488-1492, October 1974.

11. Harris, E. E., Early prosthetic rehabilitation. *Ann. Roy. Coll. Surg. Eng.*, 40:4:262-272, April 1967.

12. Kerstein, M. D., Utilization of an air splint after below-knee amputation. *Amer. J. of Phys. Med.*, 53:3:119-126, 1974.

13. Laforest, N. T., and L. W. Regon, The physical therapy program after an immediate semirigid dressing and temporary below-knee prosthesis. *Phys. Ther.*, Vol. 53, May 1973.

14. Little, J. M., L. Gosling, and A. Weeks, Experience with a pneumatic lower-limb prosthesis. *Med. J. Australia*, 1:1300-1302, June 1972.

15. Little, J. M., A pneumatic weight-bearing temporary prosthesis for below-knee amputees. *The Lancet*, pp. 271-273, February 6, 1971.

16. Little, J. M., The use of air splints as immediate prostheses after below-knee amputation for vascular insufficiency. *Med. J. Aust.*, 2:870-872, November 1970.

17. Marsden, F. W., Limb loss and limb replacement: a new confidence. *Med. J. Aust.*, 1:132-133, January 1973.

18. Mooney, V., J. P. Harvey, Jr., E. McBride, and R. Snelson, Comparison of postoperative stump management: plaster vs. soft dressing. *J. Bone and Joint Surg.*, 52-A:241-249, March 1971.

19. Redhead, R. G., The problems of the post-operative "stump/environment interface." Proceedings, Internationaler Kongress für Prothesentechnik und Funktionell Rehabilitation, Wien, Austria, March 24, 1973.

20. Sher, M. H., The air splint—an alternative to the immediate postoperative prosthesis. *Arch. of Surg.*, Vol. 108, May 1974. Copyright 1947, American Medical Association.

21. Staff, Veterans Administration Prosthetics Center, Direct forming of below-knee patellar tendon-bearing sockets with thermoplastic material. *Orth. & Pros.*, 23:36-61, March 1969.

22. Vitali, M., and R. G. Redhead, The modern concept of the general management of amputee rehabilitation including immediate postoperative fitting. *Ann. Roy. Coll. Surg. Eng.*, 40:4:251-260, April 1967.

23. Wilson, A. B., Jr., Evaluation of synthetic balata for fabricating sockets for below-knee amputation stumps. *Artif. Limbs*, 14:56-62, Autumn 1970.

24. Zettl, Joseph H., and Joseph E. Traub, Premodified casting for the patellar-tendon-bearing prosthesis, *Art. Limbs*, **15**:1:1-14, Spring 1971.

Orthotics and Prosthetics, Vol. 29, No. 2, pp 69-70, June 1975

TECHNICAL NOTE

THE ZOROC TECHNIQUE FOR EARLY OR CHECK FITTING AND ALIGNMENT OF LOWER-LIMB PROSTHESES

Zoroc is a nonelastic, resin-filled, plaster bandage made by Johnson and Johnson and is available from all Johnson and Johnson dealers. Zoroc is not expensive, and is handled in the same manner as ordinary plaster-of-Paris bandages, so there is no new handling technique to be learned. Zoroc is available in three widths: 3, 4, and 6 in. A Zoroc socket can be used in the fitting and alignment of a prosthesis so that a laminated plastic socket is not required. This is a method which, in some instances, will permit the prosthetist to cast, measure, modify and set up on an adjustable leg, and to fit and align an amputee in a single day.

The characteristics of Zoroc make it very useful in prosthetics. Zoroc can be handled like plaster bandage, and can be dried rapidly in an oven without impairing its strength. In fact, it can be used in place of a laminated plastic socket for fitting. It can be split along the anteroposterior plane for below-knee sockets and along the mediolateral plane for above-knee sockets for enlarging or reducing the size of a socket. Furthermore, it can be ground down to increase volume or built up with leather, plaster bandage, R.T.V., and other plastics to decrease the volume. Because of its strength and light weight, a Zoroc socket can be used as a check socket for final fittings and aligning. This, in turn, assures a properly fitted laminated socket and eliminates the need for extra thickness to allow later reliefs by grinding and the undesired extra weight this will cause.

The normal course in provision of a prosthesis to an amputee requires at least three appointments:

1) Casting and measuring (followed by making the socket and setting up the prosthesis).

2) Fitting and aligning (followed by alignment duplication and finishing).

3) Delivering the final prosthesis.

The Zoroc Technique can eliminate one appointment by combining Steps 1 and 2.

