JUNE 1974

Orthotics and Prosthetics

FOUNDED 1917

Orthotics and Prosthetics

VOLUME 28, NUMBER 2 JUNE 1974

Orthotics and Prosthetics is issued in March, June, September and December. Subscription price, payable in advance, is $10.00 a year in the Western Hemisphere. Rate elsewhere is $11.00 a year. Single issues, $3.00 each. Publication does not constitute official endorsement of opinions presented in articles. The Journal is the official organ of the publisher, The American Orthotic and Prosthetic Association in collaboration with the American Academy of Orthotists and Prosthetists, and serves as the U.S. organ for Interbor. All correspondence should be addressed to: Editor: **Orthotics and Prosthetics,** 1440 N St., N.W., Washington, D.C. 20005. Telephone, Area Code 202, 234-8400.

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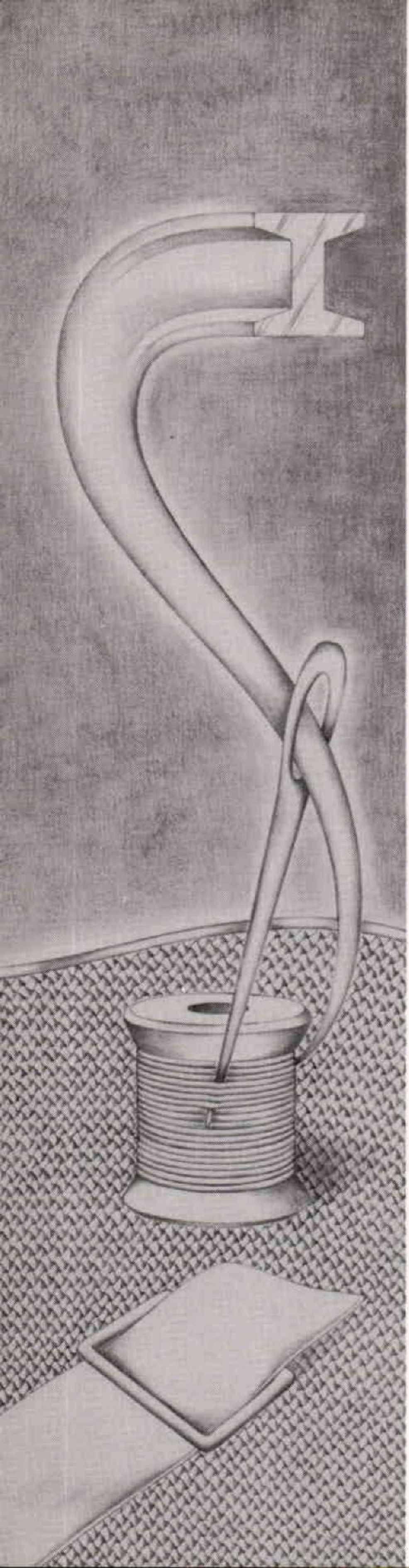

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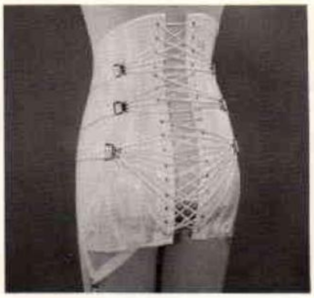

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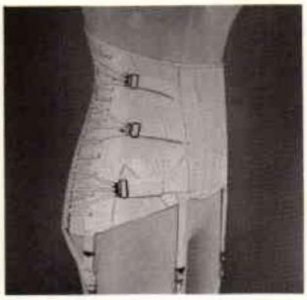

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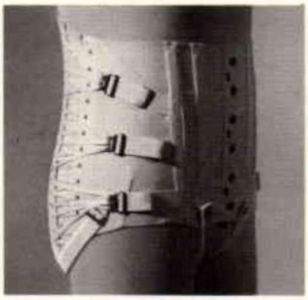

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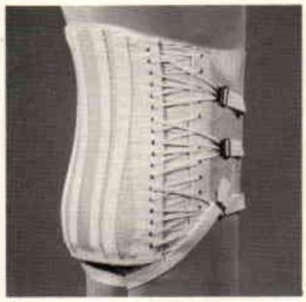

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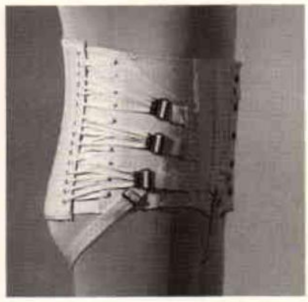

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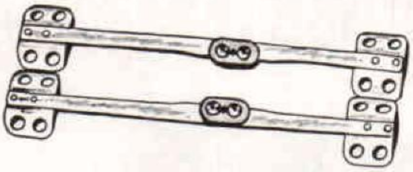

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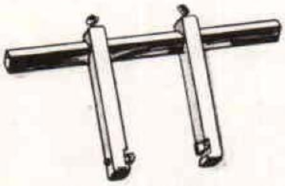

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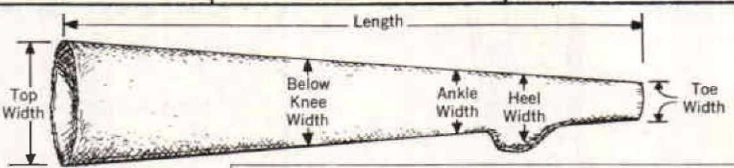

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35″	9″	5″	4″	6″	3½″
39″	9″	5″	4″	6″	3½″
42″	9″	5″	4″	6″	3½″
46″	9″	5″	4″	6″	3½″
46″	10″	6″	4½″	6½″	3½″

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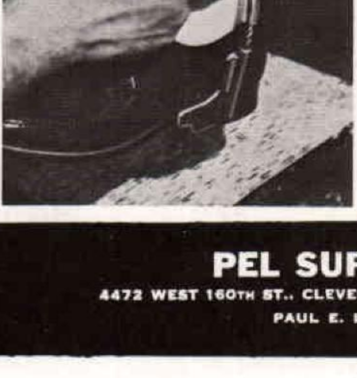

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Orthotics and Prosthetics, Vol. 28, No. 2, p. 1, June 1974

QUALITY ⇄ PROFESSIONALISM

Quality of service, quality of production, and quality of attention to detail all are hallmarks of professionalism. This simple, seemingly altruistic statement applies equally to orthotics and prosthetics, just as it does to medicine, science, engineering, law, and any number of other like callings throughout the world.

In orthotics and prosthetics it has been heartening to observe the increasing recognition of these fundamental precepts by practitioners. The day of the wood-shop-type operation is virtually over. It has been replaced by the neatly arranged facility in which orthotists and prosthetists along with their assistants and technicians render a high level of patient service in a clinic-type setting.

It therefore becomes just as important for the organizations representing these professions to reflect this enhanced professionalism and attention to quality, not only in member services, but also in publications such as "Orthotics and Prosthetics." This aspect became a particularly important mission of the National Office during 1973, and quickly led to a major redesign in the format of the journal and a concomitant effort to upgrade the technical articles appearing therein. Equally important, though, was a resolve to improve the journal's appearance still further, not only in terms of making it a more contemporary looking publication, but to add a new dimension of quality to the way in which articles were presented.

After a maturing process of more than a year, it now appears that those efforts have paid off. The most recent major step was selection of an alternate printing firm in the nation's capital which has an enviable reputation for its publication activities. Readers who compare these 1974 issues with those in 1973 will become aware of this transition in such matters as crispness of type, more balanced page layout, better reproduction of graphics, and the like.

Even with these accomplishments, however, your editors and administrators are continually on the lookout for still better ways in which to enhance the quality of AOPA's official publication. You, the readers, can help by calling attention to areas for improvement, by communicating with the editors on both the format and technical presentations, and perhaps most importantly by informing your professional colleagues through contributed articles of innovative technology which could lead to improved services for the orthopedically disabled.

David A. H. Roethel
Executive Director

Orthotics and Prosthetics, Vol. 28, No. 2, pp. 3–13, June 1974

PLASTIC SPIRAL ANKLE-FOOT ORTHOSES[1]

Hans Richard Lehneis, C.P.O.[2]

Two configurations of plastic spiral ankle-foot orthoses (AFO) have been developed at the Institute of Rehabilitation Medicine (IRM), New York University Medical Center, to provide control of the ankle-foot complex in many neuromuscular conditions that result in weakness or paralysis of the ankle and foot. They are the spiral AFO and the hemispiral AFO.

These spiral configurations in their present form are the result of work over the past approximately seven years (1) (3). The stages of design and development and detailed rationale of design are not elaborated upon in this paper. Rather, indications, contraindications, description of design and fabrication procedures are summarized here (5) (6) (7). The fabrication procedures described are not intended by any means as a substitute for formal courses of instruction in this technique.

THE SPIRAL AFO

The spiral AFO (Fig. 1) is believed to provide controlled motions in all planes; that is, adaptation to transverse rotation, as well as motions in the frontal and sagittal planes. The spiral portion of the orthosis originates from the medial side of the footplate, passes around the leg posteriorly, and terminates at the level of the medial tibial condyle. A horizontal band is attached to the spiral at the level of the calf. The thermoplastic used in the construction of the orthosis is SADUR[3], an amber-colored, acrylic-nylon material. The spiral configuration represents a new and unique concept which obviates the need for metallic joints, yet permits controlled plantar flexion and dorsiflexion. The spiral unwinds on weight-bearing to permit plantar flexion. Removal of body weight results in rewinding of the spiral, thus dorsiflexing the foot. Following the midstance phase, the spiral is stressed progressively, increasing resistance toward dorsiflexion. Thus, the spiral orthosis assists push-off following heel-off, as the stressed spiral returns to its original configuration.

Adaptation of the orthosis to transverse rotation is based on the principle of the spiral helix—that is, unwinding and rewinding of the spiral produces transverse rotation. In addition, controlled eversion and inversion of the ankle is provided by the application of the three-point pressure system inherent in the spiral configuration. The performance of the orthosis described so far is possible not only due to the design configuration but also because of the properties of the plastic used. SADUR possesses excellent memory; that is, instantaneous return to the molded, unstressed position. It is, therefore, not necessary during casting to predorsiflex the foot. Alignment of the major joints in the lower limb in the sagittal plane is thus maintained in the normal relationship; that is, the long axis of the leg should be at 90 deg. with respect to the floor, with the shoe on. This alignment, together with the dorsiflexion resistance provided by the spiral, accounts for the ability of this orthosis to influence anteroposterior control of the knee.

Indications for use of the spiral AFO are:

1. Motor weakness affecting all compartments of the ankle-foot complex which may be flaccid or mild to moderately spastic.
2. Medial-lateral instability during stance or swing phase of walking.
3. Slightly diminished motor power at the knee in addition to motor weakness at the ankle.

[1] This study is supported in part by Grant Number 23-P-55029/2-03 from the Social and Rehabilitation Service, Department of Health, Education, and Welfare.

[2] Director, Orthotics and Prosthetics, Institute of Rehabilitation Medicine, New York University Medical Center, 400 E. 34th Street, New York, N.Y. 10016

[3] Teufel Company, Stuttgart, Germany

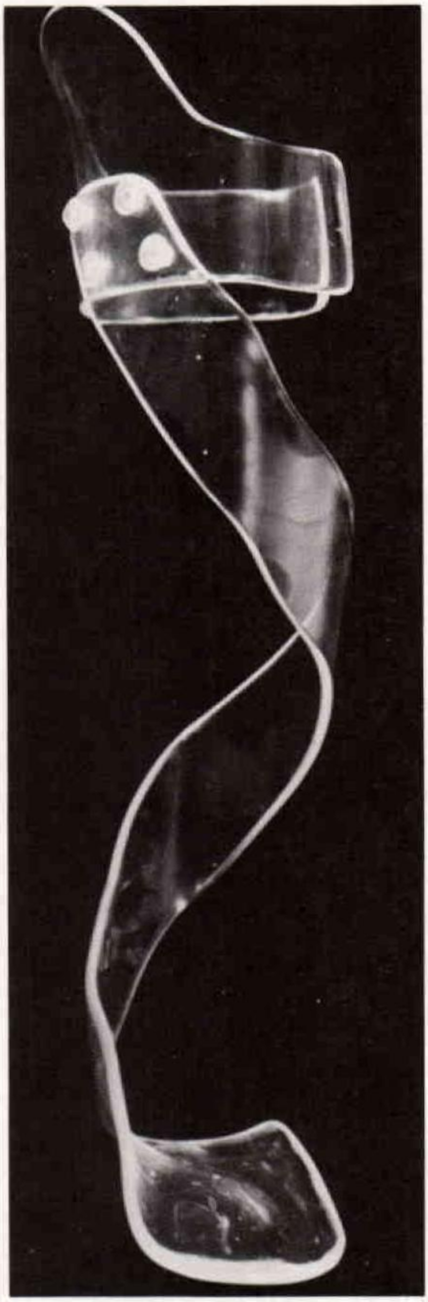

Fig. 1. Anterior view of spiral AFO.

4. Loss of proprioception at the ankle.

Contraindications for use of the spiral AFO are:

1. Pronounced imbalance of forces acting on the ankle-foot complex.
2. Greater than moderate spasticity.
3. Fluctuating edema.
4. Fixed deformities.

CASTING PROCEDURES

For casting, foot-casting boards which correspond to the heel heights of the shoe to be worn are required (Fig. 2). The head of the fibula and the medial malleolus and any bony prominences on the foot, such as the base of the fifth metatarsal, are marked on the tube gauze stocking with indelible pencil (Fig. 3).

The limb is wrapped with plaster bandages in two stages. First, the foot and ankle are wrapped to midshank; the foot is then placed on the appropriate foot board and manipulated in such a way as to provide the proper toe-out, eversion-inversion control and forefoot alignment. The foot is held in this position until the plaster hardens. At the same time the shank should be aligned so that a vertical line connects the medial condyle of the knee with the medial malleolus. An alignment reference rod inserted in the casting board will assist in this procedure (Fig. 4).

In the sagittal plane the shank should be held vertically. After the plaster hardens place both hands around the proximal portion of the shank with both thumbs pointing toward the patella (Fig. 5). The purpose of this maneuver is to shape the calf triangularly through displacement of the underlying tissue. The index finger of one hand must be at the level of the neck of the fibula, while the thenar eminence of the same hand identifies

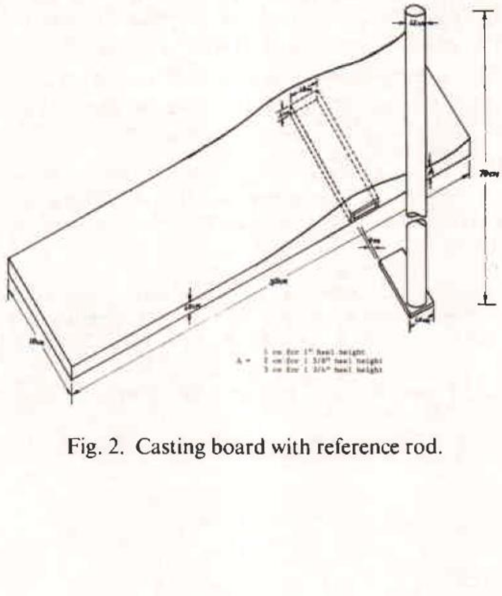

Fig. 2. Casting board with reference rod.

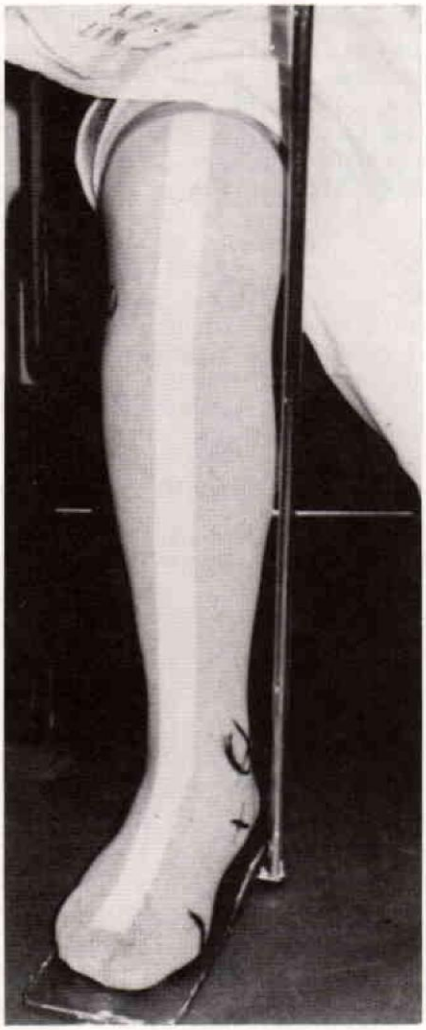

Fig. 3. The leg, with tube gauze in place, ready for casting.

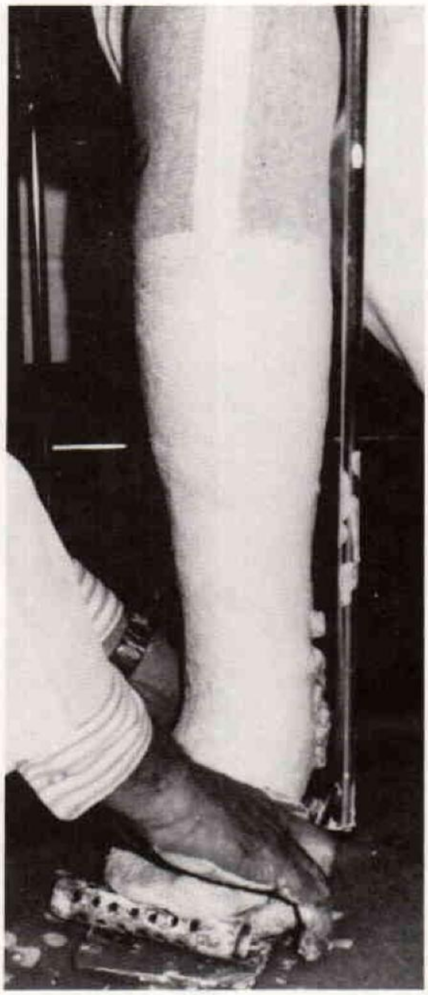

Fig. 4. Positioning the foot during casting.

the soft tissue area between the crest of the tibia and the shaft of the fibula. The thenar eminence of the opposite hand must be firmly pressed against the medial portion of the shaft of the tibia. Posteriorly, the fingers of both hands opposing the thenar eminences must exert firm forward pressure to provide a triangular cross section of the cast in that area with the posterior portion flattened along with relief for the crest of the tibia. Hand pressure must be maintained until plaster hardens. The resulting negative cast is thus functionally shaped and a minimum of modifications of the positive model are needed.

MODIFICATION OF THE POSITIVE MODEL

The longitudinal arches are shaped by removing 6 mm of plaster under the area of the sustentaculum tali and continuing toward the lateral longitudinal arch, tapering toward 3 mm plaster removal in the lateral longitudinal arch across from the sustentaculum tali (Fig. 6). The metatarsal arch is then shaped by removing at least 15 mm of plaster at the apex of the metatarsal arch, i.e., under the second metatarsal ray and about 20 mm proximal to the metatarsal heads (Fig. 6). A well-shaped metatarsal support is very

Fig. 5. Shaping the plaster bandage at the proximal portion during casting.

Fig. 6. Sketch indicating areas on the plantar surface of the male model that require modification.

important since the reaction point of the dorsiflexion-assist force is at the distal termination of the orthosis.

In the soft tissue area between the crest of the tibia and the shank of the fibula, 6 mm of plaster are removed starting 15 mm distal to the head of the fibula and extending to a point halfway between the neck of the fibula and the lateral malleolus. At the level of the medial tibial flare 4 mm of plaster are removed (Fig. 7). No further plaster removal is required except smoothing of the popliteal area. A flat if not a concave popliteal area is maintained. Six mm buildups are required in bony areas previously marked on the foot. After the entire cast has been smoothed, one or two coats of parting lacquer are applied.

MOLDING PROCEDURE

The calf band of the precut spiral kit[4] (Fig. 8) is placed in a preheated oven for a few minutes

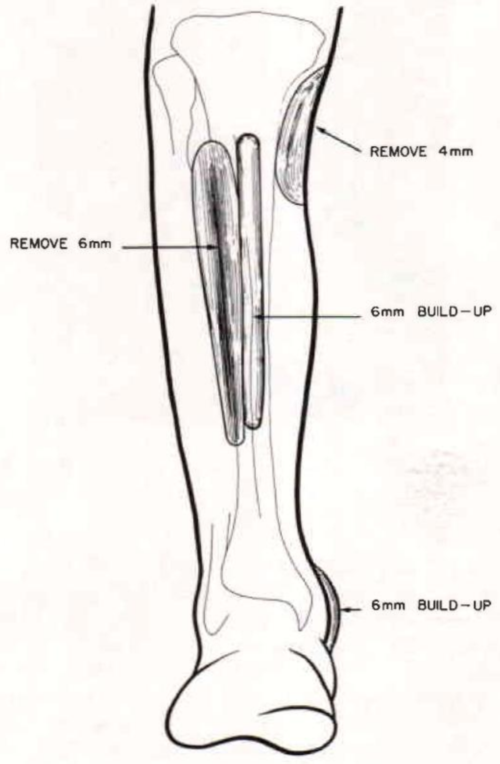

Fig. 7. Sketch indicating areas on the leg part of the male model that require modification.

[4] Manufactured by the Teufel Co., Stuttgart, Germany. Available through distributors also.

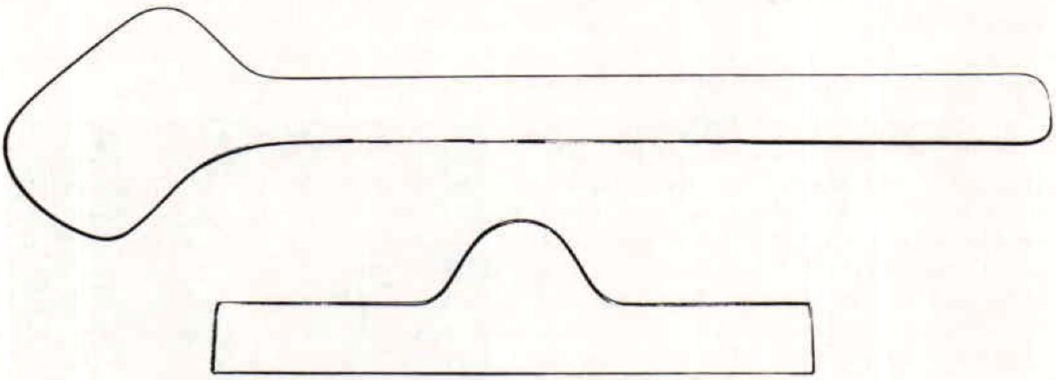

Fig. 8. Shape of SADUR parts needed for the spiral AFO.

