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CONTENTS

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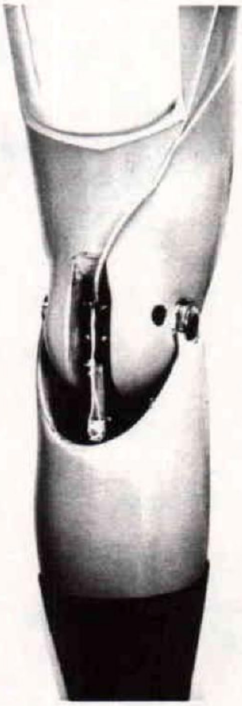

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FROM RESEARCH LABORATORY TO PATIENT

The fields of prosthetics and orthotics are unique in that, owing to the efforts of the National Academy of Sciences, the Veterans Administration (VA), and the Social and Rehabilitation Service (SRS) and its predecessors, there exists a direct link between research and application of the results of research through a formal education program. The current and ongoing Prosthetics and Orthotics Education Program had its roots in the so-called Suction Socket Program, a joint effort by the National Academy of Sciences and the American Orthotic and Prosthetic Association (AOPA) (then the Orthopedic Appliance and Limb Manufacturers Association) to introduce the concept and application of above-knee suction sockets to physicians and prosthetists. In this program, teams of orthopaedic surgeons and prosthetists conducted instructional courses in selected prosthetics facilities on a regional basis. Approximately 20 courses each of one week duration were held during the period December 1947 through January 1949. The success of these courses led to the establishment of a "permanent" program of prosthetics education at the University of California at Los Angeles (UCLA) in 1952. The UCLA program was soon followed by similar programs at New York University and Northwestern University. Initial financial support was provided by the VA Prosthetic and Sensory Aids Service. Later the Office of Vocational Rehabilitation assumed this responsibility and other educational programs such as those of Cerritos Junior College, Rancho Los Amigos Hospital and Chicago Junior College were started. With federal support, programs are currently being offered in both preparatory and continuing education. These programs appear to be meeting the needs of the professions serving the physically disabled quite adequately. The "preparatory" courses present information and teach skills relating to current practice in prosthetics and orthotics and equip practitioners with the know-how necessary to undertake certification examinations. The "continuing education" courses serve to introduce new material into the field as it emerges from the research program, and of course what is "new" one year becomes "standard practice" shortly thereafter.

Those who have been in contact with the prosthetics-orthotics schools during the past year have probably become aware of the financial predicament facing these institutions. The schools have had fiscal problems in the past, but funding has always seemed to come through just in time to save the day and permit the start of a new academic year. However, in the 1973-74 academic year, the Department of Health, Education, and Welfare (DHEW), through the Rehabilitation Services Administration (RSA), in line with its training "phase-out" policy, cut all operating funds to the schools in half, at the same time stating that all support from RSA would be withdrawn beginning July 1, 1974. This act would undoubtedly result in termination of all federally funded prosthetics-orthotics educational programs, with obvious detrimental results to the quality of physical rehabilitation services.

The Veterans Administration responded to the crisis with an emergency input of funds, in addition to their normal funding, which made it possible for the schools to operate during this present fiscal year. VA also requested the Committee on Prosthetics Research and Development (CPRD) of the National Research Council to conduct a survey of the schools in relation to VA needs. Interest and support for the study also came from SRS. An eight-person task force was organized by CPRD and I was invited to serve as its Chairman. After three meetings and a period of data-gathering, with full cooperation from all educational programs, an interim report was presented to VA and SRS for their consideration. A description of all schools, the effects of the educational programs, a profile of graduates of the programs, funding recommendations, and other recommendations were included in the report. A letter of support and endorsement from the American Academy of Orthopaedic Surgeons and from the National Office of AOPA were also included.

It is our understanding that the wheels of the funding agencies began to move soon after this report was received, and hopes are high that support for the education program will be reinstated next year.

There are few, if any, federally supported programs that have this built-in educational dispersal system by which the health care system can respond immediately to the results of research as they emerge from the Laboratory. The quality of orthopaedic and physical rehabilitation in this country is dependent upon these prosthetics-orthotics educational programs, and it is sincerely hoped that the Interim Report of the Task Force will substantiate the need for this program and help assure its support.

J. Warren Perry, Ph.D.
Task Force Chairman

Orthotics and Prosthetics, Vol. 28, No. 1, pp. 3-11, March 1974.