The materials are:

1) Plaster bandage (Orthoflex and/or regular)
2) Zoroc plaster bandage
3) Parting agent (Tincture Green Soap)
4) Ambroid lacquer and brush
5) Bucket of water
6) Casting equipment

The procedure is:

1) Take a cast of the stump.

2) Coat the inside of the cast with parting agent and fill with plaster. Modify the positive cast in the normal way. It is not necessary to prepare the cast as meticulously as would be the case for a lamination. Relief can be made with plaster bandage, hard felt, or leather stapled or tacked into place. The smoothing can be carried out after the fitting.

3) Coat the modified positive cast with parting agent and wrap with Zoroc plaster bandage that has been *thoroughly* saturated with water. Begin the wrap at the superior one-third of the cast using approximately two layers of material and continue with one layer over the remainder of the cast. If a suction valve is needed, it should be applied at this time.

4) Apply added layers of Zoroc bandage to areas which need to be strengthened, such as joint areas and where the socket might need to be relieved. Zoroc when cured has approximately the same relative strength as that of a laminated polyester and nylon lay-up. Therefore, the thickness of the wrap should be approximately the same as you would have in the laminated socket.

5) Apply layers of Zoroc bandage over the entire cast until the socket is the desired thickness.

6) After the socket has set up, a single cut can be made the entire length of the socket with a cast saw. On below-knee sockets, cut on the posterior side, and on above-knee sockets cut on the medial side.

7) Index the socket with respect to the cast and separate them, being careful not to distort the socket during the process.

8) Bring the cut edges together and hold them in place with a splint of Zoroc bandage, as well as a proximal and distal wrap.

9) Place the Zoroc socket in an oven and allow to cure for 30 min. at 275° F. or 45 min. at 250° F.

10) Remove from oven and allow to cool.

11) Trim and sand the socket edges. Apply a coat of ambroid to the interior surface. In the case of a suction socket, apply a second coat of ambroid to insure a seal as well as to provide a smoother surface. Allow each coat to dry 10 min.

The socket is now ready for attachment to the adjustable leg. The Zoroc socket can be attached to an adjustable leg as easily as a laminated socket can be attached. Suspension devices can be attached with rivets, screws, or "gunk." Once dynamic alignment has been achieved, the adjustable leg should be checked to insure that all adjustments are tight and that it is indexed if it must be broken down into its components.

The limb is now ready to be shipped to the central fabricator for duplication into a laminated socket with the required components and the achieved alignment, or to be finished in one's own facility. If central fabrication is used, be sure to include a completed measurement chart for information regarding components, such as knee-shin setup, foot, swing-phase unit, joints, etc.

If there are any questions, please write or call:

D. O. Haney
477 Orto, P.O. Box 8469
San Jose, CA 95155 Tel: (408) 295-6700

NEW PUBLICATIONS

THE ALLIED HEALTH PROFESSIONAL AND THE PATIENT, by Ruth Purtilo. W. B. Saunders Company, Philadelphia, Pennsylvania, 1973, 229 pp., $5.95.

This book is written by a physical therapist, and a reader is bound to feel the impact of her background. However, there is a great deal of application to prosthetics and orthotics if the reader substitutes "prosthetist/orthotist" for "therapist," and "prosthetics/orthotics facility" for "hospital or institution."

The goal of the book is to build effective bridges between theory and practice of effective interaction for the allied health professional. It is designed for the student and proposes to aid him in three areas: 1) Enhancing his understanding of himself, 2) helping him to understand the dynamics of the health professional-patient relationship, and 3) developing his awareness of the complementary roles of other health professionals. The author states that her intended readers should be college-level people.

Part I, "The Allied Health Professional," deals largely with helping a student determine whether or not he might choose to work in this field.

Part II, "The Patient," develops the problems of the patient and delineates very well the points which should be understood by those attempting to aid in his recovery.

Part III, "Determinates of Effective Interaction Between Allied Health Professional and Patient," contains three subdivisions: 1) Verbal Communications, 2) Non-Verbal Communications, and 3) Cultural and Personal Biases as Determinates of Effectiveness.

Part IV, "The Allied Health Professional-Patient Relationship," is one of the most important sections of the book as it deals with the problems of showing proper concern, responsibility, securing respect, and gaining the confidence of the patient — walking the tightrope between being professional and being personable.

Part V, "Effective Interaction with the Elderly Patient," covers an area with which the orthotist and prosthetist are increasingly concerned. It covers the biological and intellectual processes of aging as well as the psychological processes and problems of working with the older patient.