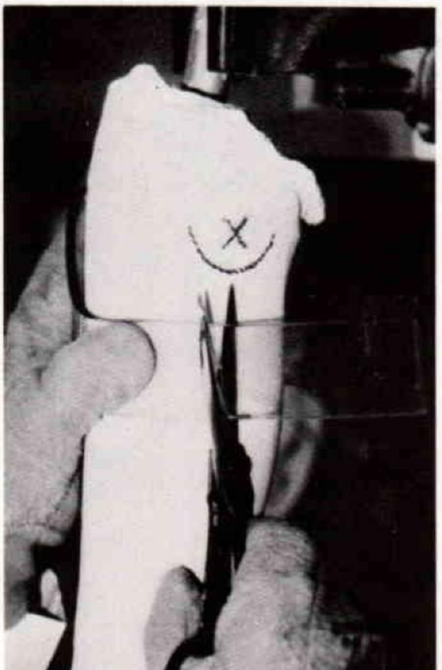

Fig. 9. Trimming the SADUR calf band.

at 140 deg. C until the calf band is limp. It is then placed on the cast with the lateral opening 20 mm distal to the neck of the fibula. Any overlap in this area is cut off with a pair of scissors (Fig. 9). The medial upper projection of the calf band should cover the medial tibial flare. A felt pad is placed over the area of the concavity between the shaft of the fibula and the crest of the tibia and the entire calf area is wrapped with an Ace bandage. When calf area is cooled, the Ace bandage is removed and the heated spiral blank with the footplate is placed on the cast so that the spiral portion extends from the medial longitudinal arch with the anterior border coinciding with the apex of the medial malleolus (Fig. 10). An extra large metatarsal pad is positioned on the footplate over the area of the metatarsal arch and held in place with an Ace bandage that is wrapped from the metatarsal area up to the ankle area. Once the footplate is held in place properly, the spiral portion is wrapped around the leg overlapping it with the medial portion of the calf band. A felt pad over the concavity in the midshank area is placed between the crest of the tibia and the shaft of the fibula to provide a "locking

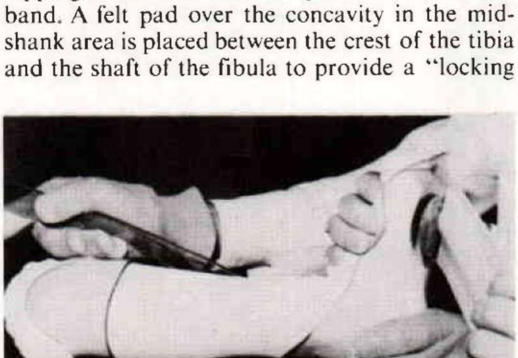

Fig. 10. Applying the SADUR spiral piece.

channel," and the entire leg cast is wrapped with additional Ace bandages.

ASSEMBLY

After the spiral has cooled sufficiently, four holes are drilled in the area of the overlap of the spiral and the calf band. A China marker is used to indicate the proximal edge of the spiral, which should be 40 mm proximal to the distal edge of the calf band and parallel to it. A mark is made on the footplate 6 mm proximal to the heads of the metatarsals. The lateral trim line of the footplate is marked as well as a line indicating the posterior distal edge as a continuation across the footplate at a point 25 mm posterior to the apex of the medial longitudinal arch and perpendicular to the long axis of the foot (Fig. 11). The components are removed from the cast and the edges are finished with a sand cone, Tycro wheel and fine sandpaper, and then buffed. The four holes previously drilled are countersunk on the inside of the calf band, and shrink-expansion rivets are introduced with the shank protruding into the countersink. Each rivet is heated with a heat gun with funnel attachment to expand the shank and thus fasten the spiral to the calf band securely (Fig. 12).

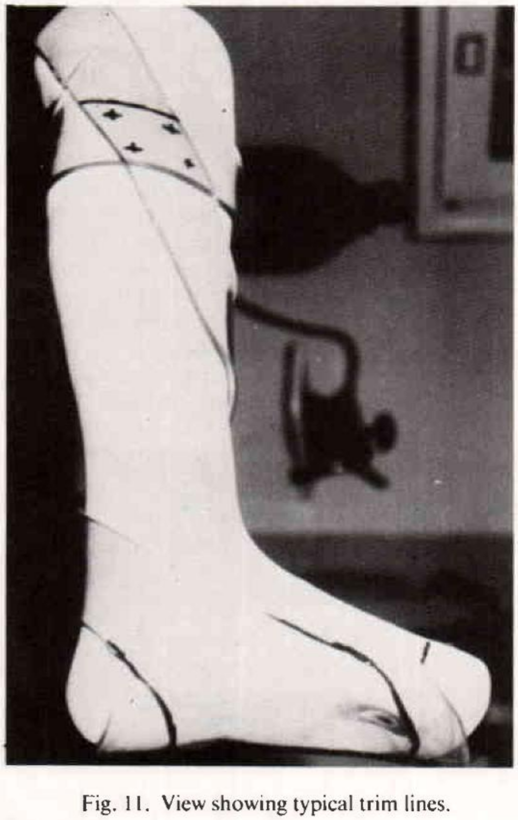

Fig. 11. View showing typical trim lines.

Fig. 12. Heating the shrink-expansion rivets with heat gun with funnel attachment.

FITTING PROCEDURE

1. The lateral opening of the calf band is increased to the point that it will pass the mediolateral width of the narrowest part of the ankle.
2. The orthosis is applied by placing the lateral opening of the calf band over the posterior portion of the narrowest part of the ankle, then twisting the orthosis onto the leg as it is pushed proximally.
3. Trim lines of the footplate as described above are checked.
4. The orthosis is then removed from the leg,

and the fit in patient's shoe is checked. Material is trimmed as necessary.

5. The orthosis and shoe are reapplied and a check is made for any areas of discomfort.
6. Necessary adjustments are made by spot-heating with a heat gun. All edges are smoothed with a Tycro wheel, sanded, and then polished on a clean buffing wheel.
7. The orthosis and shoe are applied (Fig. 13). The Bulcher-type shoe with either a tie or buckle closure over the instep is preferred. For women, modern-style shoes may be used as long as the counter is adequately stiff and high and there is an adjustable, nonelastic closure over the instep. Regular sized, lightweight, nonorthopaedic shoes may be worn since the footplate incorporates any necessary foot corrections and support without taking up an appreciable amount of room in the shoe. It is necessary to have a firm fit of the shoe for proper function of the orthosis. A knee-length sock for males or hose for ladies is recommended for comfort and ease of donning and removal of the orthosis.

Fig. 13. Completed spiral AFO on patient.

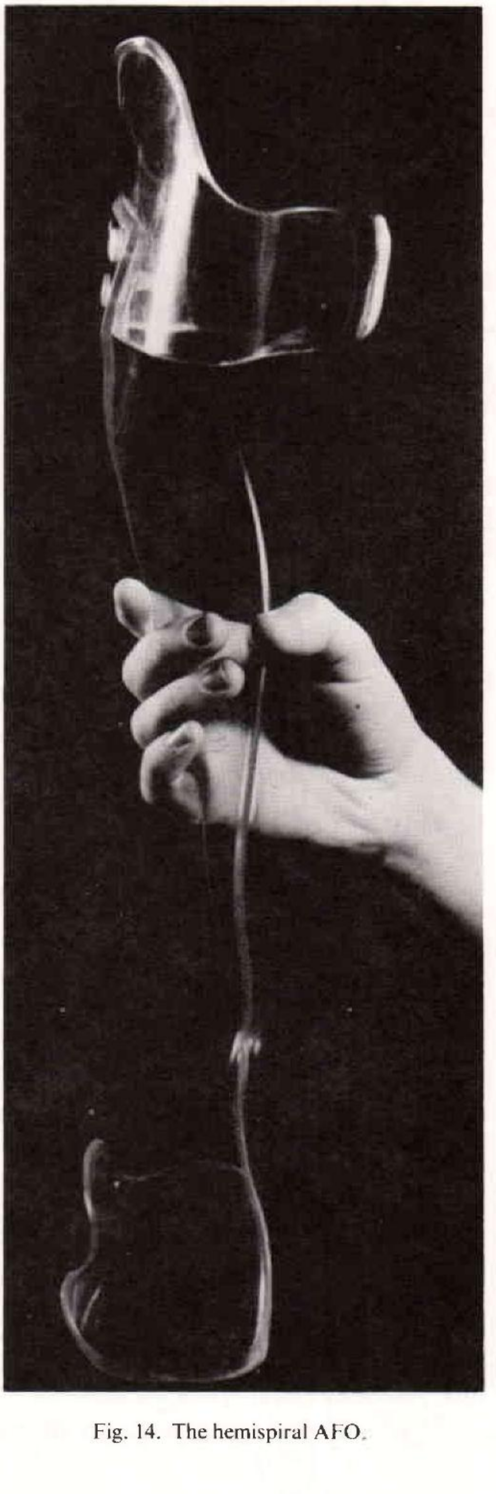

Fig. 14. The hemispiral AFO.

HEMISPIRAL AFO

In contrast to the full spiral AFO which originates on the medial side of the foot and describes a complete turn of 360 deg. around the leg, the hemispiral AFO originates from the lateral portion of the footplate, passing around the leg in a direction opposite from that of the full spiral AFO and covering only half a turn of 180 deg. (Fig. 14). Thus, the reduction of the helical turn in the hemispiral results in greater stiffness with improved resistance against the equinus tendency. At heel strike, external torque of the foot is induced by the unwinding of the spiral which, as mentioned above, is in the direction opposite from that of the full spiral AFO.

Indications for use of the hemispiral AFO are:

1. Motor weakness of the evertors and dorsiflexion of the foot with resultant imbalance of forces in the direction of equinovarus.
2. Moderate spasticity when present with condition described in "1" above.
3. Mediolateral instability during stance or swing.

Contraindications for use of the hemispiral AFO are:

1. Severe spasticity with sustained clonus.
2. Fluctuating edema.
3. Fixed deformities.

CASTING PROCEDURES

Casting procedures for the hemispiral AFO are similar in all respects to those described for the full spiral AFO with the exception that the lateral rather than the medial malleolus is marked.

CAST MODIFICATIONS

Cast modifications are also similar to those described for the spiral AFO with the following exceptions:

1. Plaster removal in the soft tissue area between the crest of the tibia and the shaft of the fibula is necessary only on the proximal shank area because the spiral portion will not cross the tibia anteriorly.
2. Plaster is removed in an area extending proximally 8 cm above the lateral malleolus.
3. The lateral malleolus is built up 6 mm while no additional plaster is necessary on the medial malleolus.

MOLDING PROCEDURES

For molding the hemispiral AFO, a precut kit is available (Fig. 15). Molding of the calf band is identical to that described for the full spiral AFO, but the hemispiral is placed on the cast so that the spiral upright extends from the footplate to cover the lateral malleolus. After the footplate has been wrapped and held in place with an Ace bandage, the spiral upright is then wrapped posteriorly around the leg, terminating over the medial tibial flare area of the calf band. This position is maintained with Ace bandages until the plastic has cooled sufficiently.

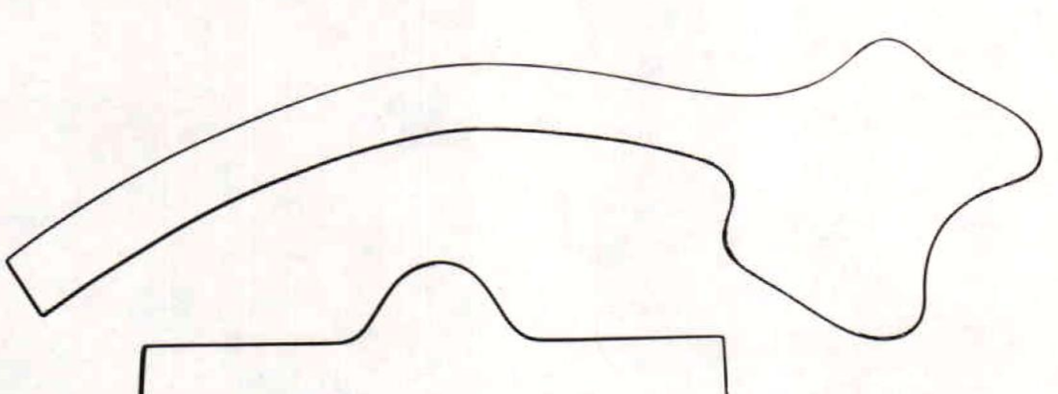

Fig. 15. Shape of SADUR parts needed for the hemispiral AFO.

ASSEMBLY

Assembly of the hemispiral is similar to the full spiral AFO with the following exceptions:

1. The medial trim line of the footplate is such that a flange of the footplate covers the area immediately behind the first metatarsal head and another flange covers the medial portion of the calcaneus. The purpose of the flanges is to prevent forefoot adduction and hind-foot inversion, respectively.
2. Normally the distal trim line of the footplate should be such that the lateral border extends distal to the fifth metatarsal head, i.e., covering the metatarsal head, while the medial aspect terminates 6 mm proximal to the head of the first metatarsal. The purpose of this trim line is to provide an increased lateral base (Fig. 16).
3. The heel section of the footplate is not removed but rather is maintained for the purpose of effectively inducing an external torque on the spiral at heel strike, thus compensating for the varus tendency in this type of patient.

FITTING PROCEDURES

Fitting procedures are again similar to those for the full spiral AFO, except for the trim line of the footplate as described above. The shoe type to be used with the hemispiral AFO is the same as for the full spiral AFO. However, a shoe 1/2 to 1 size larger and 1 to 2 sizes wider is usually required. Figure 17 shows the hemispiral on a patient.

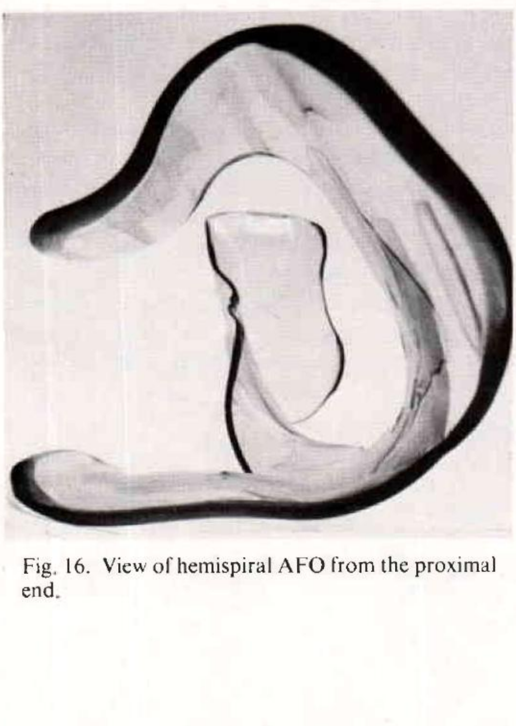

Fig. 16. View of hemispiral AFO from the proximal end.

Fig. 17. Completed hemispiral AFO on patient.

CLINICAL EXPERIENCE

Both configurations of the spiral AFOs have been extensively and almost exclusively employed in the orthotic management of patients with conditions described under the indications for each of the spiral AFOs at the Institute of Rehabilitation Medicine, New York University Medical Center, over the past five years. As compared to conventional means of bracing, patient performance with the spiral orthoses has been shown to be noticeably improved through conventional and photokinematic gait analyses (6). Substantial reduction in energy expenditures has been substantiated through measurement of oxygen consumption with these orthoses when compared with conventional braces (4). Beyond the physical effects produced by these lightweight orthotic designs (approximately 200 gm), which through a more intimate fit afford specific ankle control and better orthotic matching of the disabilities for which the orthoses are indicated than is possible with conventional braces, there has been enthusiastic acceptance by an overwhelming majority of the patients thus managed. It is believed that this not only relates to the rather readily measurable physical effects just described but to the psychosocial effects enhanced by improved cosmesis, cleanliness, and ability to interchange shoes. The results of psychosocial evaluations, as well as other biometric data relating to this research, are fully described in reference 6, to which the interested reader is referred for full details in these areas as well as statistical data on the numbers and types of patients fitted.

Breakage of the spiral AFO reported during the early stages of development has been greatly reduced in a number of ways, none of which are elaborated here. However, elimination of the heel section of the brace and the commercial availability of quality-controlled spiral and hemispiral blanks, have reduced breakage in the spiral AFO to 5-7 percent during the initial year of wear. This percentage is much higher in bilaterally involved patients, hence the orthosis is not recommended for this population. In those patients who have experienced breakage within a period of one year postfitting, it has become our practice to prelace the SADUR material with a spiral made from polypropylene. There has been no instance of breakage with polypropylene spirals which have been used for over two years, although patients report a functional difference which relates to a reduction of springiness, i.e., rebound, as the plastic memory of polypropylene is less than that of SADUR. For functional reasons, therefore, SADUR is still the preferred material, but may be substituted with polypropylene when breakage occurs within a period of one year from the date of fitting as described above. There have been very few instances of breakage with the more recently developed hemispiral which has been applied for more than three years. It is not clear whether this reduction of breakage in the hemispiral is due to its design configuration making it considerably stiffer than the spiral AFO, reducing the excursion and, therefore, the demand on the orthosis, or whether the patient indications preclude extraordinary wear.

SUMMARY

The plastic spiral and hemispiral orthoses have been described in terms of indications, contraindications for each, their physical characteristics, as well as casting, fabrication and fitting procedures. Both orthoses have been used extensively and almost exclusively in the orthotic management of patients who fit the criteria for their indications in over one thousand patient applications at the Institute of Rehabilitation Medicine, New York University Medical Center, with favorable results and patient reactions. Similar results have been reported by other institutions and practitioners who have applied these orthoses.

It is believed that the technical problems of materials and fabrication methods which precluded more general application in the early phases of development have been sufficiently overcome to warrant introduction of this system into general orthotic practice as recommended by the Committee on Prosthetics Research and Development of the National Academy of Sciences—National Research Council (2).

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Orthotics and Prosthetics, Vol. 28, No. 2, pp. 14–20, June 1974

LOWER-LIMB ORTHOTIC DESIGNS FOR THE SPASTIC HEMIPLEGIC PATIENT[1]

Herbert W. Marx, C.P.O.

Providing the spastic hemiplegic patient with a suitable orthotic device often presents a difficult problem. Since the ultimate goal is realignment of the foot-ankle complex and maintenance of this alignment during all phases of gait, it is evident that the realization of this goal cannot always be accomplished by conventional methods (1) (2).

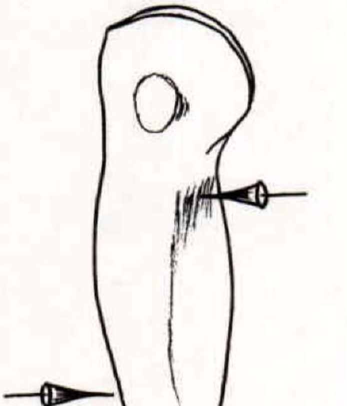

Fig. 1. Direction of forces in the frontal plane.

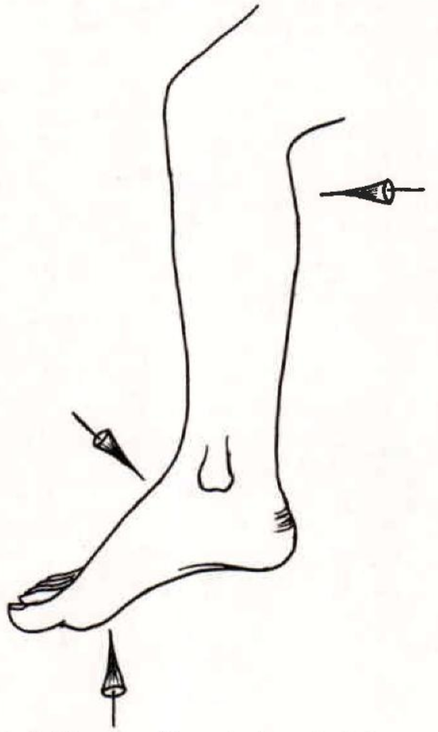

Fig. 2. Direction of forces in the sagittal plane.

To oppose the equinovarus deformity, counterforces in other areas are necessary:

1. In the frontal plane (Fig. 1),
   a) the medial aspect of the calcaneus,
   b) proximal to the head of the first metatarsal,
   c) the shaft of the fibula,
   d) the medial tibial flare.
2. In the sagittal plane (Fig. 2),
   a) proximal to the gastroc-soleus bulge,
   b) the metatarsal arch,
   c) the instep.

It becomes obvious that necessary counterforces cannot be provided effectively with a conventional below-knee orthosis with metal

[1] This study is supported in part by Grant Number 23 P-55029/2-03 from the Social and Rehabilitation Service, Department of Health, Education, and Welfare.

uprights; and that, at best, the conventional design can only be effective to a very limited extent. This is especially true because the man-machine interface is hardly intimate enough to oppose the deforming forces produced by spasticity. Therefore, the conventional ankle-foot orthosis, even if attached to a well-constructed shoe, does not lend itself very well to effective control of this type of deformity. Although sophisticated alignment principles are usually employed in the construction of a conventional ankle-foot orthosis, the complex multidirectional forces producing this deformity require more than a soft shoe-upper and a soft varus-correction-strap. In the conventional orthosis, plantar flexion is opposed by the sole of the shoe in combination with the plantar-flexion stop. However, even a well-designed shoe shank can only oppose mild to moderate spasticity effectively, and will hardly suffice for the severely spastic patient. Furthermore, inversion, that is, supination of the forefoot combined with varus deformity in the calcaneus, cannot be sufficiently opposed even with a shoe which has firm counters.

This paper presents two devices which have been applied successfully at New York University Medical Center, Institute of Rehabilitation Medicine (IRM), for the past several years. The hemispiral ankle-foot orthosis, a variation of the IRM spiral ankle-foot orthosis, and the solid-ankle ankle-foot orthosis, which was first described by Jebsen, et al. (3), have been applied in cases where moderate and severe spasticity exist.

THE HEMISPIRAL ANKLE-FOOT ORTHOSIS

The hemispiral AFO (5) (see also article by Lehneis in this issue of *Orthotics and Prosthetics)*, is made from SADUR[2], a nylon-acrylic composite, and has been designed to provide the forces necessary for continuous foot-ankle alignment during gait (Fig. 3). The footplate extends from the proximal-plantar margin of the heel pad to a point 5 mm proximal to the metatarsal heads. On its medial border, flanges extend proximally to the head of the first metatarsal to prevent forefoot adduction and supination, and at the calcaneus, flanges extend proximally to prevent varus deviation.

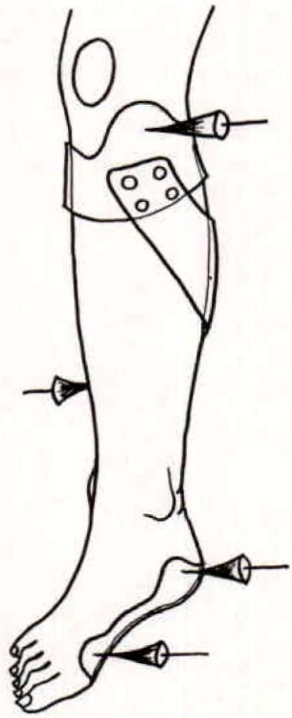

Fig. 3. The direction of the forces provided by the hemispiral AFO.

The spiral section of this orthosis originates on the lateral side of the footplate and extends almost vertically to the mid-level of the fibula at which point it turns posteriorly and attaches to the calf band at its medioposterior aspect.

The calf band, in its horizontal cross section, is triangular with a lateral opening approximately 5 mm smaller than the narrowest mediolateral dimension of the ankle. On the medial side, the calf-band flange extends proximally to cover the medial tibial flare area.

The triangular shape of the calf band and its minimal lateral opening provide a secure anchor for the spiral section and allow some degree of conformity to transverse rotation of the tibia. The pressure of the spiral section against the mid-shaft of the fibula and the pressure of the calf-band flange against the medial tibial flare provide the additional forces necessary to prevent deviation of the foot-ankle complex in the frontal

[2] Teufel Company, Stuttgart, Germany.

plane (Fig. 3). The forces which prevent equinus deviation are provided in the areas of the metatarsal arch, the flattened posterior section of the calf band, and at the dorsal aspect of the foot, by a firmly laced shoe.

The device is made from material 4 mm thick. Its appearance in the flat unmolded state is shown in Figure 4.