AMPUTEE MANAGEMENT PROCEDURES[1]

James Foort, M.A.Sc.[2]

The object of our attention is a man, woman, or child, who has undergone amputation of part of one or more limbs. Physiological, psychological, social, and economic constraints obviously influence the mode of treatment. A further constraint on the treatment process, and not so obvious, is the level of skill which can be brought to bear on the patient's problems. From a prosthetic point of view, superlative skill can do a great deal toward making inadequate hardware acceptable. Excellent components, on the other hand, cannot mask inadequate skill. The amputee's well-being rests heavily on the competence of those dealing with him, and especially on the skill of the prosthetist. Among the important skills needed by the prosthetist is the capacity to understand how the amputee feels and thinks about what is going on around him. Also, the prosthetist needs to understand his role in the treatment process and the roles of others associated with him in delivering care to the patient.

Nothing that can be said here will take the place of firsthand experience. This discussion can only draw attention to the accumulated experiences of others so that the prosthetist may confirm his own experiences, gain new insights about them, develop new insights by considering outside experiences, and set the stage for accumulating new experiences in the future.

The new amputee requires the more complicated scheme of treatment with respect to prosthetics. His stump is not stable. His concepts of his new status are just developing. He has social and psychological pressures yet to be dealt with. He may also have unresolved medical problems associated with his disability. In contrast, the experienced amputee has dealt with many of these problems as well as he ever will, and his needs are more specific and simple. In all cases, however, the prosthetist's role is to provide a prosthesis that is comfortable, will stand up in use for as long as possible, is a reasonable representation of the missing leg cosmetically and functionally, and is made in the least amount of time for the least expense commensurate with providing the required functions. In this he has the aid of the clinic team.

THE PROSTHETIST AND THE CLINIC TEAM

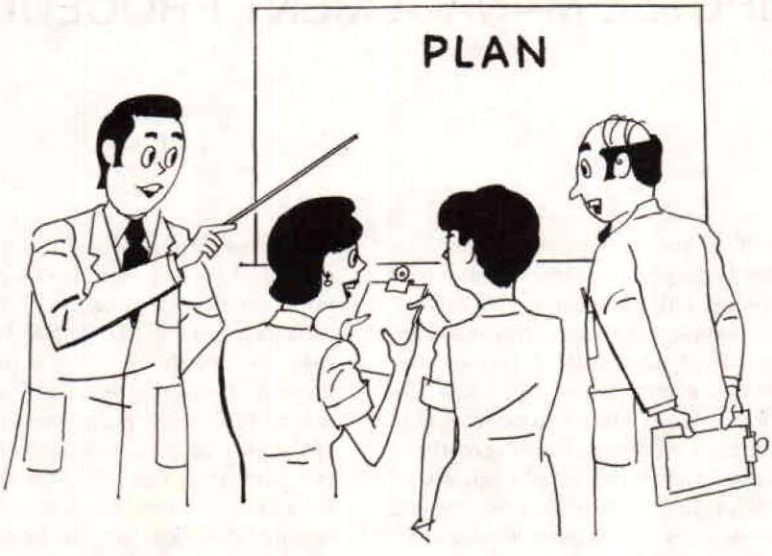
The clinic team is organized to provide the plan for prosthetics care. Before a plan can be developed, the patient must be categorized in terms of his social and physical status. The physician, social worker, therapist and prosthetist must develop as much insight as they can toward this end. The prosthetist will use information offered by the other teammates, and will contribute his share toward making a meaningful plan. Some information of use only to the prosthetist, such as that needed to design the socket, suspension, and alignment, has to be gathered as well.

At what stage data accumulation starts depends on the setting. Preferably, it will start preoperatively. The advantages of involving the prosthetist at that stage are that he can advise the surgeon, collect some of the data that will be needed later, and make himself known to the patient, and to some extent let the patient know what can be done for him. The moral support gained by the patient from contact with his prosthetist prior to amputation is tremendous, and has been demonstrated many times where immediate postoperative fittings have been carried out. When the patient sees the prosthetist after amputation, the earlier introduction has provided him with more confidence in the likelihood that he will walk again.

Preoperative involvement of the prosthetist with amputees is often held back because sur-

[1]This article is based in part on a manuscript of a book on *Lower Extremity Prosthetics for Above the Knee Amputees*, prepared under the auspices of the Sanatorium Board of Manitoba, Winnipeg, Canada, during 1970-71. Filing in the Prosthetics and Orthotics Research Reference Catalogue is under codes: A-04-10; F-13-10; H-03; and 1-05.

[2]Director, Prosthetics and Orthotics Research, Orthopaedics, University of British Columbia, Vancouver, B.C., Canada.