Part VI, "Effective Interaction with the Patient who has Terminal Illness," the final chapter, perhaps has greater meaning for nurses and therapists because they have more continuing contact with such patients, but all prosthetists and orthotists not infrequently have to be in contact with patients who do not have long to live. This section should aid in insight for the reader.

The reviewer feels that this is an excellent book for students in the allied health field and that it should be a part of the studies of students entering the prosthetics-orthotics profession.

H. Blair Hanger

INFORMATION FOR AUTHORS

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2. BIBLIOGRAPHY. This should be arranged alphabetically and cover only references made in the body of the text.
3. LEGENDS. List all illustration legends in order, and number to agree with illustrations.
4. ILLUSTRATIONS. Provide any or all of the following:
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   b. Original drawings or charts

   Do *not* submit:
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   b. Photocopies

PREPARATION OF MANUSCRIPT

1. Manuscripts must be TYPEWRITTEN, DOUBLE-SPACED and have WIDE MARGINS.
2. Indicate FOOTNOTES by means of standard symbols (*).
3. Indicate BIBLIOGRAPHICAL REFERENCES by means of Arabic numerals in parentheses (6).
4. Write out numbers less than ten.
5. Do not number subheadings.
6. Use the word "Figure" abbreviated to indicate references to illustrations in the text (. . . as shown in Fig. 14)

PREPARATION OF ILLUSTRATIONS

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2. On the back indicate the top of each photo or chart.
3. Write the author's name on the back of each illustration.
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5. Use care with paper clips; indentations can create marks.
6. Do not write on prints; indicate number, letters, or captions on an overlay.
7. If the illustration has been published previously, provide a credit line and indicate reprint permission granted.

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RESOLUTION CONCERNING THE METRIC SYSTEM

The following resolution was adopted by the Board of Directors of the American Orthotic and Prosthetic Association at its meeting in San Diego October 3, 1973:

WHEREAS by Act of Congress it has been determined that the United States should proceed towards adoption of the metric system as used almost universally throughout the rest of the world, and

WHEREAS the technological professions and many segments of the health professions have commonly used the metric system over an extended period of time, and

WHEREAS it is important for members of the orthotic/prosthetic professions to interact with their colleagues in the medical and technological communities for optimum patient service be it hereby

RESOLVED that the American Orthotic and Prosthetic Association endorses the use of the metric system by its members and other orthotic and prosthetic practitioners in the United States, and in witness of this endorsement and Association urges the editors of its journal *Orthotics and Prosthetics* to commence the dual reporting of weights and measurements in both the English and metric systems at the earliest possible date with the objective of employing the metric system solely by the time of the 29th Volume in 1975.

METRIC SYSTEM
Conversion Factors

LENGTH

Equivalencies

angstrom	= 1 x 10^{-10} meter (0.0 000 000 001 m)
millimicron*	= 1 x 10^{-9} meter (0.000 000 001 m)
micron (micrometer)	= 1 x 10^{-6} meter (0.000 001 m)

To Convert from	To	Multiply by
inches	meters	0.0254†
feet	meters	0.30480†
yards	meters	0.91440†
miles	kilometers	1.6093

AREA

To convert from		
square inches	square meters	0.00063616†
square feet	square meters	.092903

VOLUME

Definition

1 liter = 0.001† cubic meter or one cubic decimeter (dm^3)
(1 milliliter = 1† cubic centimeter)

To convert from	To	Multiply by
cubic inches	cubic centimeters	16.387
ounces (U.S. fluid)	cubic centimeters	29.574
ounces (Brit. fluid)	cubic centimeters	28.413
pints (U.S. fluid)	cubic centimeters	473.18
pints (Brit. fluid)	cubic centimeters	568.26
cubic feet	cubic meters	0.028317

MASS

To convert from	To	Multiply by
pounds (avdp.)	**kilograms**	**0.45359**
slugs‡	kilograms	14.594

FORCE

To convert from	To	Multiply by
ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).
†For practical purposes all subsequent digits are zeros.

STRESS (OR PRESSURE)

To convert from	To	Multiply by
pounds-force/square inch (psi)	newton/square meter	6894.8
pounds-force/square inch (psi)	newton/square centimeter	0.68948
pounds-force/square inch (psi)	kilogram-force/square centimeter	0.070307

TORQUE (OR MOMENT)

To convert from	To	Multiply by
pound-force-feet	newton meter	1.3559
pound-force-feet	kilogram-force meters	0.13826

ENERGY (OR WORK)

Definition

One joule (J) is the work done by a one-newton force moving through a displacement of one meter in the direction of the force.