THE POSTERIOR SOLID-ANKLE ANKLE-FOOT ORTHOSIS

While the concept of the solid-ankle laminated device was not original at IRM, the present design (Fig. 5) is perhaps more directly related to the patient's functional disability. The force system is similar to that described for the hemispiral

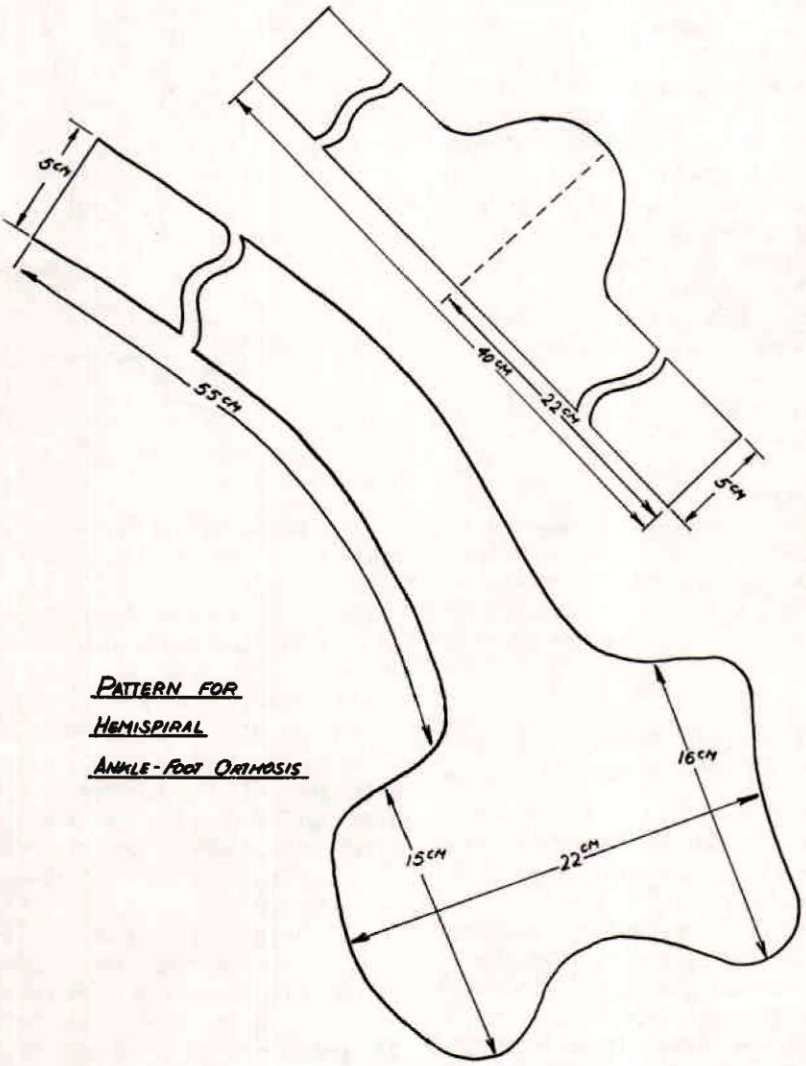

Fig. 4. The pattern for the hemispiral AFO. SADUR 4 mm thick is used. Precut kits are manufactured by Teufel Co., Stuttgart, Germany, and are also available through distributors.

AFO. Thus, to control the varus component of the equinovarus deformity, the laminate is extended proximally to fit intimately over the medial tibial flare, and support is provided behind the head of the first metatarsal and over the medial aspect of the calcaneus. In addition, a counteracting force is provided at the mid-fibula level.

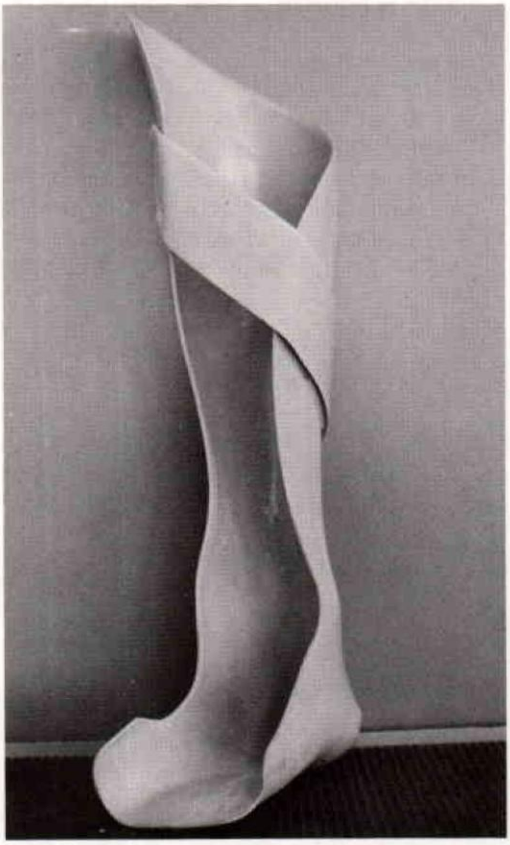

Fig. 5. Anterior view of a solid-ankle AFO for the left leg.

In the sagittal plane, the trim line extends anteriorly to the lateral midline to provide effective support (Fig. 6). The proximal medial termination also extends anteriorly to the medial midline, while all other areas recede posteriorly to the midline. As viewed in the frontal plane, the posteroproximal trim line progresses diagonally across the gastroc-soleus bulge. This posteroproximal trim line, however, will only be adequate if the dominant deforming force of the equinus deformity is relatively less severe. When, however, the equinus deforming component is dominant, the posteroproximal trim line needs to extend horizontally across the gastroc-soleus bulge at a level 20 mm below the neck of the fibula.

The solid-ankle AFO is made of a plastic laminate with fiberglass matting as the reinforcement material. Both polyester and acrylic resins have been used. Patient follow-ups have proved, however, that the acrylic lamination not only produced a lighter device but also a more durable one.

Because a smooth and natural-like transition from heel strike to toe-off is virtually impossible with the solid ankle (6), a SACH heel and rocker bottom are added to the patient's shoe to provide simulated plantar flexion at heel strike and a nearly normal transition from foot-flat to toe-off.

The importance of the shoe in these devices is frequently underestimated. Although the devices in and by themselves provide sufficient

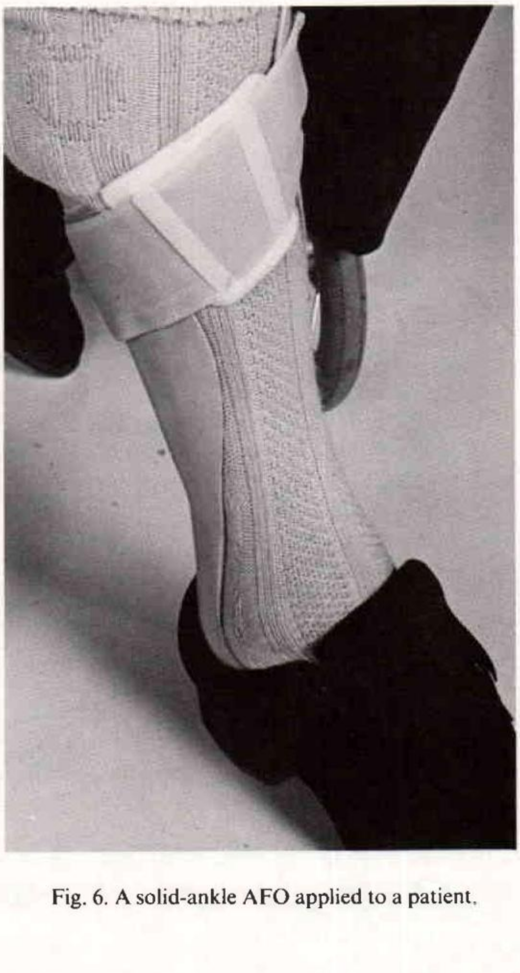

Fig. 6. A solid-ankle AFO applied to a patient.

static support for the foot-ankle complex during gait, additional support is needed. A good shoe, firmly fitted, is required to assure constant contact of the foot with the footplate.

THE CASTING TECHNIQUE

The need for a plaster cast for the construction of an orthosis made from either thermosetting or thermoplastic materials is obvious. However, the casting technique requires some elaboration, since simultaneous stabilization in three planes during casting cannot be satisfactorily achieved by an orthotist working unaided. Either a second pair of hands, or an auxiliary device, is needed. Because both AFOs are similar inasmuch as they have been designed to provide the same corrective force system, the same casting technique is applicable to both. In our experience, casting in two stages (4) (5) assures a negative cast which most closely reflects the desired alignment.

The two stages are:

1. The foot-ankle complex is wrapped to approximately the mid-shank level. While the plaster bandage hardens, the forefoot-hindfoot relationship, as well as their relation to the shank, is established and maintained. The medial aspect of the calcaneus and the area immediately proximal to the head of the first metatarsal should be compressed and contoured.
2. The proximal section is wrapped to the tibial plateau, overlapping the distal section by approximately 50 mm. While the plaster bandage hardens, the posteroproximal section, the medial tibial flare area, and mid-shaft of the fibula are compressed.

In both devices the angular relationship of foot and shank must reflect the heel height of the shoe to be worn. To assist in achieving this requirement, a casting board with a vertical alignment rod is used. This device reflects the heel height as well as the apex of the longitudinal arch (see preceding article). To preshape the metatarsal arch, a metatarsal pad is inserted between the layers of plaster wrap, while the core of the plaster bandage or any other roll of the appropriate diameter is placed under the digits to accentuate the contours of the metatarsal joints. During this procedure, one of the orthotist's hands stabilizes the hindfoot and forces the calcaneus into valgus while the other aligns the forefoot and forces it into pronation and abduction (Fig. 7). Keeping in mind that the negative cast produced should reflect proper alignment as well as tissue compression in the areas necessary for force application, the following points must be observed in casting for the solid-ankle AFO:

1. Preshaping of the cast is done with emphasis on the plane in which the dominant deforming force is present. That is, if the inversion component is the stronger, the areas of the medial tibial flare, the mid-fibula level, the medial aspect of the calcaneus and the area directly proximal to the head of the fifth metatarsal, are compressed.
2. If the equinus component is the stronger, a flat compression proximal to the gastrocsoleus bulge, parallel to the knee axis, is produced in combination with a well-defined metatarsal arch.

Fig. 7. Casting the distal portion of the leg for either a hemispiral AFO or a solid-ankle AFO.

3. When stabilization in both frontal and sagittal planes is required, the cast should reflect a combination of both preshaping techniques.

CAST MODIFICATION

Despite the emphasis on negative cast preshaping, further modifications of the positive cast are required to assure optimal effectiveness of the corrective and supportive forces. The precompressed areas usually need further plaster removal, the amount being in the range of 4 to 8 mm. Plaster buildups of 6 to 8 mm in the areas of the lateral malleolus and the base of the fifth metatarsal are required for both the hemispiral and the solid-ankle AFOs.

For the solid-ankle AFO, an additional buildup at the anterolateral, mid-fibula area is desirable to prevent trim-line pressure.

MOLDING AND LAMINATION PROCEDURES

MOLDING THE HEMISPIRAL

Before the hemispiral pattern is molded over the prepared cast, the edges of the precut plastic must be highly polished to remove scratches, and thus ensure the durability of the device. For the molding procedure, a domestic oven is satisfactory, but a commercial oven equipped with blower and thermostat is better.

Before the actual molding process is undertaken, the dry cast should also be heated to molding temperature to increase working time and reduce the possibility of stresses occurring when the plastic is molded over a cold cast. The calf band is molded over the cast first and cut to length while still in the flexible state. This, as well as the footplate-spiral section, is held on to the cast by elastic bandages until it has cooled sufficiently to maintain its shape. The footplate, which in its original form is oversized, the proximal termination of the spiral section, and the lateral opening of the calf band are trimmed and polished to appropriate proportions.

LAMINATION AND LAY-UP OF THE SOLID-ANKLE AFO

Plastic lamination is done in the conventional manner. If acrylic resin is used instead of polyester resin a lighter yet more durable device is produced. When, in combination with the acrylic resin, nylon-tricot with fiberglass matting is used instead of the more widely applied nylon stockinette, improved durability and reduced overall weight will result. Depending on the weight and height of the patient, the layers of nylon-tricot and fiberglass matting varies from 8+6 to 10+8.

RESULTS AND CONCLUSIONS

Both devices described have been used successfully at the Institute of Rehabilitation Medicine, New York University Medical Center. Since 1969, sixty-two patients have been fitted with these devices, of which nineteen were of the solid-ankle design. Most patients required the addition of a SACH heel and a rocker bar.

As with all plastic orthoses, a cast that is well precontoured and accurate is mandatory. In addition, a preconceived design contour should be firmly in the mind of the orthotist during the casting procedure so that appropriate forces and counterforces can be applied over the proper areas while the plaster hardens.

Although the areas proximal to the head of the first metatarsal and the medial aspect of the calcaneus are subject to high pressures, the medially directed force at the mid-level of the fibula frequently caused greater fitting problems in both of the designs. However, if the lateral pressure area is maintained at the mid-fibula level, is distributed as far as possible along the shaft of the fibula, and the anteroposterior dimension trim line is sufficiently wide, pressure can be avoided completely. Precontouring of the cast negative as well as appropriate modification of the positive model will help in avoiding potential problems. In the hemispiral orthosis, care must be taken that the lateral origin of the spiral section is extended proximally far enough and is contoured appropriately to avoid excessive pressure at the proximal edge, a condition that occurs frequently. The cast for the solid-ankle AFO should be modified in the lateral anterior aspect to assure sufficient spread of load in the anteroposterior dimension.

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Orthotics and Prosthetics, Vol. 28, No. 2, pp. 21-26, June 1974

RESULTS OF A SURVEY OF GRADUATES OF LONG-TERM PREPARATORY ORTHORTICS-PROSTHETICS EDUCATION PROGRAMS

Michael J. Quigley, C.P.O.[1]

A survey of the graduates of three schools that offer long-term courses was initiated in October of 1973 in order to help determine the results of these programs. The Committee on Prosthetics Research and Development (CPRD) of the National Research Council (NRC) sent out 180 questionnaires to graduates of the Chicago City College-Northwestern University (NU) program[2], New York University (NYU), and the University of California, Los Angeles Campus (UCLA). After two follow-up mailings, 162 graduates (90%) responded to the two-page questionnaire.

The major goals of the survey were to determine:

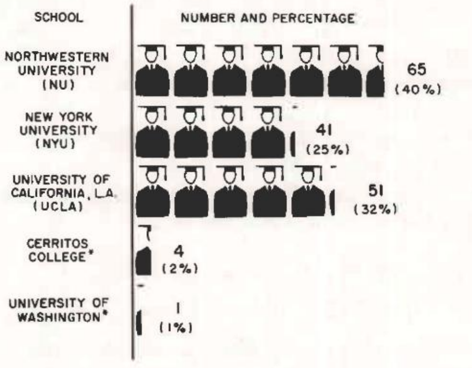
- The number of graduates still in practice
- The number of graduates needing financial assistance
- The number of graduates certified
- Areas of work responsibility of the graduates
- Manpower needs.

A breakdown of the survey results provided an abundance of additional information about how the graduates of each school fared, their average ages, number of laboratories worked in, etc. A number of interesting comparisons arose, indicating that the graduate's alma mater may be a deciding factor on his future.

PRESENTATION OF RESULTS

The comparisons are given in order to demonstrate tendencies rather than to imply that one school is superior to another. In fact, schools that appeared to lack in one area usually more than compensated in another area.

Number of Respondents & Percentage of Total Respondents by School



*Due to the small number of respondents, these schools are not included in the categorized breakdowns and total percentages are generally derived from 158 respondents.

Total Number of Respondents

Number of Graduates Surveyed	180
Number of Responses	162
Percentage of Responses to Total	90%

The imbalance of responses for the first three schools is due to the different number of graduates actually contacted in the survey and the actual number of graduates from each school, which were nearly proportional to the responses. Neither Cerritos College nor the University of

[1] Staff Prosthetist/Orthotist, Committee on Prosthetics Research and Development, National Academy of Sciences—National Research Council, Washington, D.C.

[2] Degree awarded by Chicago City College, actual laboratory courses given by Northwestern University, and graduates consider themselves Northwestern alumni.

Washington was intentionally surveyed. If they had been, obviously a higher number of responses would have resulted.

YEAR OF GRADUATION

The graduating classes of the respondents ranged from 1961 to 1973, with an average of 1969.

AVERAGE AGE

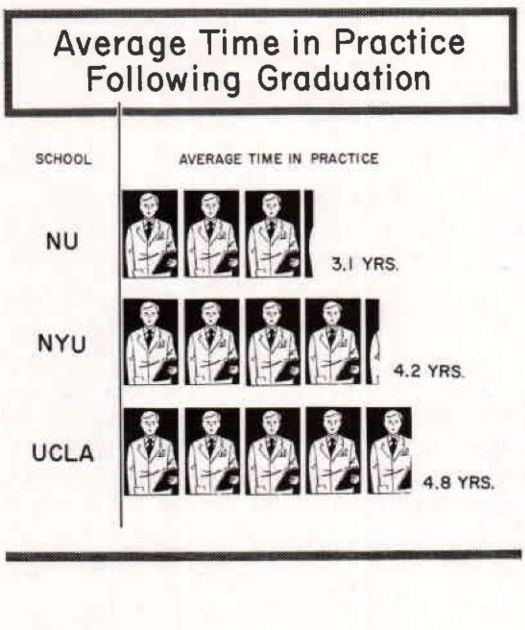
The average age of the respondents at the time of the survey was 29.1 years. By schools, the average ages were:

School	Average Age
NU	25.1 years
NYU	30.6
UCLA	33.1

Graduates from the Northwestern program could begin the course immediately following high school graduation and graduate with an Associate of Applied Science degree in two years. New York University students attend a four-year program and earn a Bachelor of Science degree upon successful completion. Students at UCLA generally have a degree *prior* to beginning the one-year certificate course.

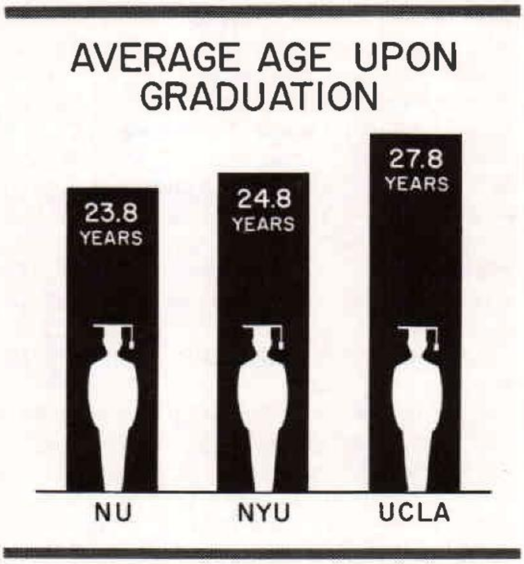
AVERAGE TIME IN PRACTICE FOLLOWING GRADUATION

The average time in practice is given as the time *following* graduation. Many of the respondents had practiced before entering school, but that time was not included. This average for all respondents was 3.9 years.



AVERAGE AGE UPON GRADUATION

The average age of all respondents at the time of graduation was 25 years.



GRADUATES NOT IN PRACTICE

Nine graduates no longer practice either prosthetics or orthotics, which means 94 percent of the graduates remain in the field. This high figure directly relates to the large percentage of males in the profession. Other professions with a larger female populus find that marriages and families cause many female practitioners to stop practicing or to practice only part time.

Of the nine graduates not in practice, four are in the medical and rehabilitation fields. One is working for a vacuum-forming company related to orthotics, one is in nursing school, one is teaching physical therapy, and one is a rehabilitation counselor. None of them is certified. The remaining five are in jobs ranging from a truck driver to a used-car salesman. Some of the reasons given for leaving the field were: (1) could not find an interesting or satisfactory job in the field (most common reason); (2) reverted to former occupation; (3) prejudice against females; and (4) allergy to plastics.

GRADUATES HOLDING ADDITIONAL DEGREES

Additional degrees, generally not in prosthetics or orthotics, were held by 49 graduates (31%). Degrees ranged from a Bachelor of Science in Zoology to a Masters degree in Divinity, but generally centered around business, education, and therapy. As might be expected, UCLA graduates held the greatest number of additional degrees as students with previous degrees are preferred for acceptance.

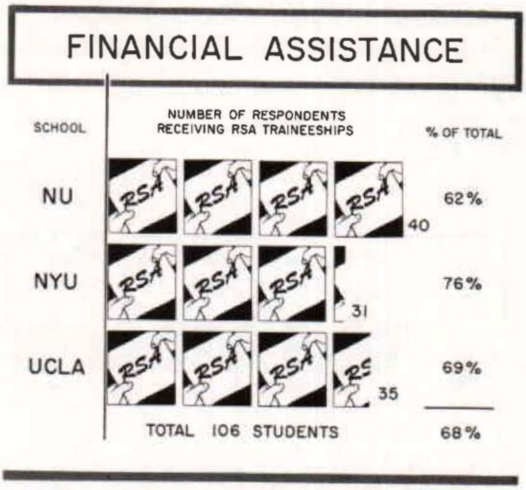
Number of Graduates with Additional Degrees, By School

- Northwestern University—8 respondents (12%) held additional degrees—all 8 were Bachelors degrees, 2 of them from NYU.
- New York University—14 respondents (34%) held additional degrees—3 A.A. degrees (2 from Northwestern, 1 from Cerritos College), 10 B.S. degrees (1 in occupational therapy, 1 in physical therapy).
- University of California, Los Angeles—17 respondents (34%) stated they held additional degrees:
  - 7 A.A. Degrees (6 from Cerritos College)
  - 2 B.S. Degrees (1 in occupational therapy, 1 in therapy)
  - 4 B.S. and M.A. Degrees
  - 3 M.A. Degrees (1 in rehabilitation counseling)
  - 1 M.A. and Ph.D. Degrees

FINANCIAL ASSISTANCE

The major source of financial assistance previous to 1974 has been traineeship grants from the Rehabilitation Services Administration (RSA) of the Department of Health, Education, and Welfare. The other sources, in order of frequency were (1) tuition remissions—usually for students also working at the school; (2) G.I. Bill; and (3) state vocational rehabilitation agencies.

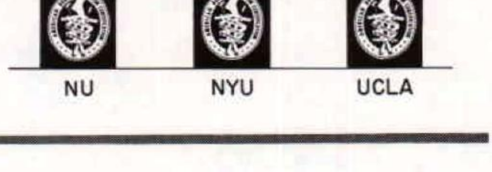
Forty-two graduates indicated that they did not need financial assistance, although 27 of them received it. These 42 graduates that did not need assistance represent 26 percent of the total number of graduates. Of those that did receive assistance, 25 percent did not feel they needed it. This



indicates that students should probably be screened more carefully before financial assistance is awarded.

CERTIFICATION

Certification was attained by 110 graduates, or 69 percent of the respondents. This is a high percentage considering that the average time in practice since graduation is only 3.9 years and 20 of the respondents graduated in 1973. Approximately 80 percent of respondents who had graduated prior to 1972 attained certification.



The certification status varied greatly by school, mainly because some schools stress one area excessively and because long-term orthotic education has become generally available only in the last few years.

The following figures present the number and percentage of respondents in each certification specialty, by school:

Number, Percentage of Certified Respondents and Average Age by School and Discipline

SCHOOL	CERTIFIED ORTHOTIST (C.O.) # of RESP.	% of RESP.	AVG. AGE	CERTIFIED PROSTHETIST (C.P.) # of RESP.	% of RESP.	AVG. AGE	CERTIFIED PROSTHETIST-ORTHOTIST (C.P.O.) # of RESP.	% of RESP.	AVG. AGE
NU	3	5	26	26	40	29.5	8	12	26
NYU	6	15	28	14	34	29.8	17	41	28
UCLA	1	2	52	30	59	30	6	12	33

As can be seen from the figures, certified orthotists make up less than 5 percent of certified graduates. The three C.O.s from NU all graduated from that school's first orthotic program in 1972 and six of the remaining seven C.O.s are from NYU, where both prosthetics and orthotics are taught equally. Both prosthetics and orthotics have been taught at UCLA for years but prosthetics has been heavily stressed over orthotics, resulting in the imbalance from that school. Another interesting note is that at NU, A.A. degree students are taught either prosthetics or orthotics, not both, but this school still has the same percentage of C.P.O.s as UCLA, according to this survey.