The clinic team is organized to provide the plan for prosthetics care.

geons have not developed a sense of the potential value of the prosthetist at this stage. Immediate postoperative fittings have highlighted this potential somewhat, but amputation surgery is not done frequently enough by surgeons familiar with prosthetics and willing to see the amputee through his entire rehabilitation process. From the rehabilitation point of view, it would be more satisfactory if amputation surgery were a specialty. Then continuity would be ensured, and stronger team support would develop. The ideal arrangement is to have the team on the job from beginning to end, with the prosthetist included as an important team member.

Such ideal circumstances seldom exist. The worst state likely to be encountered by the amputee is when the prosthetist receives him without a plan, and must provide an artificial limb, give some training, and maintain care without assistance. Such conditions are encountered very much less often now than was once the case. When they are, the prosthetist should try to get the involvement of other professionals. Fortunately, it is more usual now for a rehabilitation unit with a team to guide the rehabilitation of the amputee, and for all members within the team to guide the rehabilitation of the amputee, and for all members within the team to cross-educate each other and to attend formal education courses and seminars together. There is an increasing incidence of amputation for diseases of old age. Such patients need not only prostheses but medical care as well. Prosthetists need to know how to function within the medical setting and to understand their role and that of the other team members in planning the amputee's care.

RAPPORT

Service provided in a local limb shop without the assistance of a clinic team runs smoothest for the established amputee. Established patients, under these circumstances, develop a good relationship with the prosthetist, and the clinic teammates must be careful not to damage this rapport. Similarly, when the clinic team must become involved with an established amputee, the prosthetist must be careful not to undermine the team.

Often, involvement with the clinic team brings the prosthetist into contact with other prosthetists. Here he must be careful not to cause discord, and if necessary must foster good relationships between patients and other prosthetists. It is a matter of ethics—the patient comes first. Doubts that exist concerning what his prosthetist colleagues are doing for a patient must be aired in such a way that the patient's confidence is not undermined, and the patient's interests are fostered best.

A prosthetist who is a member of a clinic team should always be a paid member so that he has no division of loyalty toward the patient. He is there as an expert to give the best advice he can. Team members should nurture the relationship be-

Doubts brought about by disagreement among prosthetists.

tween a patient and his prosthetist for smooth implementation of the plan, regardless of whether the prosthetist is based in the rehabilitation unit or in a commercial limb shop. Displays of contempt toward the prosthetist, who has the hardest job and must deal with the amputee for the longest time, can only undermine the effectiveness of treatment. The situation the prosthetist has to deal with is not a static one. Plans must be sufficiently flexible to permit adaptation to realities.

Frequent socket changes, especially for patients receiving their first prosthesis, can lead to misunderstandings between prosthetist, clinic team members, the amputee and sponsoring agencies. Money and time are involved. Critical judgments must be made during planning so that potential frictions are avoided. Thus, the prosthetist will be more likely to get the sympathetic and practical support he needs as he proceeds with the established plan. The well-being and security of all team members are prerequisites for the best use of existing skills.

The clinic team is not only a planning and review body but a forum for self-education of its members. Where skills are deficient, special training is required. If incompetence persists, change is mandatory. The patient comes first.

THE PROSTHETIST IN THE CLINIC TEAM

Because this discussion pertains primarily to the prosthetist, his role in the clinic team must be examined. A yes-man or rubber stamp will not do. He must have, and demonstrate, as much knowledge as the patient's needs require of him. This understanding will include knowing what the other team members do and their relationship to his role in the rehabilitation of the amputee. When a problem arises, he must be able to deal with it by application of his art and through communications with other members of the team. He must keep the clinic chief informed, leaning on his advice as necessary. He must help to keep things moving by dealing with problems promptly. They seldom go away. Often, the clinic team functions best when the details of planning are dictated by the course of events in the rehabilitation process, so that problem-solving develops out of continuous, spontaneous intercommunications. The formal clinic may best be reserved for solving major problems in depth, and for review-

A "yes" man or "rubber stamp" is not satisfactory.

ing progress on established plans, leaving the routine parts of treatment to be dealt with on a day-to-day basis by those qualified to make decisions.

It is not typical for prosthetists to do a prior work-up of patients. Hence a prosthetist often comes to a clinic "cold." This type of procedure is unsatisfactory. The prosthetist should be in a position to tell members of the team what can be expected in terms of stump shrinkage, the number of sockets likely to be required, how the patient might be handled to minimize cost and time requirements, the types of components and the system of suspension best suited to the patient, and what is likely to unfold in terms of the patient's performance on a prosthesis. This requires a study of the patient by the prosthetist before the clinic deliberations begin.