1 cal (gm) = 4.1840 joules

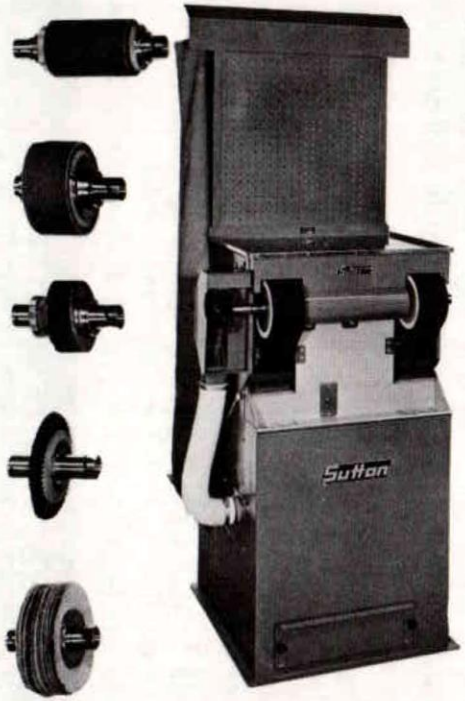
To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	1×10^{-7}†
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

To convert °F to °C $\quad °C = \frac{°F - 32}{1.8}$

°F	°C
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

*A slug is a unit of mass which if acted on by a force of one pound will have an acceleration of one foot per second per second.



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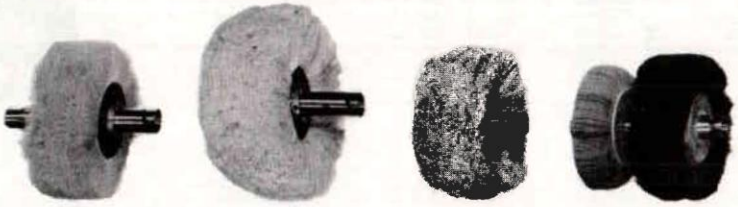

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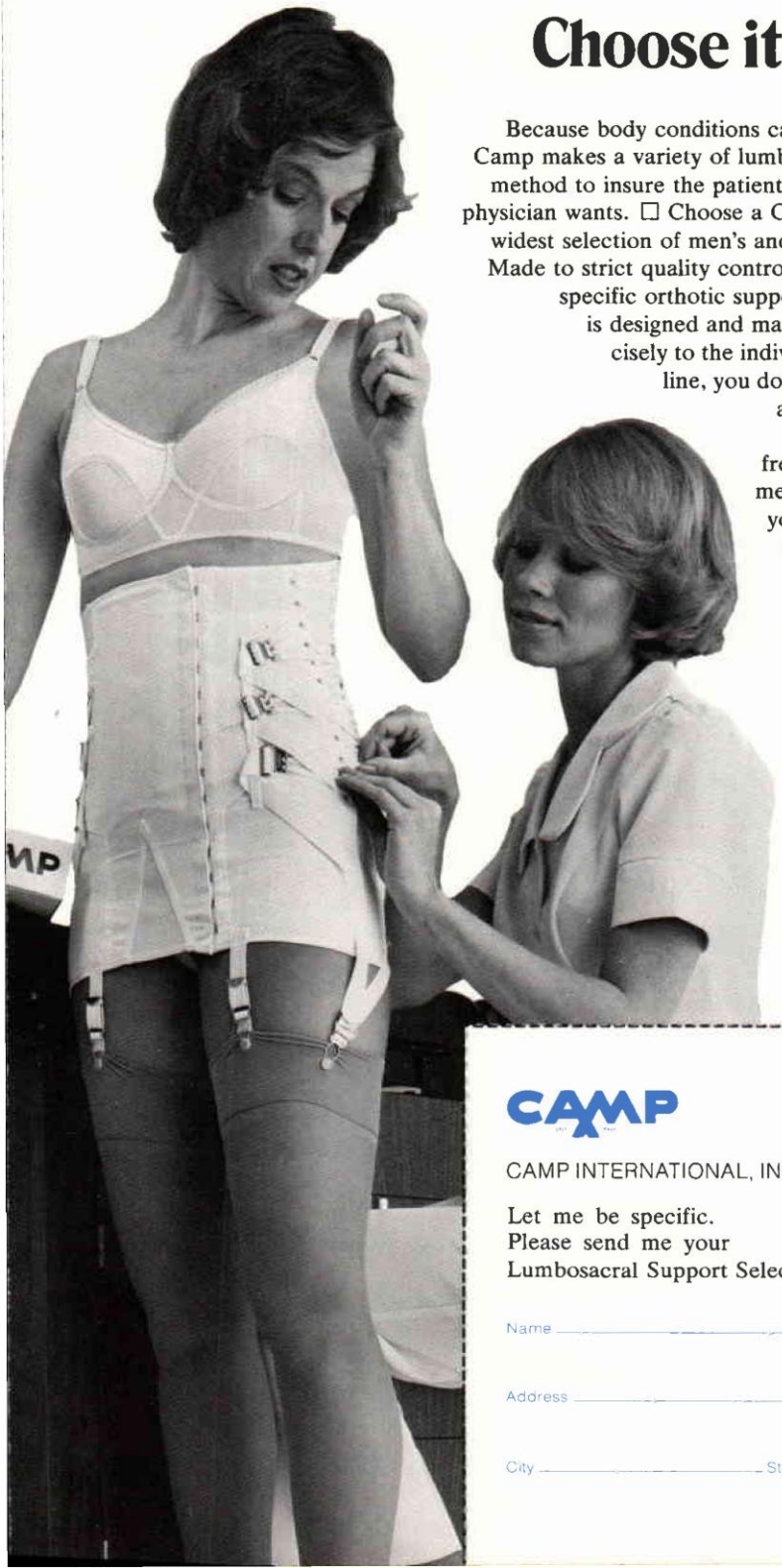