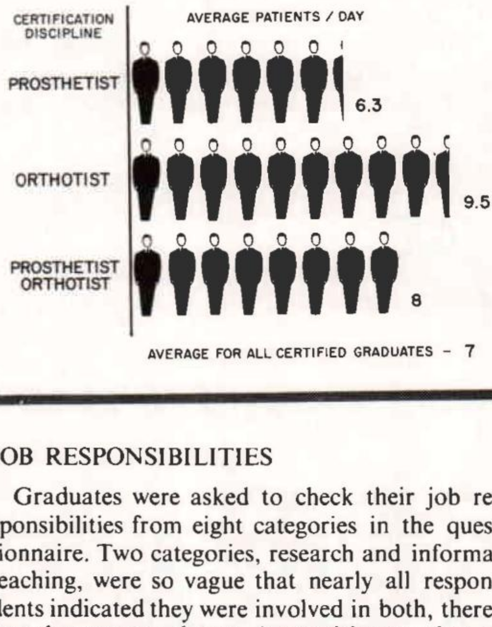
The average age of certified graduates at the time of the survey, *not* at the time when they were certified, was 27.2 years for a C.O., 29.8 years for a C.P., and 28.2 years for a C.P.O. Note that the average age for a C.P.O. graduate is younger than that for the C.P. graduate. This can probably be attributed to the age difference between NYU and UCLA graduates upon graduation. Graduates from NYU are an average of three years younger than UCLA graduates.

Another interpretation of the figures could be that the vast majority of graduates attain certification in prosthetics first and then add on orthotic certification at a later date. It may be that prosthetics is stressed more in the schools, it is a more attractive field, or it is easier to learn.

PATIENTS TREATED PER DAY

Graduates were asked to estimate how many patients per day they were responsible for treating. The range of patients per day treated was from 0 to 25. The average for all respondents who actually treated patients (excluding those that did not respond or stated they treated none) was 4.9 patients per day. Certified practitioners had a higher average.

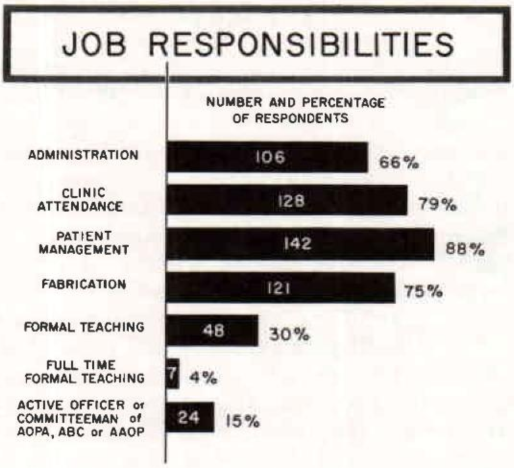
Patients Treated per Day by Certified Graduates



JOB RESPONSIBILITIES

Graduates were asked to check their job responsibilities from eight categories in the questionnaire. Two categories, research and informal teaching, were so vague that nearly all respondents indicated they were involved in both, therefore they are not shown. A surprising number of respondents indicated that they were involved in formal teaching in a school, although, upon further investigation, it was determined that only seven respondents were full-time instructors at prosthetics-orthotics schools. The remainder teach either part time or lecture occasionally at these schools or teach different subjects elsewhere.

There were 121 graduates involved in fabrication, or 75 percent of the total. This fact, coupled with the recurring statement that technicians were needed, implies that the majority of job openings could be filled by technicians or assistants, rather than practitioners. Practitioners, by definition, generally are not actively involved in the fabrication process. Many areas have a surplus of practitioners but need technicians. When an abundance of technicians and assistants become available, a problem arises similar to that in other fields, wherein the job market is tight for professionals or journeymen because employers prefer to hire assistants or technicians who generally only lack judgmental experience, will do the necessary work, and are willing to accept a lower wage.



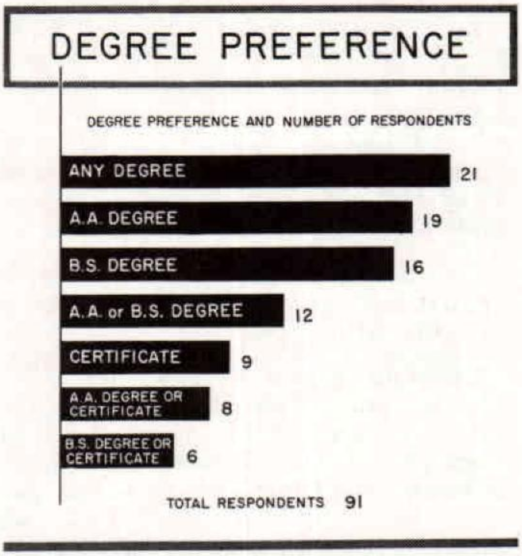
JOB MOBILITY

Graduates were requested to list the number of laboratories in which they had worked *since* graduation in order to determine their job mobility. Whether the mobility was upward or lateral was not determined. The 162 respondents held 280 jobs in laboratories since graduation, or an average of 1.75 jobs in 3.9 years. The number of jobs per graduate ranged from 0 to 4.

MANPOWER NEED

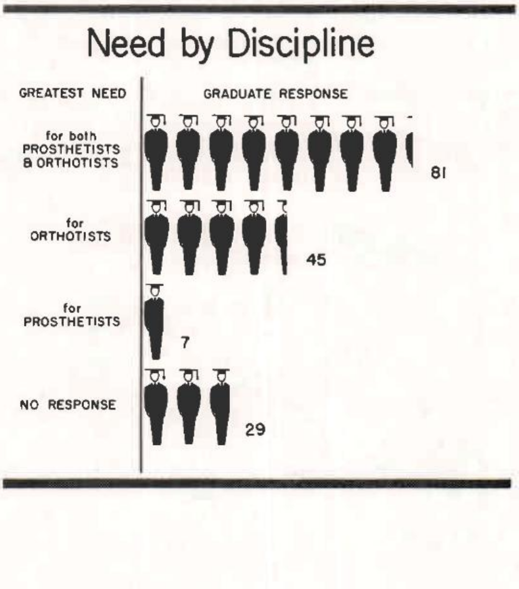
Graduates were asked if they would hire another graduate if they were responsible for employing new practitioners. Although 113 respondents indicated they would hire a graduate, only 91 responded to further questions regarding starting salaries and degree preference.

The general tendency of respondents was to prefer to hire graduates from schools from which they themselves had graduated. The small number of respondents that preferred the certificate graduates was probably due to general ignorance of what the certificate actually is. The certificate (from UCLA) is awarded to students successfully completing a 9–12 month course in prosthetics and orthotics and the general entrance requirement for the program is a prior degree (not necessarily in a related field) and other entrance examinations.



NEED BY DISCIPLINE

Graduates were asked whether they felt the greatest need for practitioners was in prosthetics, orthotics, or both fields.



The results shown definitely relate to the present needs of the field. One might think that prosthetists would indicate a need for prosthetists or for both prosthetists and orthotists, but the fact that 45 respondents indicated they felt the greater need was for orthotists in the field means that the manpower shortage in orthotics must be very obvious. A recent article[3] states that there are approximately 476 prosthetics patients to one prosthetist but the ratio of potential orthotics patients to orthotists is 4,000/1. A greater manpower shortage in orthotics is apparent despite the fact that most orthotics patients are not permanently disabled, as are prosthetics patients.

This situation does not appear to be changing. As stated previously, the vast majority of graduates prefer to be certified in prosthetics even though eight of the nine educational outlets in this field include orthotics in their programs.

ADDITIONAL SHORT-TERM COURSE ATTENDANCE

Sixty of the graduates attended a total of 142 short-term orthotics and prosthetics courses in addition to their long-term courses. The most common short-term courses taken were "Immediate Postoperative Fitting Techniques" and "Advanced Below-Knee Prosthetics." These two courses were so well attended that there are very few prosthetists in the field presently who have not attended them but want to. The next most common course attended was "Fracture Orthotics." Graduates from Northwestern University, who were educated in either prosthetics or orthotics but not both, very often attended short-term courses in the second discipline following graduation. Graduates averaged taking less than one short-term course (.9) per person following graduation, although of the graduates that took any short-term courses, the average was 2.4 courses per person. The range of short-term courses taken was from one to seven. A mounting interest in courses on powered orthoses and prostheses was also apparent.

SUMMARY

A survey of the graduates of long-term programs from Northwestern University (degree awarded by Chicago City College), New York University, and the University of California, Los Angeles Campus, was made. Responses to the survey were made by 162 graduates. Results indicated an average age upon graduation of 25 years, and an average age at the time of the survey of 29 years. Seventy percent of the graduates were certified, although they had only been out of school for an average of 3.9 years. Only 10 of the 110 certified graduates were certified orthotists. Additional degrees were held by 31 percent of the graduates and 30 percent indicated they were involved in teaching some type of formal education. Most graduates treated about five patients per day. Graduates felt there is a greater shortage of manpower in orthotics than in prosthetics.

[3] LeBlanc, M.A., *Patient Population and Other Estimates of Prosthetics and Orthotics in the U.S.A.*, Orth. and Pros., 27:3:38–44, September 1973.

Orthotics and Prosthetics, Vol. 28, No. 2, pp. 27-32, June 1974

AMPUTEE SURVEY, 1973-74: PRELIMINARY FINDINGS AND COMPARISONS*

Hector W. Kay† and June D. Newman‡

Twelve years ago the late Dr. Harold W. Glattly, then Executive Secretary of the Committee on Prosthetic-Orthotic Education, Division of Engineering and Industrial Research, National Research Council, initiated a study which he hoped would provide answers to a number of questions: What was the character, in terms of sex, age, and site, of the group of individuals in the United States upon whom limb amputations were being performed? What proportion of the amputations derived from the various causes—disease, trauma, and tumor? With the cooperation of the American Orthotics and Prosthetics Association and the help of some 200 prosthetics facilities in the United States, Glattly's "Amputee Census"[2] provided a profile of the "new"[§] amputee population being fitted with prostheses during a two-year period. Perhaps even more significantly, this study brought into sharp focus major regional differences in surgical practices for elderly patients with vascular disease.

In 1973 the Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education (CPRD-CPOE), Division of Medical Sciences, National Research Council, felt that it would be appropriate to conduct a survey of the same type so that any changes in the amputee population since the October 1961-September 1963 study could be identified. As Dr. Glattly himself reported, the term "Amputee Census" was a misnomer because no actual head count of amputees on a national basis was involved. Hence, the new study was initiated as a "survey," rather than a "census." Again, almost 200 prosthetics facilities of the American Orthotic and Prosthetic Association volunteered to accumulate data on "new" amputees fitted with prostheses from July 1, 1973, through June 30, 1974.

When Glattly reported the first results[1] of his "Amputee Census," he compared the findings to "early election returns," which can often reveal national trends, but are sometimes misleading. A similar analogy may be made in presenting this first sampling of statistical data for the 1973-74 Amputee Survey conducted by CPRD-CPOE in collaboration with the American Orthotic and Prosthetic Association. Some ratios will probably not change significantly during the remainder of the one-year study. These stable ratios might include males to females, right to left sides, and upper to lower limbs. Findings with regard to the frequency of less common levels of amputation may be unreliable at this date because of the small number of cases in the present sample. Information relating to these amputation levels should become more accurate as the study progresses.

Dr. Glattly's earlier report[1] was based on data from more than 5,000 patients accumulated during an 11-month period. The current sampling (Table 1) is much smaller, and is based on 1,654 cards received primarily during the three months of August, September, and October, although

*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.

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§ A "new" case was defined as an amputee who had not been fitted previously. Those patients who were furnished replacement prostheses were not included.

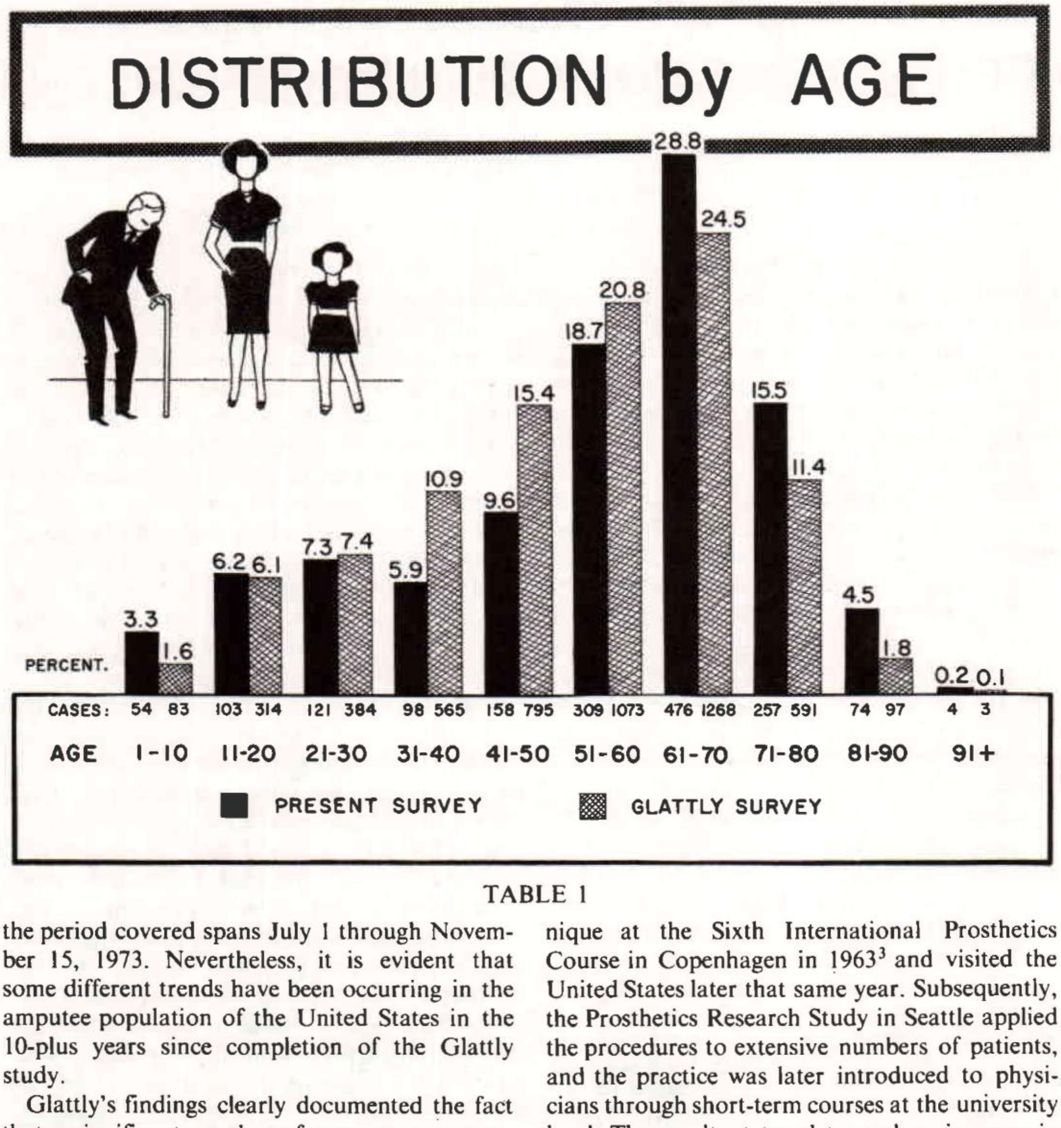

TABLE 1

the period covered spans July 1 through November 15, 1973. Nevertheless, it is evident that some different trends have been occurring in the amputee population of the United States in the 10-plus years since completion of the Glattly study.

Glattly's findings clearly documented the fact that a significant number of surgeons were performing amputations for vascular disease at an unnecessarily high level, thereby depriving many amputees of maximal rehabilitation. In the years following the publication of his final report,[2] much attention and publicity were given to the advantages of preserving the knee joint in elderly patients, and surgeons were urged to amputate at lower levels whenever possible. During that same period, immediate postsurgical fitting procedures came to the attention of Americans. Dr. Marian Weiss of Konstancin, Poland, had presented his modification of the Berlemont technique at the Sixth International Prosthetics Course in Copenhagen in 1963[3] and visited the United States later that same year. Subsequently, the Prosthetics Research Study in Seattle applied the procedures to extensive numbers of patients, and the practice was later introduced to physicians through short-term courses at the university level. The resultant trend toward an increase in the rate of below-knee amputations is clearly evident in the data obtained so far. Glattly's early report showed a 44 percent incidence of above-knee and a 37 percent incidence of below-knee amputations. In the current findings (Table 2) below-knee amputations have risen to 57.3 percent, with a consequent decline to 29.3 percent in above-knee amputations.

Male amputees outnumbered their female counterparts by a ratio of roughly 4 to 1 in the first Glattly report, based on the higher incidence of amputation in males by reason of trauma and

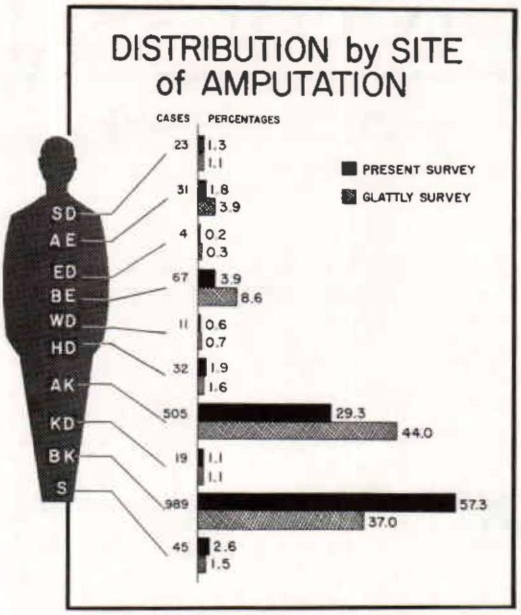

TABLE 2

disease. The gap is narrowing. Current findings (Tables 3 and 4) indicate a ratio of approximately 2-1/2 to 1, males over females, for all amputations.

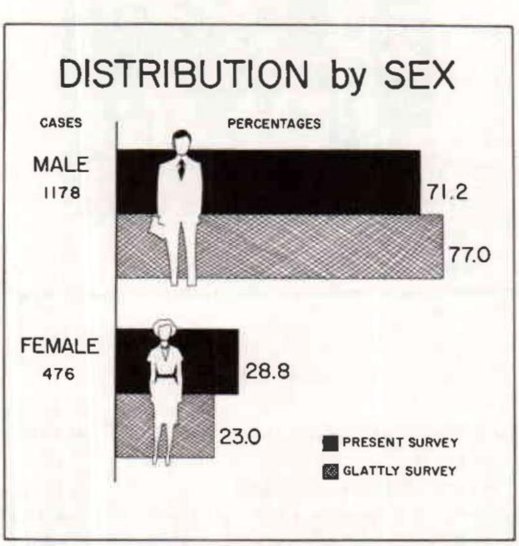

TABLE 3

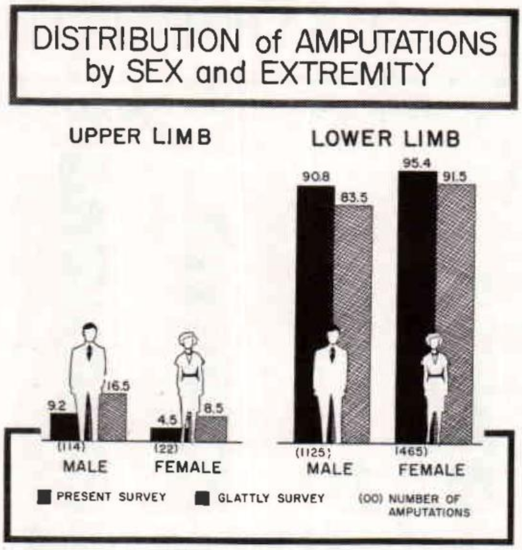

TABLE 4

Moreover, Glattly reported that amputations by reason of injury were nine times as frequent in males as in females. The trauma ratio is 7.33 to 1 in the present report (Table 5), with males still in the lead. "Women's Lib" notwithstanding, vocational hazards apparently are still greater for males, although decreasingly so. For amputations performed by reason of disease, the ratio of males to females has remained fairly constant. Dr. Glattly found that such amputations were 2-1/2 times as frequent in males as in females. This corresponds roughly to the current finding of a 2-to-1 ratio of male to female amputees (Table 5).

Disease is the major reason for amputation, and its incidence, particularly for those persons over 50 years of age, is increasing. For males of all ages, disease is the cause of amputation in 66.8 percent of cases reported—a substantial increase over Glattly's figure of 54.0 percent. For females of all ages, there is a similar rise to 79.6 percent from the earlier figure of 70.4 percent. Individuals 51 years of age and older constitute 88 percent of the entire group amputated because of disease, and 62.2 percent of all amputations for any reason.

As in the Glattly study, trauma is the second most frequent reason for amputation, although the trend seems to be downward. Current findings (Table 5) are that trauma accounts for 28.0

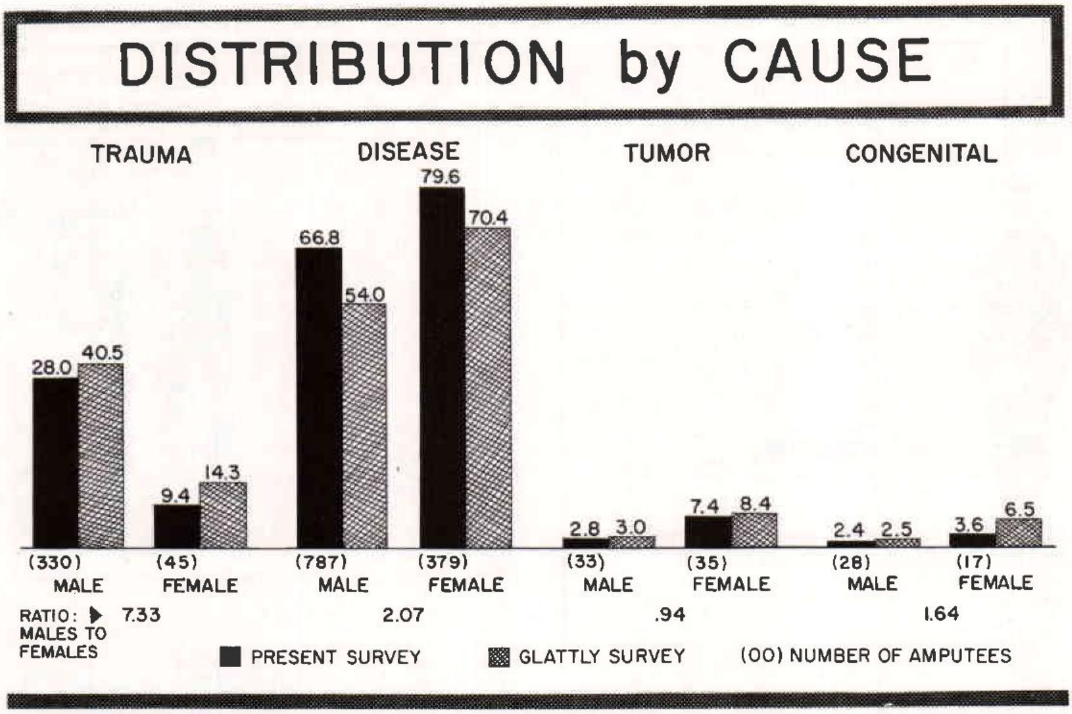

TABLE 5

percent of amputations in males, down from Glattly's 14.3 percent to the current rate of 9.4 percent.

Findings regarding congenital amputations and amputations due to tumor are roughly comparable to those reported by Glattly (Table 5). His figures for male and female amputations due to tumor were 120 and 122, respectively; CPRD-CPOE/AOPA Amputee Survey figures are 33 and 35. Similarly, Glattly reported that 103 males and 84 females were amputated for congenital deficiencies; current findings are 28 and 17. Percentage comparisons are close.

The current study shows a definite correlation between age and cause of amputation (Table 6). While disease is the major cause of amputation for persons 50 years of age and older, trauma is the major cause of amputation for persons under 50. Those in the latter category account for 80.5 percent of all trauma amputees and 61.5 percent of all amputees below the age of 50 who lose their limbs for any reason.

To his apparent surprise, Dr. Glattly found that 13.5 percent of all lower-limb amputees being fitted with prostheses were 70 years of age and over. Current figures for the presently smaller study group show that this figure has risen even higher —to 23 percent (Table 7).

As was found in the early Amputee Census report, there is no significant difference between the incidence of left- and right-sided amputations in either the upper or lower limbs (Table 8).

DISTRIBUTION by AGE and CAUSE of AMPUTATION*

AGE	TRAUMA	DISEASE	TUMOR	TOTAL
1 - 10	17 (54)	0 (18)	2 (11)	19 (83)
11 - 20	64 (210)	8 (42)	24 (62)	96 (314)
21 - 30	105 (315)	7 (42)	9 (27)	120 (384)
31 - 40	58 (386)	29 (148)	11 (31)	98 (565)
41 - 50	58 (408)	93 (358)	7 (29)	158 (795)
51 - 60	41 (268)	260 (767)	7 (38)	308 (1073)
61 - 70	24 (160)	446 (1090)	6 (18)	476 (1268)
71 - 80	5 (48)	248 (543)	3 (0)	256 (591)
81 - 90	3 (9)	71 (87)	0 (1)	74 (97)
91+	0 (0)	4 (3)	0 (0)	4 (3)

(00) GLATTLY SURVEY

*TOTAL NUMBER OF AMPUTEES = 1609; 45 CONGENITAL CASES NOT INCLUDED

TABLE 6

DISTRIBUTION by AGE and LEVEL

• AGE GROUP 70 AND OVER • LOWER-LIMB AMPUTEES ONLY

AGE	HD	AK	KD	BK	SYME	Total
70-80	2	107	2	191	1	303
81-90		21		53		74
91+				4		4
Totals	2	128	2	248	1	381

23% OF 1654 AMPUTEES

TABLE 7

DISTRIBUTION by SIDE of AMPUTATION

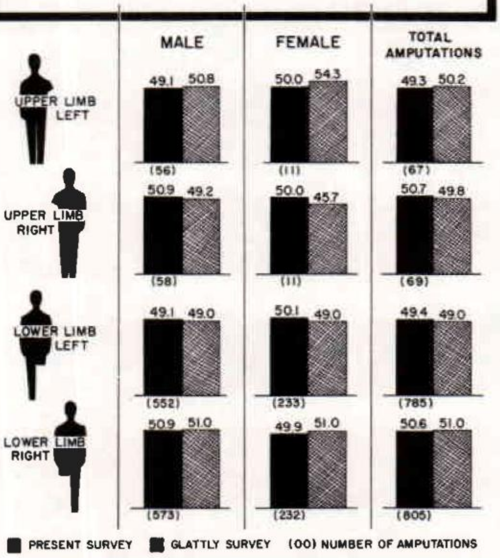

TABLE 8

DISTRIBUTION by SITE, CAUSE, and SEX

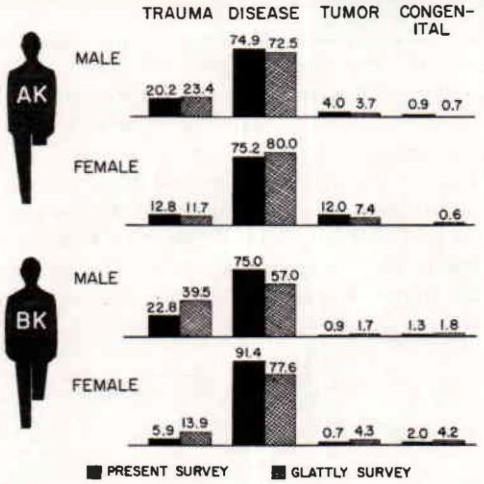

TABLE 9

For the last table (Table 9) comparisons for above- and below-knee levels only are shown, since percentages for other amputation levels would be misleading in view of the few cases recorded thus far. Again, the proportionate increase in incidences of disease and decrease in trauma are evident. Percentage increases in disease for both males and females at the AK level are slight, but at the BK level the increases are significant. Trauma-related amputations show a definite decline at the BK level for both sexes, but at the AK level changes in percentages from Glattly's first report are minor. Comparisons of incidences of amputations for tumor and congenital deficiencies may or may not be significant in view of the small numbers of amputees in these two categories.

Glattly's results were essentially the same for the 12,000 cases reported at the end of his two-year study as they were for the 5,000 cases accumulated during the initial 11-month period. In the current survey an attempt will be made to determine how few cases will suffice to give an accurate picture of the types of amputees being fitted with prostheses. The present study, therefore, will be terminated on June 30, 1974, at which time a further analysis of the data will be made and compared to these preliminary findings. If no substantial changes in ratios are evident in the larger number of cases, it will be assumed that the data accurately reflect current incidences of amputation practice. The results of the later analysis will also be compared with those presented in Glattly's final report.

It is hoped that, as greater numbers of cases are reported, the accumulated data will document the character and magnitude of the amputee population of the United States in terms of sex, levels of amputation, causes of amputation, and ages of amputees.

For those individuals with long experience in the field of prosthetics who have developed their own impressions of the amputee population, the figures presented here and in the future report may contain few surprises. For others, the new reading may reveal significant changes in amputation statistics.

To all of the facility owners and managers who have participated in this survey to date, we express gratitude and look forward to continued support. Those who are not as yet contributing to the study are urged to do so immediately. The final available information will only be as complete and accurate as the data supplied by the facilities.

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Orthotics and Prosthetics, Vol. 28, No. 2, pp. 33–48, June 1974

A PROPOSED INTERNATIONAL TERMINOLOGY FOR THE CLASSIFICATION OF CONGENITAL LIMB DEFICIENCIES*

The Recommendations of a Working Group of the International Society for Prosthetics and Orthotics
Hector W. Kay, *Chairman* (U.S.A.); H. J. B. Day (England); H.-L. Henkel (West Germany); Leon M. Kruger *Rapporteur* (U.S.A.); Douglas W. Lamb (Scotland); Ernst Marquardt (West Germany); Ross Mitchell (Scotland); Alfred B. Swanson (U.S.A.); H.-G. Willert (West Germany).

During the past twenty years the treatment of children with limb deficiencies has emerged as a recognizable subspecialty in both medicine and prosthetics. These children can be divided into two broad categories—those whose amputations are acquired as the result of trauma or disease; and those who are born with a limb defect or anomaly.

With the first group, classification of the presenting condition usually poses little difficulty either nationally or internationally as the terms used are common throughout the world. For example, a partial limb loss described as a short-below-elbow stump in English would be reported as a kurzer Unterarmstumpf in German, and the translation is straightforward. However, in the case of congenital deficits or anomalies, the situation has been quite the reverse in that different systems of nomenclature are used in different parts of the world. In some cases there are even different systems in use within the same country.

TWO PRIME SYSTEMS OF TERMINOLOGY

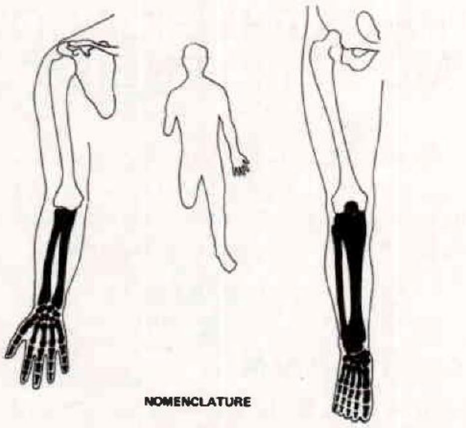
The two mainstreams of nomenclature for congenital limb deficiencies are those developed and in vogue in the United States of America; and those which originated in Germany and are used extensively in European countries:

U.S. TERMINOLOGY

In the U.S.A. the classic work of Frantz and O'Rahilly (2), published in 1961, provided a clear, concise, and comprehensive system of nomenclature which was rapidly adopted by clinicians in that country. However, although this system offered many advantages, it did contain a number of terms, chief among them hemimelia, which were unacceptable to European orthopedic surgeons. Figure 1 shows the elbow-disarticulation and knee-disarticulation types of what might be called true forms of *terminal transverse* hemimelia, or half a limb. Figure 2 shows the above-elbow and above-knee forms of the same defect. Figure 3 illustrates the deficiency classified as terminal transverse *partial* hemimelia. The terminal longitudinal defects identified as complete *paraxial* hemimelia are shown in Figure 4 and the incomplete forms of these deficiencies are shown in Figure 5. The complete and incomplete forms of the *intercalary longitudinal* type of paraxial hemimelia are indicated in Figures 6 and 7. Hemimelia literally means half a limb, which may be variously interpreted as being present, absent, or affected. Hence these terms admittedly could be somewhat confusing to the uninitiated.

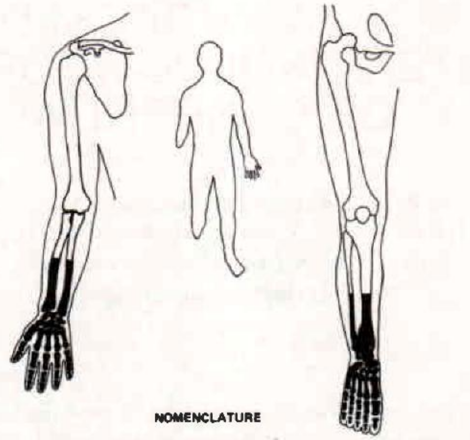
In an effort to eliminate features of the Frantz-O'Rahilly system that were objectionable to overseas clinicians, and to provide a means for classifying conditions not possible by that system, a proposed revision of the Frantz-O'Rahilly scheme was published in 1966 (1). This revision eliminated the term hemimelia by referring to all partial-limb absences as meromelias, but it did retain the four major Frantz-

*Prepared for the Group by Hector W. Kay, Assistant Executive Director, Committee on Prosthetics Research and Development, Division of Medical Sciences, National Research Council, Washington, D.C.



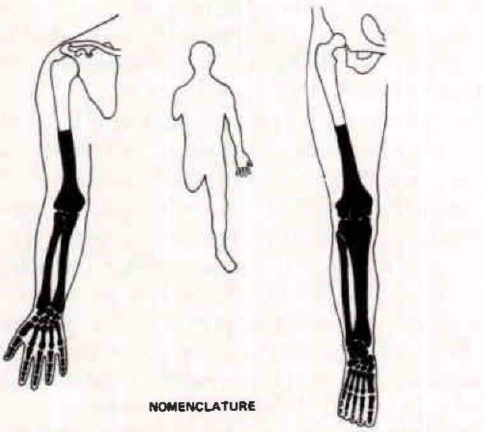
	NOMENCLATURE	
Hemimelia (T-) (E-D type) right	Original Frantz-O'Rahilly	Hemimelia (T-) (K-D type) right
Peromelia, at the level of the right elbow	European	Peromelia, at the level of the right knee
Meromelia (T-) Radio-Ulnar, right	Revised Frantz-O'Rahilly	Meromelia (T-) Tibio-Fibular, right

Fig. 1. Absence of forearm and hand, or leg and foot.



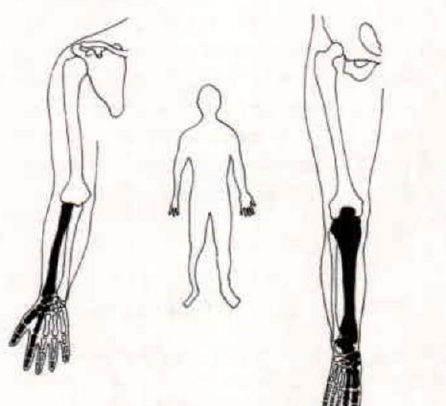
	NOMENCLATURE	
Partial Hemimelia (T-) right	Original Frantz-O'Rahilly	Partial Hemimelia (T-) right
Peromelia at mid-radio-ulnar level; partial aplasia of the radius and ulna, right	European	Peromelia at mid-tibio-fibular level, partial aplasia of the right tibia and fibular
Meromelia (T-) radius M, ulna M, right	Revised Frantz-O'Rahilly	Meromelia (T-) tibia M, fibula M, right

Fig. 3. Absence of part of forearm and hand, or part of leg and foot.



	NOMENCLATURE	
Hemimelia (T-) (A/E type) right	Original Frantz-O'Rahilly	Hemimelia (T-) (A/K type) right
Peromelia, upper right, mid-humeral level; (short, above-elbow stump)	European	Peromelia, lower right, mid-femoral level; (short, above-knee stump)
Meromelia (T-) humerus M, right	Revised Frantz-O'Rahilly	Meromelia (T-) femur M, right

Fig. 2. Absence of part of arm and all of forearm and hand, or part of thigh and all of leg and foot.



	NOMENCLATURE	
Complete Paraxial Hemimelia, Radial (T/I) upper right	Original Frantz-O'Rahilly	Complete Paraxial Hemimelia, Tibial (T/I) lower right
Ectromelia with axial aplasia; radial, carpal, metacarpal, and phalangeal; right	European	Ectromelia with axial aplasia; tibial, tarsal, metatarsal, and phalangeal, right
Meromelia (T/I) Radial	Revised Frantz-O'Rahilly	Meromelia (T/I) Tibial

Fig. 4. Absence of the radius and the corresponding skeletal elements of the wrists and hand, or absence of the tibia and the corresponding skeletal elements of the ankle and foot.

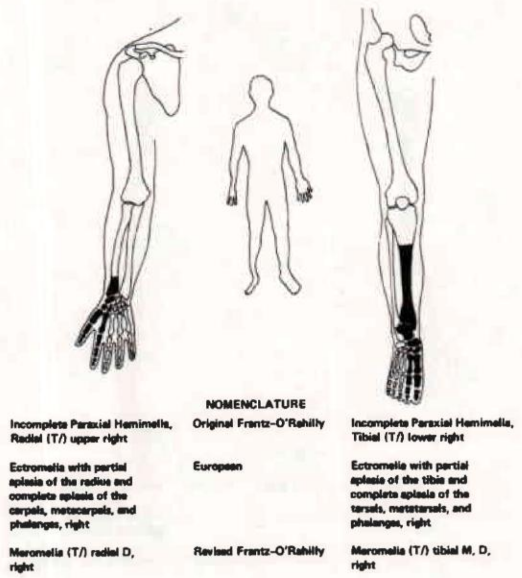


Fig. 5. Absence of part of the radius and the corresponding skeletal elements of the wrist and hand, or absence of part of the tibia and the corresponding skeletal elements of the ankle and foot.

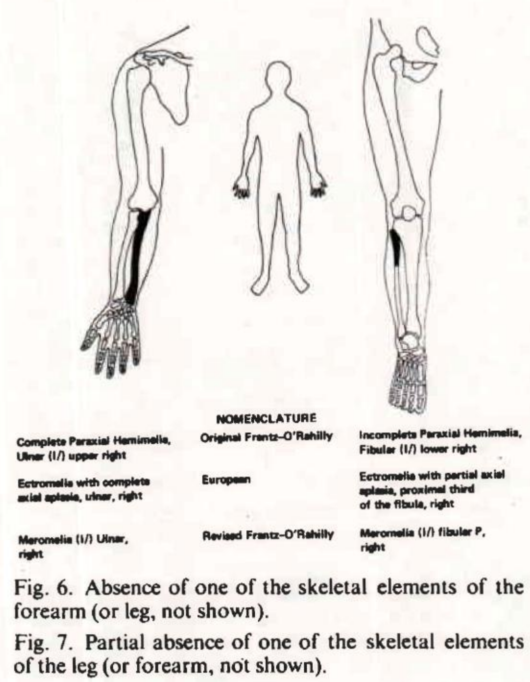


Fig. 6. Absence of one of the skeletal elements of the forearm (or leg, not shown).

Fig. 7. Partial absence of one of the skeletal elements of the leg (or forearm, not shown).

O'Rahilly categories (terminal transverse, terminal longitudinal, intercalary transverse, and intercalary longitudinal), as shown in the previously cited illustrations (Figs. 1 through 7). However, instead of serving to replace the original Frantz-O'Rahilly classification system in the U.S.A., the proposed revision came into use as an additional classification method, i.e., it has been adopted by some practitioners while others have continued to use the original Frantz-O'Rahilly terminology.

The third component in the U.S. picture is the classification procedure first proposed by Swanson in 1964 (6) and amplified in 1966 (7). This system covers soft tissue as well as skeletal considerations, and such anomalies as duplications (Fig. 8), overgrowth (Fig. 9), and the congenital constriction band syndrome (Fig. 10) which are not included in the other (skeletal deficiency) classifications.

GERMAN TERMS

In Germany nomenclature for the classification of limb deficiencies followed a different

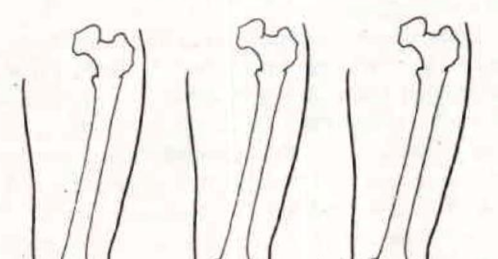


Fig. 8 *(left)*. Duplications: foot. Fig. 9 *(middle)*. Overgrowth: foot. Fig. 10 *(right)*. Congenital circular constriction band syndrome: leg.

course and by the early 1960s such terms as peromelia, ectromelia, and dysmelia, which are not used at all in the U.S.A., were common in the German literature (3, 4, 5). The only terms in fact on which there has been some degree of general agreement in Europe and America have been amelia and phocomelia (Figs. 11 through 14). It remained for Willert and Henkel in 1969 (8, 9) to attempt a systemization of the German nomenclature based on a pattern of orderly "Reduktion" or progression in the severity of a defect, and characterized by such terms as hypoplasia, partial aplasia, and total aplasia (Fig. 15).

THE DUNDEE WORKSHOP

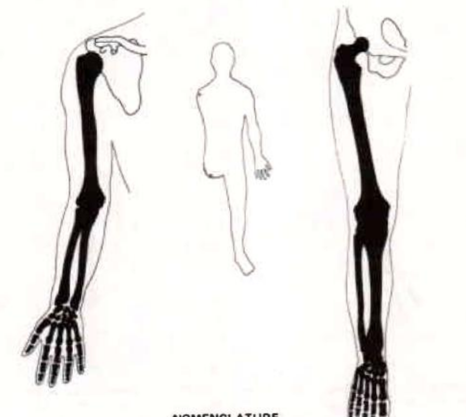
It was against this background then that a working group met in Dundee, Scotland, under the auspices of the International Society for Prosthetics and Orthotics, in June 1973, charged with the responsibility of proposing a terminology which might be acceptable internationally.

The proceedings opened with brief presentations by members of the working group concerning terminology systems in current use, plus some preliminary thoughts as to procedures for the development of some unanimity of opinion on nomenclature.

In the discussion which followed it was readily agreed that, while the use of words derived from Greek and Latin roots was common in medicine and was theoretically attractive for a classification nomenclature, the implementation of this practice in the past had led to considerable confusion. People had tended to invent Greek- or Latin-derived words and attach their own special meanings to them. Moreover many languages in the world were not related to the classical languages and translations were sometimes difficult. Hence it was decided to eliminate such terms as peromelia, ectromelia, hemimelia, and meromelia, and attempt to describe deficiencies in the simplest yet most precise language which would be understandable by all in the English-speaking world and be easily translatable into other languages.

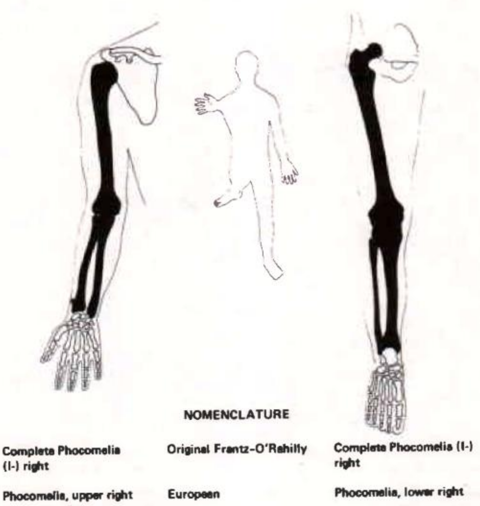
SUBCATEGORIES

Attention was directed to a consideration of the four basic categories of limb deficiencies proposed in the original Frantz-O'Rahilly work. These categories were:



	NOMENCLATURE	
Amelia (T-) upper right	Original Frantz-O'Rahilly	Amelia (T-) lower right
Amelia, upper right (Shoulder-Disarticulation)	European	Amelia, lower right (Hip-Disarticulation)
Amelia (T-) upper right	Revised Frantz-O'Rahilly	Amelia (T-) upper right

Fig. 11. Absence of entire limb.



	NOMENCLATURE	
Complete Phocomelia (I-) right	Original Frantz-O'Rahilly	Complete Phocomelia (I-) right
Phocomelia, upper right	European	Phocomelia, lower right
Meromelia (I-) Humeral, Radio-Ulnar; right	Revised Frantz-O'Rahilly	Meromelia (I-) Femoral, Tibio-Fibular; right

Fig. 12. Absence of the skeletal elements of the arm and forearm with the hand attached to the trunk, or absence of the elements of the thigh and leg with the foot attached to the trunk.

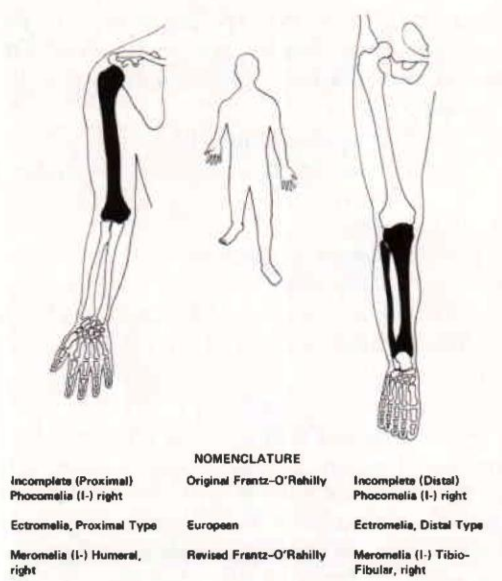


Fig. 13. Absence of arm elements with forearm attached directly to the trunk, or absence of thigh elements with leg attached to the trunk.

Fig. 14. Absence of leg elements with foot attached directly to the thigh, or absence of forearm elements with the hand attached to the arm.

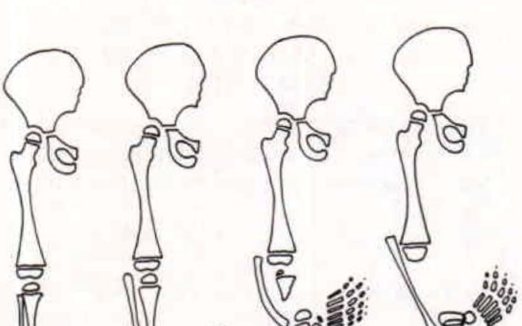


Fig. 15. Distal form of ectromelia. *a*, Tibia hypoplasia; *b*, Partial tibia aplasia; *c*, Subtotal tibia aplasia; *d*, Total tibia aplasia.