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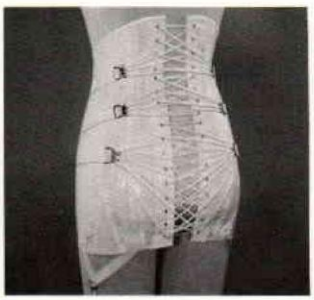

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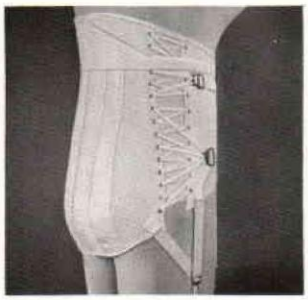

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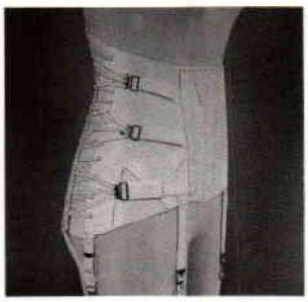

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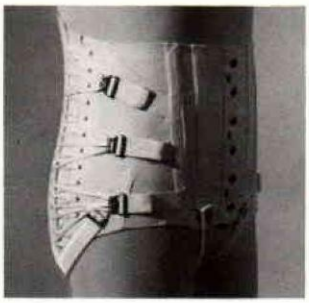

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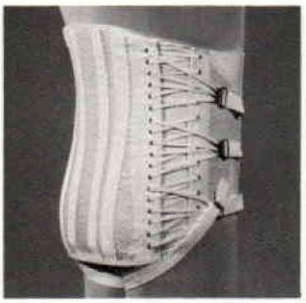

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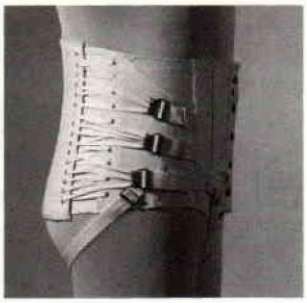

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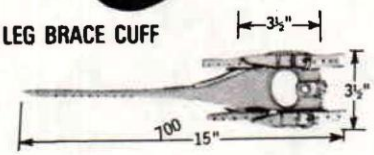

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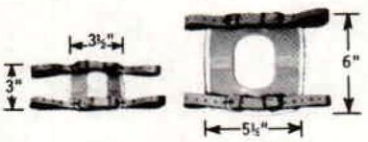

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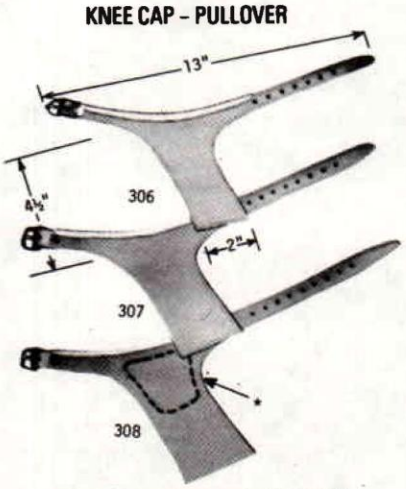

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