Terminal — Transverse and Longitudinal

and

Intercalary — Transverse and Longitudinal

Unanimity of opinion was reached immediately concerning terminal transverse conditions, i.e., those presenting a congenital amputation-type stump. However, the existence of true intercalary deformities was questioned.

After considerable discussion and review of prior presentations involving both x-rays and diagrammatic representations of limb deficiencies, general agreement was reached that true intercalary deficiencies rarely if ever existed. It was postulated that all "phocomelias" or "intercalary deficiencies" had some terminal manifestation—be it a tarsal or carpal aberration, a defect of a finger or toe, or a deficiency of muscle, tendon, skin or nail. From this evolved an approach to classification which suggested that these intercalary defects were in reality variable degrees of longitudinal deficiencies. It was concluded that with the single exception of the previously mentioned transverse deficiencies all others were a manifestation of some longitudinal aberration in the formation of parts—thus even that condition described as "hypoplasia" of a limb or skeletal element in reality had a longitudinal (in the sense of the long axis of each bone) failure. Similarly, although "phocomelia" had a major manifestation of failure of formation in the long bones, there was also a lesser and perhaps minimal failure in the peripheral elements which, although present, were never truly normal. This concept of progressive longitudinal reduction can be carried to a point where only a single digital remnant of a limb remains and ultimately to the situation in which even this vestigial peripheral element failed to form—the true amelia. This, therefore, might be considered a maximum longitudinal deficiency although presenting as a transverse-type defect. For simplicity of designation, however, amelia might best be categorized as a transverse deficiency. It was recognized that in clinical practice the use of such well-established terms as amelia, phocomelia, and proximal femoral focal deficiency (PFFD) would likely continue.

Based on this line of reasoning, a decision was reached to consolidate all limb deficiencies into two groups:

1. Transverse
2. Longitudinal

The transverse defects would encompass all so-called congenital amputation-type conditions and include what heretofore were referred to as terminal transverse deficiencies. The second major category would then become the longitudinal deficiencies which would encompass in effect all deficiencies which were not in the transverse category. It was agreed that the longitudinal category would require subdivision into 1) proximal longitudinal, 2) distal longitudinal, and 3) combined longitudinal deficiencies.

In further discussion of subdivisions under these two major categories, it was generally agreed that transverse deficiencies could be described and characterized by the level at which the limb terminated, but that in the longitudinal deficiencies such a description was unnecessary and that each deficiency could be described by naming the bone(s) affected and indicating whether they were completely or partially absent. It was recognized that conditions referred to as hypoplasia or underdevelopment in any one or all of the bones of the limb did exist, and could be described in the proximal, distal, or the combined form, again by naming the bone(s) affected and indicating the presence of hypoplasia.

OVERALL CLASSIFICATIONS OF MALFORMATIONS

At the request of Dr. Swanson the overall classification for congenital malformations, which had been accepted previously by the American Hand Society, was considered. This system encompassed seven categories:

I. Failure of formation of parts
II. Failure of differentiation (separation) of parts
III. Duplication
IV. Overgrowth (Gigantism)
V. Undergrowth
VI. Congenital constriction band syndrome
VII. Generalized skeletal abnormalities.

While there was tacit acceptance of the rationality of these categories, it was unanimously agreed that the prime and virtually sole concern of the workshop was with nomenclature and classification in congenital *skeletal limb deficiencies*. In terms of the classification categories listed above these conditions would generally fall into the grouping designated as "failure of formation of parts," although some conditions might also involve failure of differentiation of parts, e.g., synostosis, or even occasionally undergrowth, e.g., a radius which was complete but hypoplastic.

PROPOSED INTERNATIONAL NOMENCLATURE FOR CLASSIFICATION OF DEFICIENCIES

The workshop members then proceeded to the development of a schema which was unanimously proposed for international adoption, as follows:

FAILURE OF FORMATION OF PARTS

1. *Transverse Limb Deficiencies (congenital amputations)*

UPPER LIMB (UL)		LOWER LIMB (LL)
Arm (Ar)	Complete Upper 1/3 Middle 1/3 Lower 1/3	Thigh (Th)
Forearm (Fo)	Complete Upper 1/3 Middle 1/3 Lower 1/3	Leg (Le)
Carpal (Ca)	Complete Partial	Tarsal (Ta)
Metacarpal (MC)	Complete Partial	Metatarsal (MT)
Phalangeal (Ph)	Complete Partial	Phalangeal (Ph)

DISCUSSION

A few illustrations are presented to clarify the application of this classification procedure. It should be noted that in each case *the designation indicates the level of absence;* it being understood that all skeletal elements distal to that level are also absent. Each classification would, of course, include right (R), left (L), or bilateral (Bil).

1. Complete absence of an upper or lower limb (Figs. 16 and 17) would then be a transverse deficiency—arm (Ar), or thigh (Th), complete. The term amelia (Fig. 11) would probably continue in clinical use to characterize this condition.

2. A transverse deficiency, Ar, upper, would indicate a short-above-elbow amputation-like limb which terminated in the upper third of the humerus (Fig. 18); a transverse deficiency, Th, lower, would be the term applied to a long above-knee amputation-like stump which terminated in the distal third of the femur (Fig. 19).

3. An elbow-disarticulation-type deficit (Fig. 20) would be classified as a transverse deficiency, forearm (Fo), complete; while below-elbow-type stumps would be designated Fo, upper, middle,

or lower, depending on the third of the forearm in which the limb terminated (Figs. 21, 22, and 23).

4. For transverse deficiencies which terminate in the carpal, tarsal, metacarpal, metatarsal, and phalangeal areas, only the designations complete and partial are used to denote the level of loss in that particular area. For example, Carpal (or Ca), complete, would indicate a wrist-disarticulation-type stump (F-O'R's acheiria); MC, complete, a F-O'R adactylia, and Ph, complete, a F-O'R aphalangia (Figs. 24-A, 24-B, and 24-C). If for example one row of carpals still remained, the term used would be Ca, partial (Fig. 25).

It is obvious that although all limb deficiencies will fall into the broad categories of upper- or lower-limb deficits it is unnecessary to spell out this identification in classifying them, since the information will be self-evident from the bone(s) named.

In developing the examples presented the author found it tedious to write out the general category each time. He suggests, therefore, that the abbreviation (T-) from earlier classification systems be used. Fully abbreviated then the deficit shown in Figure 18 would be written: (T-), R, Ar, upper.

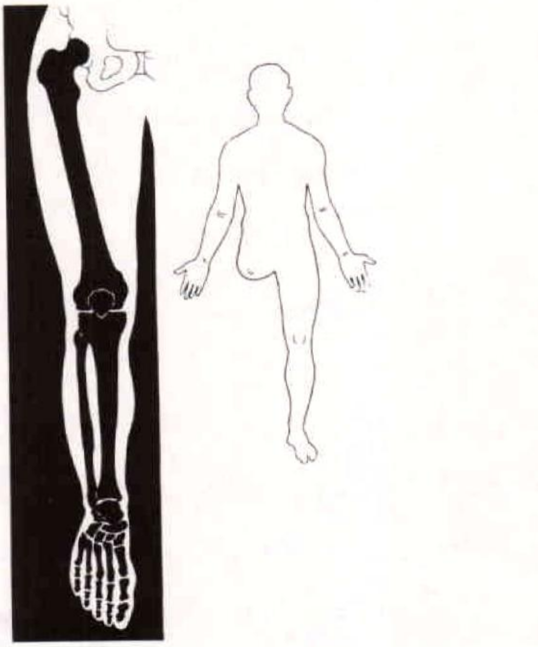


Fig. 17. A transverse deficiency—right, thigh (Th), complete.

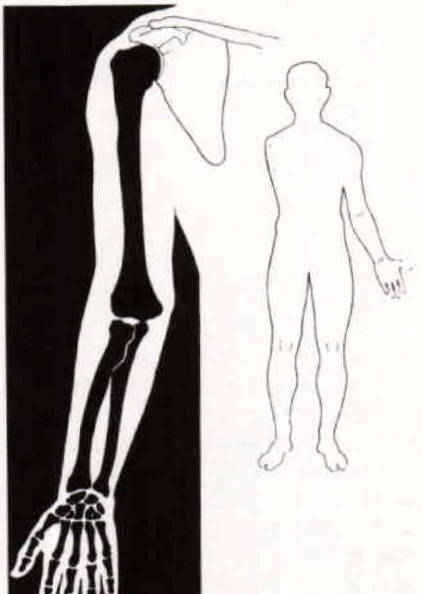


Fig. 16. A transverse deficiency—right, arm (Ar), complete.

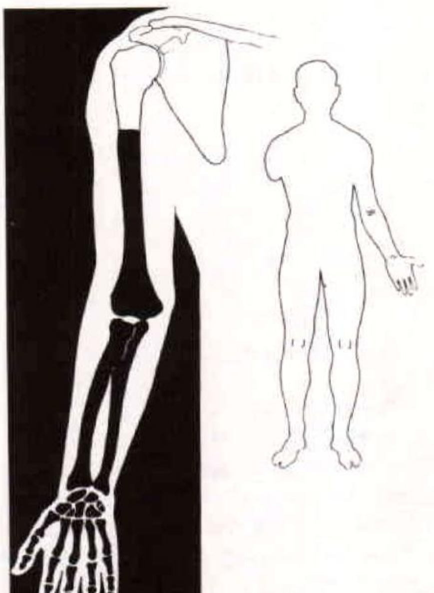


Fig. 18. A transverse deficiency—right, Ar, upper.

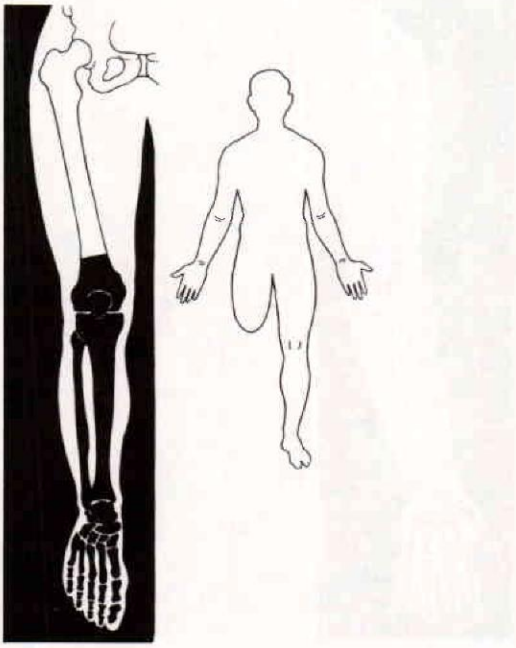


Fig. 19. A transverse deficiency—right, Th, lower.

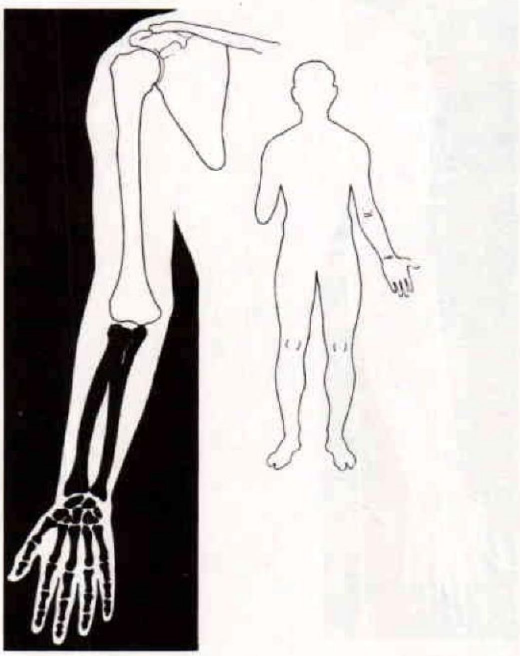


Fig. 20. A transverse deficiency—right, forearm (Fo), complete.

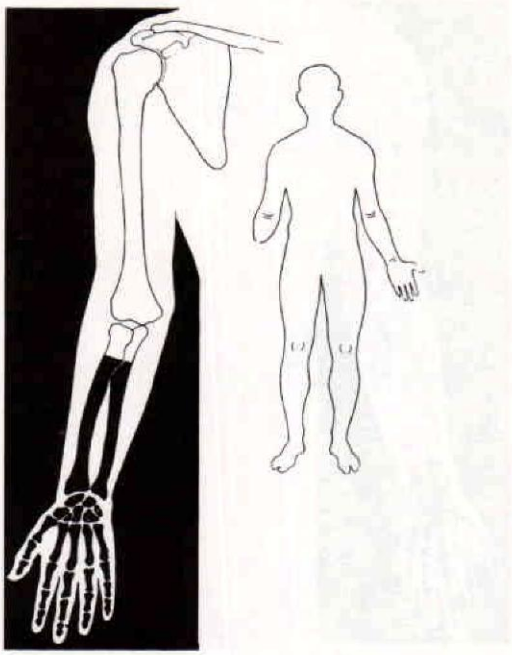


Fig. 21. A transverse deficiency—right, Fo, upper.

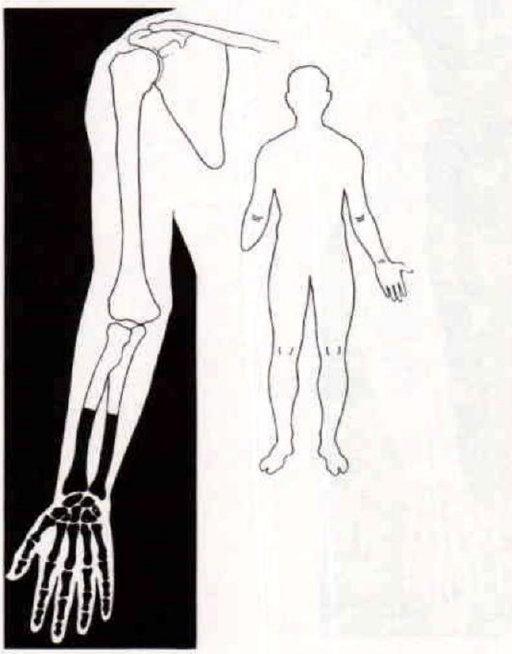


Fig. 22. A transverse deficiency—right, Fo, middle.

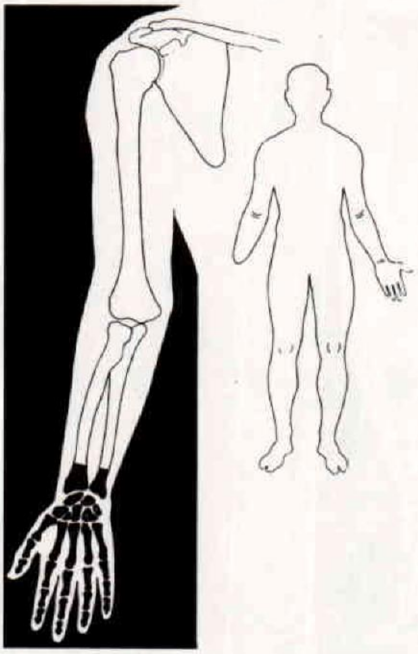


Fig. 23. A transverse deficiency—right, Fo, lower.

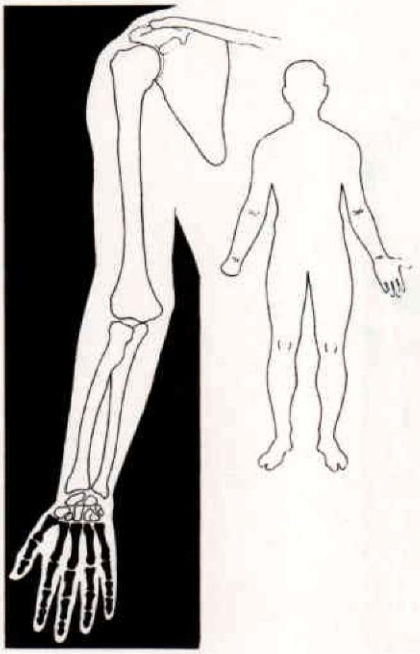


Fig. 24-B. A transverse deficiency—right, metacarpal (MC), complete.

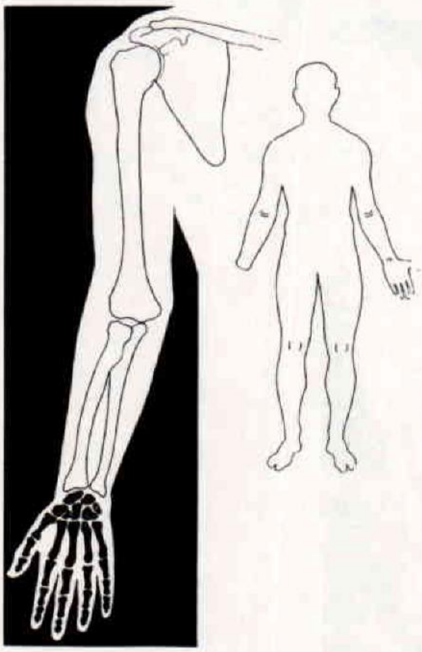


Fig. 24-A. A transverse deficiency—right, carpal (Ca), complete.

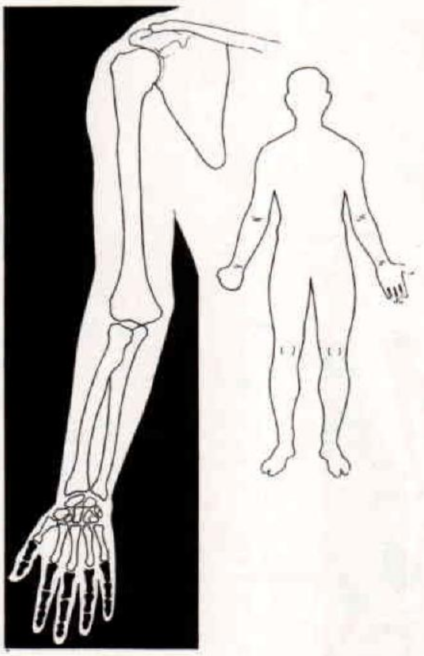


Fig. 24-C. A transverse deficiency—right, phalangeal (Ph), complete.

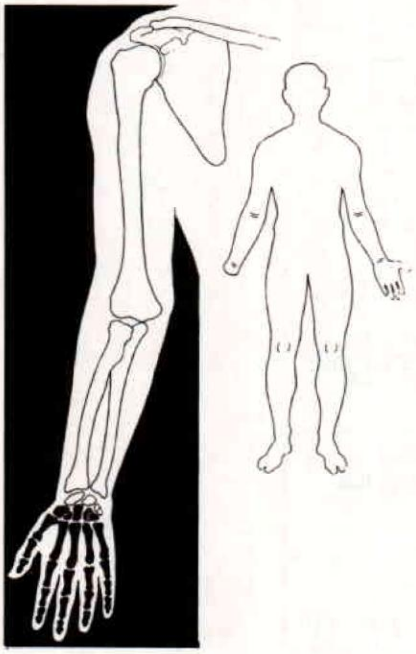
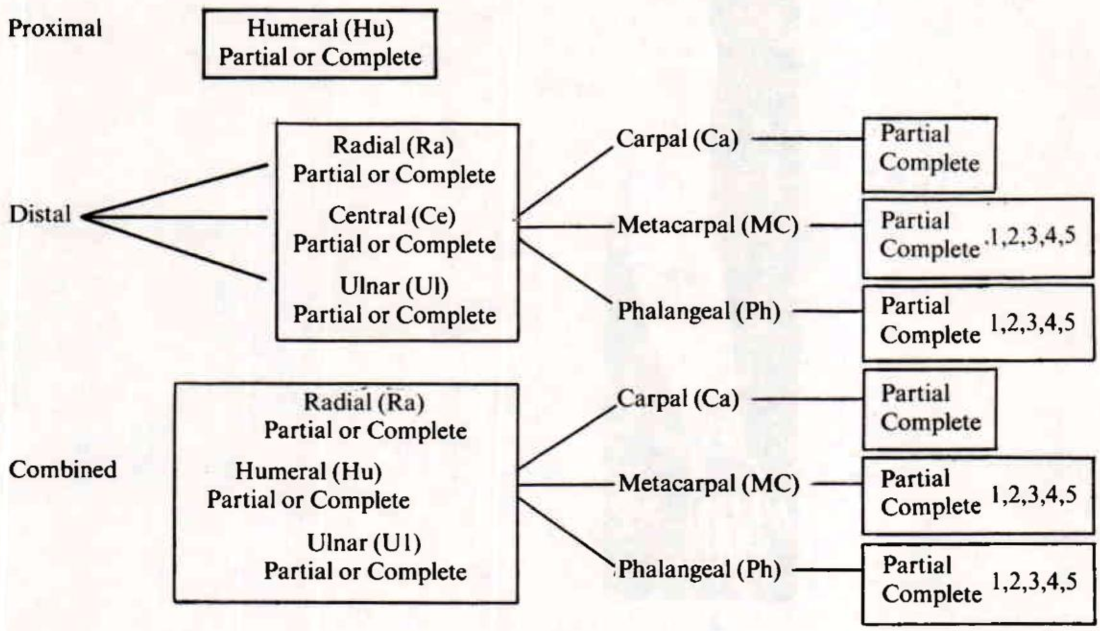


Fig. 25. A transverse deficiency—right, Ca, partial.

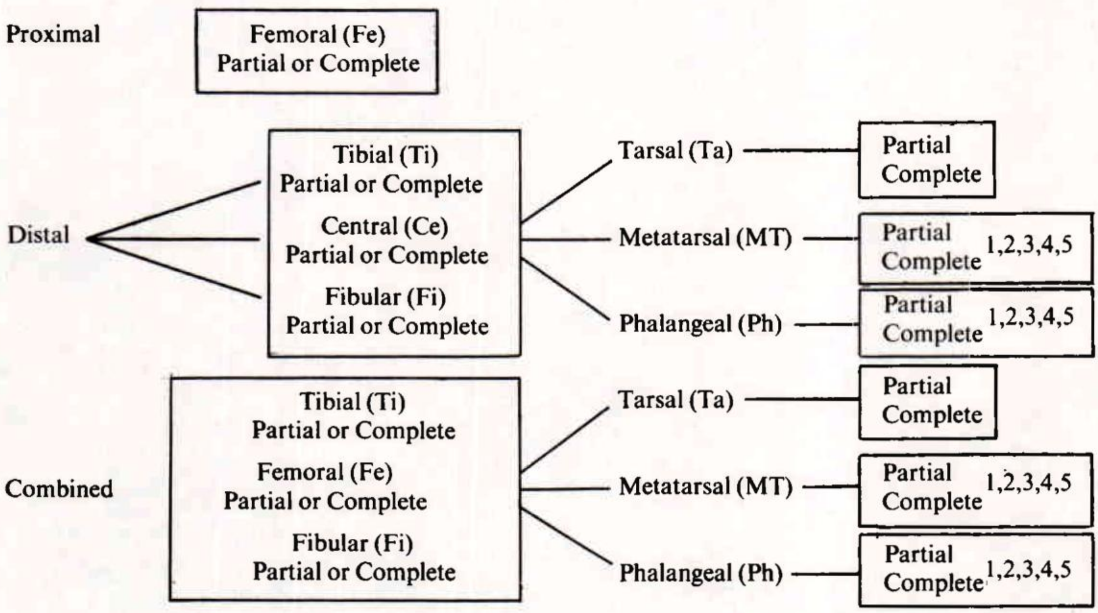
2. *Longitudinal Deficiencies*

ALL BONES NAMED TO BE DESIGNATED AS PARTIALLY OR COMPLETELY ABSENT

UPPER LIMB (UL)



LOWER LIMB (LL)



DISCUSSION

Obviously the application of the proposed schema for longitudinal deficiencies is considerably more complex than that involving the transverse variety. However, if we proceed from the simplest situation to the more complicated and relate new terms to old, a pattern is readily discernible. It should be noted that the principle followed in earlier systems, that of naming bones that were absent rather than those that were present, is also followed here. While the term intercalary has been eliminated from the proposed international terminology, this condition, both in its transverse and longitudinal form, can be described readily in the new system.

1. A longitudinal deficiency (proximal) Hu or Fe, complete, would correspond to the intercalary transverse defect—proximal phocomelia—of Frantz-O'Rahilly (Fig. 26). Similarly the distal forms Radial-Ulnar (Ra-Ul) or Tibial-Fibular (Ti-Fi), complete, would correspond to Frantz-O'Rahilly's distal phocomelia (Figs. 27 and 28).

2. In other distal forms, Radial (Ra), Ulnar (Ul), Tibial (Ti), or Fibular (Fi), complete, would be the new terms for the old Frantz-O'Rahilly intercalary longitudinal defects—complete par-

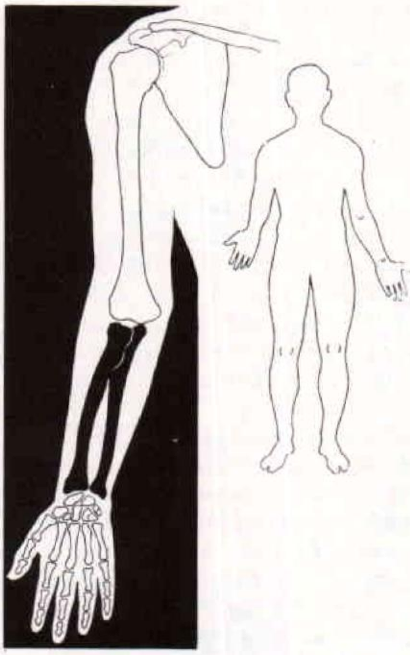


Fig. 27. A longitudinal deficiency—right, radial-ulnar (Ra-Ul), complete.

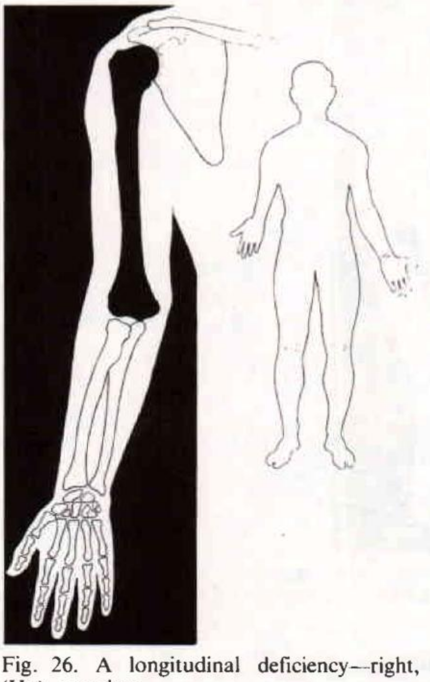


Fig. 26. A longitudinal deficiency—right, humeral (Hu), complete.

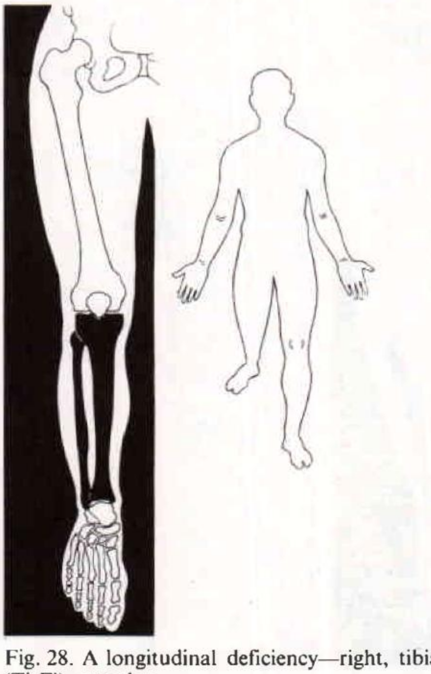


Fig. 28. A longitudinal deficiency—right, tibial-fibular (Ti-Fi), complete.

axial hemimelia radial, ulnar, tibial, or fibular (Fig. 29). Ra, Ul, Ti, or Fi, incomplete, would, of course, be the incomplete forms of these same conditions (Fig. 30).

3. Samples of distal forms which also involve hand or foot elements would be a) Ra, complete; Ca, partial; MC 1.2, complete; Ph 1.2, complete, to describe what had been known heretofore as the terminal longitudinal deficiency—complete paraxial hemimelia, Radial, of Frantz-O'Rahilly (Fig. 31); or b) Ti, partial; Ta, partial; MT 1.2, complete; Ph 1.2, complete, to describe the defect shown earlier as incomplete paraxial hemimelia, Tibial, in the Frantz-O'Rahilly terminology (Fig. 32).

4. Combined types of longitudinal deficiencies would essentially be those erstwhile phocomelias in which elements were defective or absent at all levels of a limb. An example is shown in Figure 33 from Willert and Henkel. Described by these authors as an "Axiale Form der Ektromelie" (kurzer Achsentyp mit radio-ulnärer Synostose), its full description in the proposed international terminology would be a longitudinal deficiency; Hu, complete; Ra and Ul, partial with synostosis; Ca, partial; MC 1.2, complete; and Ph 1.2, complete. Clinically the condition would doubtless still be called a phocomelia, or perhaps a proximal phocomelia.

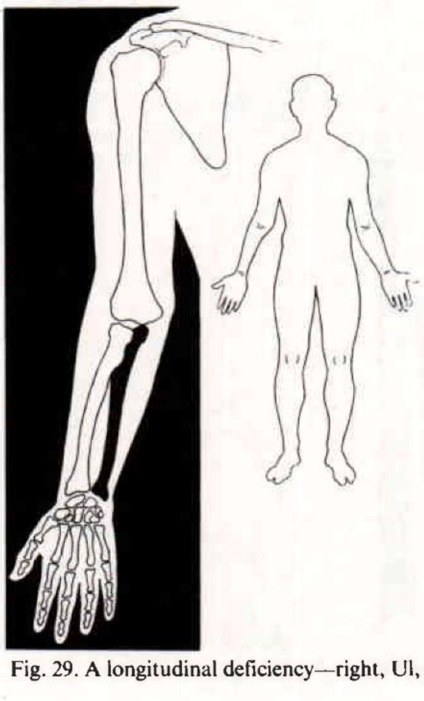


Fig. 29. A longitudinal deficiency—right, Ul, complete.

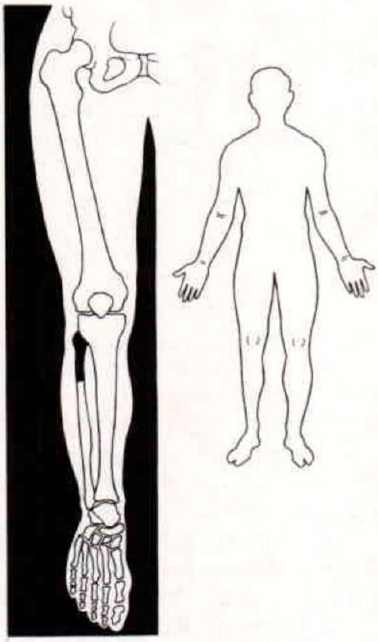


Fig. 30. A longitudinal deficiency—right, Fi, partial.

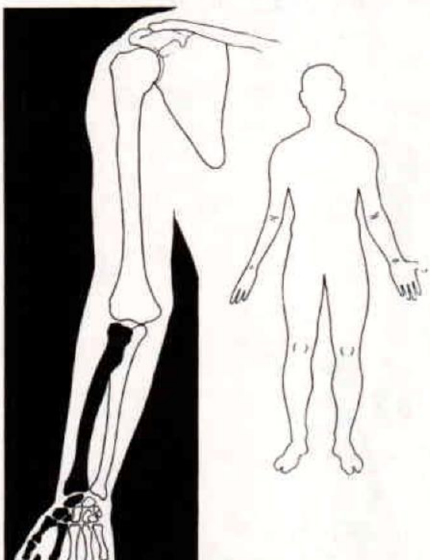


Fig. 31. A longitudinal deficiency—right, Ra, complete; Ca, partial; MC 1.2, complete; Ph 1.2, complete.

It should be emphasized that in the longitudinal deficiencies only the absent bone (or bones) is

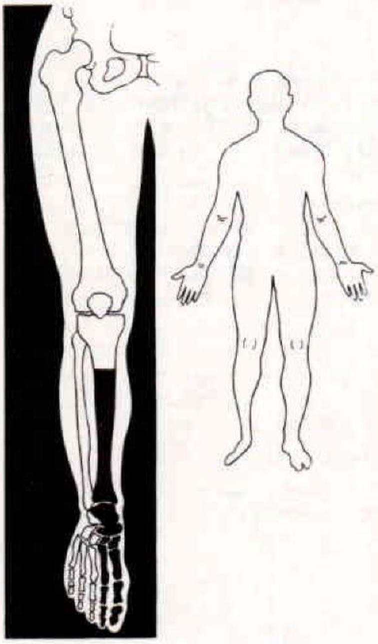


Fig. 32. A longitudinal deficiency—right, Ti, partial; Ta, partial; MT 1.2, complete; Ph 1.2, complete.

Fig. 33. A longitudinal deficiency—left, Hu, complete; Ra and Ul, partial, with synostosis; Ca, partial; MC 1.2, complete; and Ph 1.2, complete.

cited no assumptions being made that more distal elements are also absent.

Again it is evident that, while the categories of UL and LL, and proximal, distal, or combined would be useful in organizing statistical or census data, these terms are not essential for classification. As in the transverse deficiencies this information is self-evident from the bone(s) named.

In preparing the examples for this paper the author again found it tedious to have to write out "a longitudinal deficiency" each time. Use of an abbreviation L slash in parentheses (L/)-to avoid confusion with L for left-is proposed.

It should also be emphasized that the examples presented in this section are for illustrative purposes only. Some of the deficiencies classified may not exist clinically in as "pure" a form as depicted here.

FURTHER RECOMMENDATIONS

Following the development of the proposed international nomenclature as described, members of the working group tried out the new system by reclassifying a number of the deficiencies presented in slides earlier in the workshop. No difficulties were experienced. However, it was recognized that more extensive trials were desirable. Members of the workshop agreed to continue trying out the new system themselves but also recommended that field trials be carried out internationally under the auspices of the International Society for Prosthetics and Orthotics. These trials would be conducted in the U.S.A. through the medium of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development; and elsewhere in the world through selected child amputee clinics. Plans are now being made to implement these recommendations.

It was further recommended that the proposed international terminology for the classification of congenital limb deficiencies, as described in this paper, be brought to the attention of the World Health Organization for possible inclusion in the revision of standard nomenclature now being undertaken by that body. This recommendation has since been followed.

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ILLUSTRATION CREDITS

Figs. 1-7, 11-14—Adapted from illustrations used in "Limb Development and Deformity: Problems of Evaluation and Rehabilitation" by Chester A. Swinyard, M.D., Ph.D., (ed.). Charles C Thomas Publisher, Springfield, Ill., 1969.

Figs. 8-10—Based on illustrations used in "Classification of Limb Malformations on the Basis of Embryological Failures: A Preliminary Report" by A. B. Swanson, Inter-Clin. Inform. Bull., 6:3:1-15, December 1966. Drawings redone by George Rybczynski.

Figs. 15 and 33—Adapted from illustrations used in "Klinik und Pathologie der Dysmelie: Die Fehlbildungen an den oberen Extremitäten bei der Thalidomid-Embryopathie" by H.-G. Willert, and H.-L. Henkel. Springer-Verlag, Heidelberg, New York, 1969.

Figs. 16-32—Drawings by George Rybczynski.

Descriptors: Classification; longitudinal limb deficiencies; nomenclature; terminology.

Orthotics and Prosthetics, Vol. 28, No. 2, pp. 49-50, June 1974

TECHNICAL NOTES

COSMETIC SHAPING OF A PROSTHESIS

After the prosthetist has achieved an alignment and prosthetic fit that are satisfying to him and the patient, the next factor to consider is cosmesis. Smooth-flowing lines and flawless lamination can do much to help achieve good appearance.

A little time in shaping a lower-limb prosthesis is well spent, and is greatly appreciated by the patient, especially women. The short skirts and other modern fashions that increasingly call attention to legs make it very important to match closely the shape of the opposite leg.

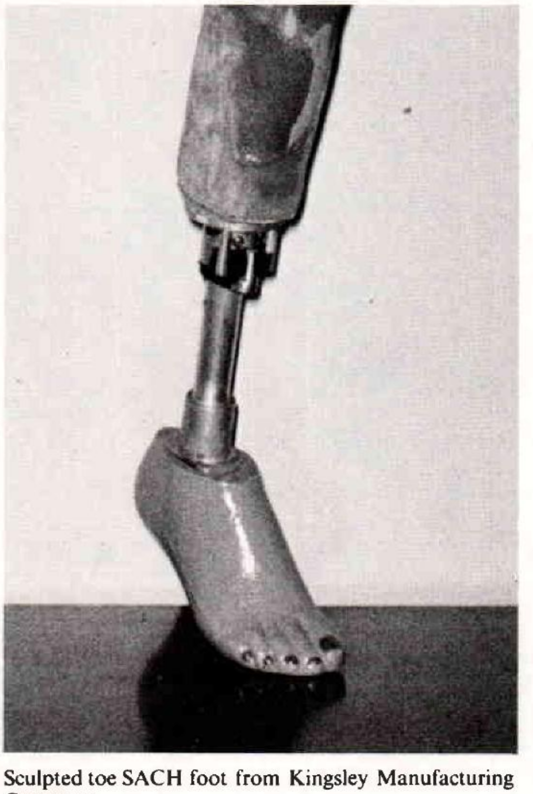
Men aren't usually as vain about their appearance and, because of long pants, artificial legs are seldom noticed on a man. A prosthesis is at best a poor substitute for a limb, and we as prosthetists owe it to our patients and ourselves to do the best job possible.

In shaping a man's leg, usually all that is necessary generally is to match the profiles of the limb and maintain circumferential measurements as closely as possible. The ankle measurement can be matched, but the calf circumference will almost invariably be greater on the prosthetic side. In total-contact patellar-tendon-bearing prostheses without liners, the calf circumference can be approximated closely. However, when a soft insert is used, the circumferential calf measurement is increased greatly. The addition of side joints increases this even more, and pants must be selected carefully to allow for this increase.

One of the most important factors to be considered but often overlooked is the shape of the foot. It must be shaped so as to afford a minimum of difficulty in donning the shoe. On a low-quarter shoe, the width of the lace holes should match so that both shoes appear symmetrical, i.e., present mirror images of each other. Care must be exercised to give enough clearance behind the head of the first metatarsal so that the foot does not "rock" in the shoe and, finally, the toes and dorsum of the foot must be modified to give the foot enough room to move in the shoe without binding and thus restricting the desired action of the foot. This is especially critical with a SACH foot, but it is also important with an articulating ankle.

The ankle circumference is noticeable and important with respect to cosmesis, but not too critical unless the man is going to wear boots, and most men at some time desire to wear boots, if only rubber boots for fishing or wet weather. The instep must be relieved to allow donning of boots.

Shaping the prosthesis for a woman is an exacting, time-consuming procedure when done



Sculpted toe SACH foot from Kingsley Manufacturing Company.

properly. On an above-knee prosthesis all circumferential measurements can be exact if the proper selection of a knee is made. It must be remembered that allowance must be made for the lamination to follow. The most noticeable portions of the prosthesis are the ankle and the calf. In a below-knee case, the calf measurements will be oversized so the leg must be contoured to the distal measurements. Profiles are more noticeable than size so if the profiles are matched from all angles, the size difference is not so noticeable. Placement of the malleoli is one of the most noticeable features. Both malleoli must be level with their anatomical counterparts. The medial malleolus is higher and more anterior than the lateral malleolus.

After preliminary shaping of the foot and leg, both may be covered with stockinette. This will eliminate color distortion and make shape differences more readily apparent. Women will especially appreciate your efforts at achieving a cosmetic prosthesis when they apply their nylons. The sculpted-toe ladies' foot by Kingsley will be of great benefit to prosthetists and their patients.

In conclusion, aside from all of the functional and cosmetic benefits, there is a feeling of real pride when you can stand twenty feet away and not tell the difference in legs.

Andy Parmley, C.O.
Manager, Pocatello Branch
Orthotic and Prosthetic Services
Pocatello, Idaho 83201

Orthotics and Prosthetics, Vol. 28, No. 2, p. 51, June 1974

IS LEATHER YOUR BAG?

If you have worked with soft, stretchy cowhides and then with firm elk and molding leathers, you have perhaps wondered how the same animal can produce such different products. Of course, the poor animal could care less how the leather is finished. In fact, you might say it's no skin off his hide! The condition of the leather is controlled by the ingenuity of the tanner.

Our common elk leathers are tanned in a process called Chrome Tanning. The hides, as they come to the tannery, are in stiff, dirty, smelly bundles. The first steps are to make them soft and pliable and to remove the hair and dirt. This is done by soaking in a lime solution. When you approach a tannery you can smell this part of the process from some distance away!

After soaking, the hide must be sliced to take off any flesh and surplus thickness. It is then sliced down the back, so that from each hide we get a left and a right side. Perhaps you have held up a side of leather and noticed the neck, legs, and tail end of the animal—you are seeing only the left or right side.

The next step, after washing again in a chrome salt solution, is drying the hides on racks that pass through a huge dryer. From here the sides are smoothed, a color finish is sprayed on, and then each side goes through a plating machine to give a smooth glossy finish.

Good, firm, jacket leather is more expensive than strap leather or soft cowhides because the tanner must spend more time and effort to make it firm. Jacket, or molding, leather is made by a process called vegetable tanning. The hides are suspended in a solution made of bark, wood, and chemicals until each side has been well soaked. The hide is passed through several successive vats, each containing a little stronger solution than that contained in the preceding vat. After each side is well impregnated with the solution, the hides are then put out to one side to mature. This is a long, slow process that gives excellent results; but, because of the extra time and handling, it is more expensive than other methods of tanning.

Soft, stretchy cowhides are made by a combination of tanning methods. The soft hides are put in tumblers containing dye and are spun until the dye has completely penetrated the hide. They are then stretched on frames to dry.

Leather is as old as man himself. Primitive man used hides to protect his feet, to power his slingshot, and to keep him warm. Today we have improved leather to make it soft or firm, but in all cases strong, long-lasting, and a thing of beauty.

Ray Bentley
C. N. Waterhouse Leather Co.
Boston, Mass. 02110

LETTER TO THE EDITOR

Dear Sir:

I have just read the comments of Dudley S. Childress in the December 1973 Journal regarding the use of the word "stump" to which I say Amen. For the past three years of my practice I have not used the word "stump" with the patient but refer to the amputated limb as his limb. The patient is well aware of which limb I am talking.

In correspondence I have used the word "remaining limb" in lieu of stump. This is very similar to Mr. LeBlanc's "residual limb" and I am sure that either would suffice.

Sincerely,
Loren B. Ceder, C.P.O.
TACOMA BRACE & LIMB CO.

NEW PUBLICATIONS

BULLETIN OF PROSTHETICS RESEARCH, SPRING 1973 (BPR 10-19), 254 pages, published by the Prosthetic and Sensory Aids Service, U.S. Veterans Administration, and available for $2.05 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Following past custom, the Spring 1973 issue of the *Bulletin of Prosthetics Research* consists of individual papers concerned with results of research coupled with reports on the status of research projects in limb prosthetics, orthotics, and aids for the blind and hard-of-hearing.

INSTRUCTIONAL MATERIAL AVAILABLE FROM THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES

Because many young men working in orthotics who are studying for the certification examinations have written to UCLA asking where to obtain manuals and books on orthotics and anatomy that might be helpful to them, especially in preparation for certification, UCLA has prepared the following list:

Manual of Lower Extremities Orthotics, England, Fannin, Skahan, and Smith, 1972, 522 pages, 1,319 illustrations. Covers external shoe modifications, internal shoe modifications, below-knee orthoses, above-knee orthoses, knee orthoses, foot and ankle orthotic devices, and hip orthoses. Per copy, $19.50

Manual of Upper Extremities Orthotics, Anderson, 1970, 460 pages, 1,013 illustrations. Covers upper-limb anatomy, functional hand splints, arm braces, and special assistive devices.

Per copy, $15.50

Basic Anatomy Series. These spiral-bound, paperback, illustrated texts are self-instructional. Originally designed to teach anatomy and medical terminology to medical records technicians, they have been found valuable by many allied health professions groups as a quick, easy way to learn the fundamentals of human anatomy.

The illustrated text material includes practice exercises and self-tests. The texts are supplemented with tape cassettes that can be played in the portable cassette tape recorders that are very popular and are reasonable in cost. The tape cassettes have proven very valuable in learning medical terminology, as they provide the learner with the correct pronunciation of the words and also enable him to recognize them when he hears them spoken. This ability can mean a great deal to the student orthotist when talking to physicians, therapists, and other medical personnel. The following texts and tape cassettes in the anatomy series are now available:

1. Musculoskeletal System
2. Circulatory System
3. Respiratory System
4. Nervous System
5. Digestive System
6. Genitourinary System

Tape Cassette for each system	$4.00
Textbook for each system	$3.00

To obtain the instructional materials you need, mail your request to:

Division of Vocational Education
Allied Health Professions Research and Instruction Projects
12016 Wilshire Boulevard
Los Angeles, California 90025

together with your check or money order made out to "The Regents of the University of California," and they will be forwarded immediately. There is a charge of $1.50 for postage and insurance.

CHILD AMPUTEES: DISABILITY OUTCOMES AND ANTECEDENTS: PART 1. Initial Follow-up Study of Selected Patients of an In-Patient Service. Final Report—July 1969. G. E. (Ned) Sharples, University of Michigan. (Carried out under Grant Nos. PC-1003 and PC-1003 C1 from the Children's Bureau, DHEW.) 90pp. + 150 tables.

Abstract by the Maternal and Child Health Program, School of Public Health, University of California, Berkeley, August 1973.

This report describes the characteristics of unilateral upper-limb amputees and identifies differences in physical and social outcomes. From records of all unilateral upper-limb amputees examined at the Area Child Amputee Center, Grand Rapids, Mich. (a total of 214 people), 160 people aged 13 or older, who had normal intelligence or better and no significant medical problems other than limb deficiency, were chosen as study subjects. Although the study concerned subjects whose amputations occurred before the age of 21 (thus making them eligible for care at the child amputee center), actual ages of interviewed amputees varied from 14 to 41 years. The majority of respondents were located in upper and lower Michigan.

Six interviewers conducted 2- to 4-hour interviews at the amputees' homes from October 1967 through August 1968. The interview schedules were pretested among amputee patients at the University of Michigan Hospital. In the pretests, respondents were asked to perform those tasks which they claimed to be able to do, and members of the families were asked to confirm responses about physical performance. These pretests demonstrated that respondents understood the items and gave accurate answers. Data were also abstracted from patient records.

Indexes of social and physical performance were developed from the interview items. The final social performance scale included the following items: degree bothered by unwanted help; degree bothered by questions about arm; amount of self-consciousness; highest school grade; education compared to siblings', to father's, to mother's; time spent on recreation; family activities (walks, games, church, visiting friends, outings); type of occupation; chances for a better job; difficulty getting a job; job achievement (general improvement, working conditions, hours, responsibility, and importance); difficulty changing jobs; social status (home furnishings and dwelling type); and estimated social class.

Questionnaire items chosen for the physical performance index included: how long cables lasted, how long the harness lasted, how often repairs were needed, amount of time prosthesis got in the way, finding special ways to use prosthesis, whether the prosthesis needed repairs at time of interview, kinds of stump discomforts, wearing the prosthesis to improve appearance only, frequently needing more energy than people with limbs to perform the same tasks, help often wanted that was not given, and specific task performance (cut steak, wash all body, deal playing cards, dress self fully, button all buttons, place heavy box overhead, knit or sew, cut and manicure nails, put on watch or bracelet).

RESULTS

Descriptive Data

Of the people studied, 29.4 percent were adolescents still in school. Housewives also constituted a sizeable proportion (19.0 percent) of those interviewed.

The population studied had various types of amputations. The most common were below-elbow amputations, more than half of the total (56.0 percent). Above-elbow amputation accounted for one-fifth or 20.1 percent of the sample. The remainder were joint disarticulations; 13.8 percent at the wrist, and 4.4 percent at the shoulder. (Wrist disarticulation was the minimum amputation included in the study.) The acquired limb losses occurred most frequently in the autumn and were mainly caused by farm accidents (21.8 percent), gunshot wounds (17.9 percent), and automobile accidents (14.1 percent).

More than 95 percent of all people interviewed had at some time had an artificial limb. Slightly more than 60 percent had a satisfactorily fitting prosthesis at the time of interview. About 40 percent were actually seen wearing their prosthesis at the time they first met the interviewer. The proportion of all amputees who were regularly wearing an artificial limb at follow-up was variously estimated at 40 to 70 percent; the lower figure being the proportion who actually had the prosthesis in place at the beginning of the home interview, and the higher figure being the proportion who claimed to wear their limb "usually" or "frequently." Use rates among acquired amputees were substantially higher, by all estimates, than among congenital amputees.

Congenital upper-limb amputees did not appear to have more medical problems than amputees with acquired losses. The degree of acceptance of the loss did not differ by etiology. Persons born with a limb deficiency were less likely to retain an artificial limb in operating order, and, if they did, were less likely to use it. People with congenital amputations were more likely to try a limb for a few weeks and never become regular wearers. Clinic records revealed no differences in the frequency of problems with prostheses among congenital amputees compared to acquired amputees. The latter group did report more breakage of major components.

Less than half of all those interviewed were both eligible to visit the Amputee Center in Grand Rapids and were doing so. Almost two-thirds of all persons interviewed were no longer eligible for services at the Center. Among those eligible, almost half were not currently using the Center. Factors which impressed the interviewers as being responsible for nonreturn to the Center were distance, time, costs, disruption of other activities, and the lack of relevant services for nonwearers of prostheses.

Physical Outcome Data

The investigators found that amputees with higher physical-performance scores tended to be older at the time of interview, to have lost the limb at a later age, to have had few talks with the Center's social worker, to wear the prosthetic limb for longer periods of time, and to obtain needed limb repairs within a few days. People with high physical performance scores also seldom changed residences while growing up, were seldom aware of being awkward, and more frequently repaired their limbs at home.

Analysis of the interview data showed the following statistically significant relationships: The physical outcome, as measured by the index developed for the study, tended to be poor if the interviewed subject mentioned other problems with his prothesis besides those brought up by the interviewer. If he said he sometimes or frequently wanted help and it was not given, if he had specific expectations about what his treatment at the clinic would be like, or if the prosthetic device frequently got in his way, ultimate physical performance measured lower. In contrast, higher scores were obtained by male amputees whose condition was congenital (as opposed to acquired), amputees who wore their prostheses frequently, who had no socket problems during fitting, whose cables wore out quickly, who had no specific expectations about what their clinic experience would be, had never wanted to avoid others, did not discuss the problem of stopping unwanted help, were rated by interviewers and clinic personnel as accepting their loss very well, and who had a part-time or permanent job.

Social Outcome Data

For high social outcomes, the statistically significant associations were: fewer social-service contacts, fewer problems noted during social-service contacts, repair of prosthetic devices within a few days, satisfaction with present job, going out frequently with spouse, and frequently entertaining at home. The amputee who was seldom self-conscious, whose father worked at a white-collar job, who rarely or never experienced unwanted help, and who made friends of other patients at the clinic typically had high social outcome scores. A post-high-school education, a first contact with the clinic in the summer season, being referred to the Center by an agency rather than by himself, having moved at least once during residence apart from parents, and having had special job training were additional factors associated with successful social outcomes.

CONCLUSIONS

Examining the pattern of associations listed in "RESULTS," the investigators came to the following conclusions:

1. There were basic differences between the people who had congenital limb deficiencies and those with acquired limb losses. While the degree of acceptance of loss and the degree of self-consciousness were the same for each group, people with congenital losses were less likely to report wanting to avoid other people and more likely to begin dating between the ages of 13 and 16. They reported fewer problems in obtaining jobs. A far greater proportion of congenital amputees (15.1 percent compared to 2.5 percent of acquired loss patients) had experimented with

prosthetic limbs and discarded them.

2. Individuals who discarded their prostheses early in the treatment program were likely to perform well on physical tasks. Amputees who stopped wearing their limb after having a regular pattern of wear were the people likely to score low on physical performance measures later.

3. The meaning of an artificial arm to its wearer may be the single most significant predictor of outcome. This conclusion was supported by the findings that people who found unusual problems with their limbs scored low on physical measures and people who rarely noticed that they were awkward with the limb and who claimed it never got in their way scored high on physical performances measures. Self-consciousness, avoidance of others, and acceptance of loss also affected physical-performance outcomes.

4. The clinic record of broken appointments was not a predictor of performance outcomes. Over 3/4 of all patients never or rarely failed to keep their appointments.

5. Respondents to the interview and questionnaire preferred the terms "amputee" and "patient." They disliked the terms "crippled" and "handicapped."

RECOMMENDATIONS

The data implied that workers with amputees could best improve physical- and social-performance outcomes by emphasizing social factors rather than physical characteristics of patients. The researchers suggested that patient dependence upon the clinic or staff members for identification and/or solution of personal problems be minimized at the same time that amputees were enabled and led to means of dealing with the critical social and psychological implications of being an amputee. One means of doing this might be to group patients into cohorts. That is, certain patients might be admitted as inpatients at the same time and their interaction and mutual teaching abilities and opportunities promoted. Members of this inpatient "class" might then return to the clinic at the same time for their later appointments.

An improvement in the organization of care could be to increase the convenience and decrease the time and cost of transportation of patients to the site of treatment. It is probable that the number of people who could benefit from this service is far greater than the number who now use the driver employed by the State of Michigan.

The authors concluded that a significant improvement in the outcome for amputees could be attained by providing services to them after age 21.

The frequency with which prosthetic limbs are prescribed should be reassessed, since a large percentage of amputees eventually stop wearing them.

Most unilateral upper-limb amputees were able to reorganize physical tasks normally accomplished by two hands so that the tasks could be accomplished by one hand aided by body pressure from some other limb. The important characteristics of artificial limbs need to be reassessed, starting with the assumption that artificial limbs used by this population may not need to approximate the physical functions of an arm and hand.

Individuals who could be identified at intake as likely to have difficulty attaining maximum performance levels:

- People who are surprised about the nature of the clinic
- People who indicate in any way that they have not accepted their loss
- People with histories of several changes of residence during childhood
- Amputees who tend to depend on others for help, decisions, or other kinds of assistance
- Children of families with low social class, as defined by father's occupation
- Children who have wanted to avoid other people before the age of 10 or after the age of 14.

Individuals who can be identified during the period of active treatment as needing greater attention:

- Amputees, especially those with acquired losses, who do not use many cables and who need few repairs to the limb
- Amputees who experience problems in getting a socket fitting that is comfortable
- People who need to have several harnesses made before one fits them adequately
- Patients who mention prosthesis problems of an unusual and nonroutine nature or who seem unusually concerned with trivial maintenance and repairs
- Amputees who do not get immediate repairs
- Amputees who avoid other people
- Amputees who want help to accomplish tasks of daily living

- Patients who want to discuss unwanted help and the undesirable attentions of others
- Those who are unwilling or unable to attempt minor repairs by themselves
- Those who admit noticing that they are awkward or that the limb occasionally gets in their way
- Those who are extremely self-conscious
- Those who claim that they are frequently helped by others when they do not want to receive assistance
- People known to have social or behavioral problems and to have sought or been contacted by social-work services
- Amputees who are reported by any source to be not fully accepting of the loss
- People who have little social activity
- People who postpone the beginning of dating
- Those who had no job or only irregular jobs during their schooling
- Those who make few visits to the clinic during the early part of their treatment program
- Patients who cease coming to the clinic without giving a reason
- Patients who seek to become close friends with staff members, having repeated extraprofessional and perhaps extraclinic contacts with them.

Services that should be added to the clinic program:

- A cost-free trial period for prostheses, so that those who discard their limbs could do so more economically
- Instruction in the maintenance and repair of prostheses
- Counseling for acceptance of their loss, avoidance of others, dating and social activities, awkwardness, how to answer strangers' questions, how to get a job, and how to keep the limb out of the way
- Promote job satisfaction
- Promote peer group friendships.

Practices that should be avoided:

- Patients coming to the clinic without previous orientation.
- Time delays in the adequate fitting of the socket and harness and in repairs
- Personal friendships with staff
- Self-referrals to vocational rehabilitation agencies.

Personal advice to be given to the amputee:

- Encourage holding a regular part-time job during school
- Encourage participation in social activities
- Encourage self-repair of limb.

What should be done for patients who are no longer eligible for the Center:

- Clinic should establish sources of limb repair for the patient by referring the patient to a prosthetist and by training him in limb repair.
- Patients might be referred to organizations which will help the amputee become socially active in recreation, entertainment, or other spheres.
- Referrals should be made to other agencies such as vocational rehabilitation services.
- A prosthesis repair kit for amputees should be developed.

CHILD AMPUTEES: DISABILITY OUTCOMES AND ANTECEDENTS: PART 2. A Long-Term Follow-up Study of Child Amputee Patients, Final Report—December 1972. G. E. Sharples and R. L. Crawford, University of Michigan. (Carried out under Grant Nos. PC-1003 C2,3 and MC-R-260044-05,06.) 121 pp. + 248 tables.

Abstract by the Maternal and Child Health Program, School of Public Health, University of California, Berkeley, August 1973.

This is the second study of the outcomes of amputees who as children had been eligible for treatment at the Area Child Amputee Center, Grand Rapids, Michigan. Subjects of the first study were unilateral upper-limb amputees. Subjects of this study were patients with lower unilateral and patients with upper bilateral limb amputations. Only patients 13 years old or older, of normal intelligence, residing in the continental United States, and having no additional physical problems besides the amputation, were selected.

As in the previous study, data were collected through home interviews which lasted from 2 to 4 hours. Each subject also received a self-administered questionnaire prior to the personal interview. Abstracts of clinic records also provided data. The interview and questionnaire were used to construct scales of physical and social performance similar to those used in the first study but adapted for use with bilateral upper-limb or unilateral lower-limb amputations.

The physical performance items designed for bilateral upper-limb amputees recorded degree of ability to: (1) tie own shoes, (2) cut meat on a dinner plate, (3) carry a full bag of groceries, (4) shuffle playing cards, (5) dress self completely, (6) button all buttons, (7) comb/brush own hair, (8) lift a heavy box over head, (9) wash hair, and (10) use a camera.

The items dealing with lower-limb function recorded degree of ability to: (1) run one-half block, (2) climb stairs which have no railing, (3) walk on an icy sidewalk, (4) walk in deep mud, (5) stand and work for 4 hours, (6) stand and work for 8 hours, (7) walk without making any noise, (8) kneel on both knees and rise without use of hands, (9) carry full suitcase 1 city block, and (10) carry a full suitcase 8 city blocks.

Physical performance items common to both conditions were: (1) any athletic or exercise activity, (2) need to expend no more energy than people with limbs for the same task, (3) does not describe self as limited, (4) does not mention additional difficult taskes, and (5) is satisfied with physical abilities.

The social performance index items were: (1) has employment, (2) not bothered by questions about the amputation, (3) currently self-conscious, (4) not bothered by unwanted help, (5) frequency of visiting in homes of friends, (6) frequency of visits by others in respondent's home, (7) ever refused a job because of amputation, (8) ever left a job or wanted to because of amputation, (9) feels amputation affects chances of getting a given job, (10) feels amputation decreases chances for advancement, (11) feels amputation affects relations with co-workers, (12) feels amputation affects relationship with superiors/supervisors, (13) satisfaction with job, (14) frequency of attendance at informal entertainment outside the home, (15) interviewer's rating of home furnishings, (16) housing space and size, (17) interviewer's estimate of respondent's social class, (18) highest school grade completed, (19) education achievement compared to mother, (20) education achievement compared to father, (21) education achievement compared to nearest sibling, (22) amount of recreation, (23) attendance at religious activities, and (24) interviewer's assessment of condition of home.

For 227 eligible respondents, 185 interviews were reported (81.4 percent). Comparison of respondents to nonrespondents using data available from clinic records showed that nonrespondents tended to be older than respondents. On those clinic records where the emotional status of the patient was noted, nonrespondents were seen as having more emotional problems than respondents. The sample of interviewed people was broken down as follows:

29 upper-limb deficiency
24 congenital
5 acquired
156 lower-limb deficiency
41 congenital
115 acquired

Since only 5 upper-limb amputees had acquired losses, statistics were not computed for this group.

RESULTS

The measurements and the impressions obtained by interviewers indicated that most amputees had the ability to perform the wide variety of tasks required in daily life, to maintain homes and to function normally in job settings, with the same degree of success as nonamputees of similar background. In general the impact of limb deficiency seemed to be that it delayed achievement rather than depressed it.

Use of Artificial Limbs

Nearly all of the lower-limb amputees wore their artificial limbs (98 percent of those with congenital deficiencies and 94 percent of those with acquired losses). Four out of 5 upper bilateral amputees with acquired loss were wearing prostheses; one-third of the upper bilateral congenital amputees were using their artificial limbs, and one-third of all bilateral amputees who tried artificial limbs discarded them.

Sources of Medical Care

General health care was obtained by most individuals from a general practitioner. Fourteen percent of lower acquired amputees had consulted osteopaths. A large number of amputees (85.7 percent) reported having visited a doctor within the last 2 years. Amputees went most often for limb care to the Area Child Amputee Center, Grand Rapids. The lower acquired amputees were atypical in making more use of limb shops as their primary source of limb care.

Problems and Unmet Needs

General health was self-reported as an important problem by 13.0 percent of those with lower acquired amputations. This was the group in which progressive disease was most likely, and it included several cases of amputation for carcinoma (14.8 percent). Phantom limb sensation was reported by less than 15 percent of the congenital amputees with upper-limb involvement, by 42 percent of those with congenital deficiency of a lower limb, and by 83 percent of those with acquired limb loss. Nearly 3/4 of all individuals with lower-limb prostheses reported having had blisters, sores, ulcerations, and rashes associated with wearing a prosthesis.

About 10 percent of the lower-limb amputees experienced chronic malfunction of their prostheses. These people indicated the artificial limb was in proper operating condition less than half of the time. Among congenital and acquired lower-limb amputees, 29 percent reported that their limbs malfunctioned more than 10 percent of the time. Frequent problems occurred in the operation of joints, terminal devices, sockets, and the harnesses. Between 1/4 and 1/2 of each group also had fitting needs at time of follow-up interview. The time required for repairs to prostheses was not a problem for most individuals; same-day service was obtained by most. Only about 1 in 7 individuals indicated dissatisfaction with the quality of prosthetic work done at limb shops. Almost all (82.5 percent), however, indicated that their prostheses could be improved. All groups combined placed comfort as the first priority, appearance as a second priority, and function as a third consideration. Durability and more realistic characteristics (including tactility, odor, noise) were also mentioned as desirable features.

The lower-limb acquired amputees appeared to have the greatest difficulty accepting limb loss. About 28 percent of these amputees indicated on the Gurin Psychological Adjustment Scale that they were significantly psychologically impaired (scoring less than 65 points). The rate for lower-limb amputees with congenital loss was 24.4 percent, and for upper bilateral amputees with congenital deficiencies the rate of serious psychological problems was 21.7 percent.

Self-consciousness was a recurrent problem among all amputees. Half or more of each group indicated self-consciousness at some time in their lives. Only half of each group indicated they were not self-conscious at the time of interview.

Physical Performance

Statistical tests showed that the following variables were associated with high scores on the physical performance index:

- Site of the amputation (people with longer limbs remaining performed better)
- Wearing the prosthesis 14 hours or more a day
- Incidence of phantom limb sensation (people without phantom limb do better)
- The feeling that the amputation had no effect either on choice of occupation or choice of spouse
- Frequency of visits to Center (lower-limb amputees who in their first year of limb care had 3 or more visits to the Center did better than those with fewer visits)

Factors associated with lower levels of physical performance for all amputees were:

- Doing fewer household chores than most children
- Feeling that the childhood was unhappy
- Believing that parents advised limiting career goals
- Being self-conscious
- Avoiding awkward tasks
- Dating less frequently because of limb
- Feeling that prosthesis has negative impact on dating
- Strong and specific dislikes of aspects of their prostheses, particularly among upper bilateral amputees

Factors associated with lower levels of physical performance among lower acquired amputees only were:

- Concern about the difference in appearance between a prosthesis and a normal limb
- Losing a limb due to disease
- Losing a limb late in childhood (after age 16)
- Lasting negative reaction to loss
- Fitting problems with prosthesis.

Many factors had no demonstrable effect on physical performance outcomes. Health and weight of respondents, use of a prosthesis, patient satisfaction with the facility where they obtained care, special schools or classrooms for handicapped children, difficulty in finding a job, participation in teenage activities, amount and kind of parental concern and protection, socioeconomic status, age, sex, and urban-rural status did not differentiate between amputees with poor physical performance and those with high physical performance.

Social Performance

The authors concluded that the social performance index was a more sensitive indicator of amputees' well-being than the index of physical performance. The physical performance scores were spread across a relatively narrow range, with most respondents clustered closely around an adequate level of performance. Few had poor or inadequate scores. In contrast, the overall distribution of social performance scores was more widely spread and showed a range from outstanding social function to pathological states of withdrawal and psychopathology (as measured by the Gurin Psychological Test).

A second conclusion regarding social performance was that it was consistent over time. Individuals who had low social performance scores on the interview were very likely to have been rejected by their peers as children, unpopular as teenagers, and unable to maintain stable, supportive relations with their families or to succeed in prototypical social institutions such as school. By contrast, individuals who were happy, accepted, and successful in their early years had a high probability of continuing to do well as young adults.

Social class emerged as an influential determinant of social function outcomes. The effects of differences in stimulation experience, contacts, opportunity motivation, and other class-linked factors appeared to be so strong that the authors concluded an amputee from a lower class background had distinctly less chance of adequate social performance, while children raised in higher socioeconomic surroundings were much more likely to function well socially. At the same time, the findings showed no association between social class and physical performance. No other demographic factors were found to be closely associated with social performance.

Diagnostic characteristics associated with social performance included:

- Bilateral upper amputees more frequently had low levels of performance
- Congenital lower amputees more frequently scored at high levels
- Amputations due to disease were associated with low scores
- Amputations occurring in middle childhood years were associated with low scores.

As in the earlier study, prosthesis experiences (such as wearing habits, non-use, the condition of prostheses) did not influence social performance outcomes. Individuals, especially congenital lower-limb amputees who expressed concern about the realistic appearance of their prostheses, often had low social performance scores.

Factors which were associated with a poor social outcome were:

- Broken homes or parents who got along poorly
- Moving frequently during childhood
- Being raised in large families—for bilateral upper amputees
- Being an only child—for acquired lowers
- Excesses in parental attention or child-rearing techniques, as self-reported by amputees
- Being rejected and taunted in childhood play
- Unpopularity as a teenager
- Not being invited to social functions
- Difficulty getting dates
- Not being able to obtain or hold a satisfactory job
- Sheltered workshop experience
- Perceiving self as very different from others
- Having an uncomfortable phantom limb (especially for acquired lowers)
- Poor prosthetic awareness, as measured by confusion about limb position, inability to judge distances, and not remembering that the limb is shorter than normal
- Feelings of self-consciousness
- Being bothered by unsolicited assistance

Factors associated with a good social outcome:

- Follow-up by the treatment facility—particularly clear for unilateral lower amputees
- Receiving social services (except for congenital lower amputees, who performed better socially when they needed no counseling)

- Feeling that clinic services only slightly improved physical function (except congenital lowers, who showed no association at all with this factor. Bilateral uppers who felt that they had greatly improved in physical function scored on the low end of the social performance scales)
- Friendships with staff or other patients (bilateral uppers did not show this association)

Being able to obtain and hold a satisfying job, to get along with others on the job, and to learn sufficient income were associated with high levels of social performance. Individuals who saw themselves as similar to nonhandicapped people on the Attitudes Toward Disabled Persons Scale (ATDP) frequently scored high on the social performance index. Engaging in physically active recreation, voluntary groups, and hobbies also typified high social performers to a greater extent than those with poorer social function. As in the earlier study, a principal conclusion drawn from these data was that social and psychological factors play a greater role in determining physical and social outcomes than do physical factors, or factors relating to the design of prostheses.

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

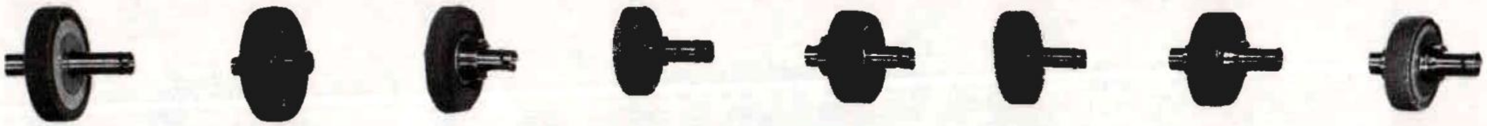
To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	1×10^{-7}†
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

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

°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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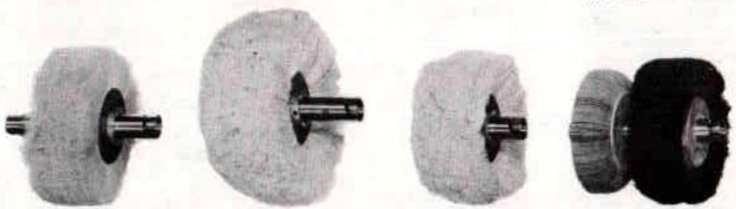

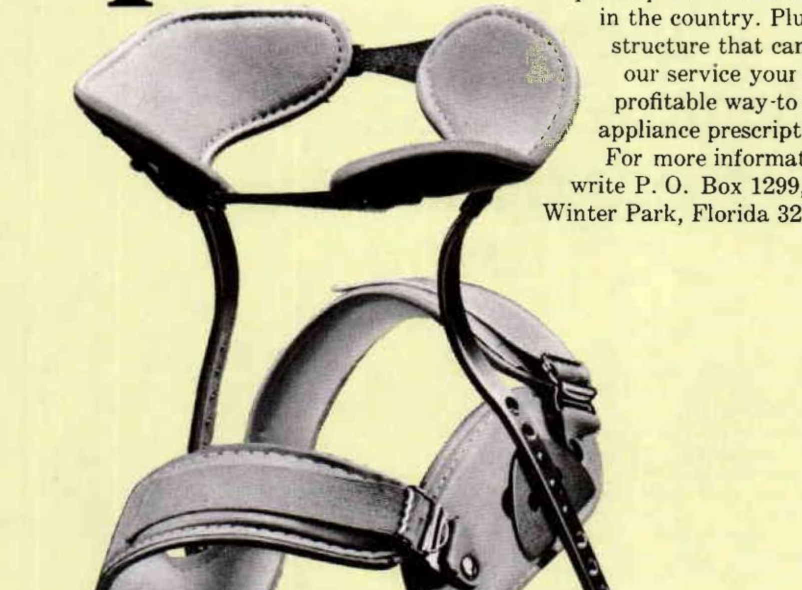

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