In his work-up of the patient, the prosthetist is interested primarily in the stump. But he should also be interested in the psychological, medical and social factors which are likely to influence results, and attempt to gain insights directly from the patient without prying in order to supplement what he will get from other team members. How he proceeds with the work-up will depend on whether a new or established amputee is being dealt with. In the first case, he has to start from scratch. He may, for example, wish to do a trial fitting as a part of his investigation of the amputee, or have him on a temporary prosthesis. With the mature amputee, he has access to previous records, X-rays, etc., which he should study. He will also have built up a detailed collection of facts and impressions about the patient from previous encounters. For this reason, it is best that an amputee not be shifted arbitrarily from one prosthetist to another. Such a change should be reserved for cases where the patient has lost confidence in the prosthetist. When a prosthetist is new to a patient, he must build up understanding about his patient. He doesn't start from "square one," however. The prosthetist can learn quite a bit from the patient, from the previous prosthetists, and from the prosthesis being used. Records and advice from other team members will fill out the details.

Also influencing the prosthetist's work-up is whether the planning relates to a new prosthesis for an established amputee, involves tracking down problems with an existing prosthesis, or involves making a replacement socket. When making plans for replacement of a socket, it is sometimes wise to make a replica of the existing socket if the stump is healthy and the socket is functional. In any case, when the amputee is already wearing a prosthesis, the prosthetist's work-up must include a careful evaluation of the existing prosthesis and an examination of the stump for effects the prosthesis may be having on it.

To assist him, the prosthetist has the contributions that can be made by the other team members. The physician is the main support because he knows what has gone before and what other people are doing for the patient, and it is towards him that the patient usually looks for help in a variety of matters. It is the doctor's role to evaluate the patient medically, as the medical factors relate to prosthetics, and to tell the prosthetist what he needs to know. This includes:

- when the patient is ready for fitting
- the patient's potential as a prosthesis user
- any medical factors which might influence prosthetics care as management proceeds
- any factors inherent in the stump which might bear on how the fitting should be done

Any stump conditions that X-rays may reveal should be demonstrated to the prosthetists by the doctor. Pain and its probable cause, whether related to neurological conditions, such as neuromas, or circulatory disturbances such as are encountered in arteriosclerosis, need discussion and clarification. The rate and vigor with which prosthetics management can proceed need to be defined. Heart condition, condition of the remaining limb, and general body condition are other factors which are relevant.

HELP FROM THERAPISTS

The therapists can help. They will know about the strength of the patient, and particularly about his coordination and muscle tone. Between them, the doctor and the therapists can develop a plan of therapy that will make the most of what potential the patient has.

The occupational therapist can help assess the capabilities of the patient to handle daily routines of living and working so that the prosthesis can be designed to make the best use of existing potential, and best serve the patient's needs. When the social worker knows what level of restoration is possible through therapy and prosthetics, it is possible to make provision for whatever social adjustments are required to derive the best benefit for the patient.

The therapists can also keep track of progress during the treatment process, communicating findings freely to the prosthetist so that adjustments and socket replacements, or progress from stage to stage can proceed without unnecessary interruptions and delays. Often, the therapist who trains the patient to use the prosthesis will learn from him sooner than the prosthetist just how he really feels about his artificial limb. The prosthetist should take such information in an impersonal way, and use it to get the best results possible for the patient.

The therapist can let the prosthetist know of factors developing out of therapy which seem connected to the prosthesis so that adjustments to alignment or to the socket can be made opportunely. Often, a therapist and prosthetist work together so harmoniously that the therapist can make minor changes in alignment and length without the prosthetist being involved. Such arrangements can be very useful and develop out of mutual respect based on each educating the other.

THE ENGINEER

More frequently now, the engineer becomes involved in treatment. This is especially so where there are research units associated with clinical activities. New devices and techniques must be checked out clinically. The engineer needs to learn the prosthetist's language and teach other team members his own. He must refrain from meddling where he is not competent. At the same time, if he does become involved clinically, he must be prepared to take full responsibility for all areas of his involvement. Patient care must not be dragged out or interrupted. Constant monitoring by the doctor, under whom the whole process goes on, must be carried out so that the patient's welfare remains paramount.

With the prosthetist, the engineer needs to establish a careful and considerate bond. It is too easy to confuse higher education with higher capabilities. Usually, as programs are currently organized, the engineer is involved for reasons other than the management of the patient. The engineer's needs must take a backseat to management while he uses his analytical skills to influence other team members through questions and answers. He must be prepared to accept the fact that his bright ideas will move into practice only at a slow rate.

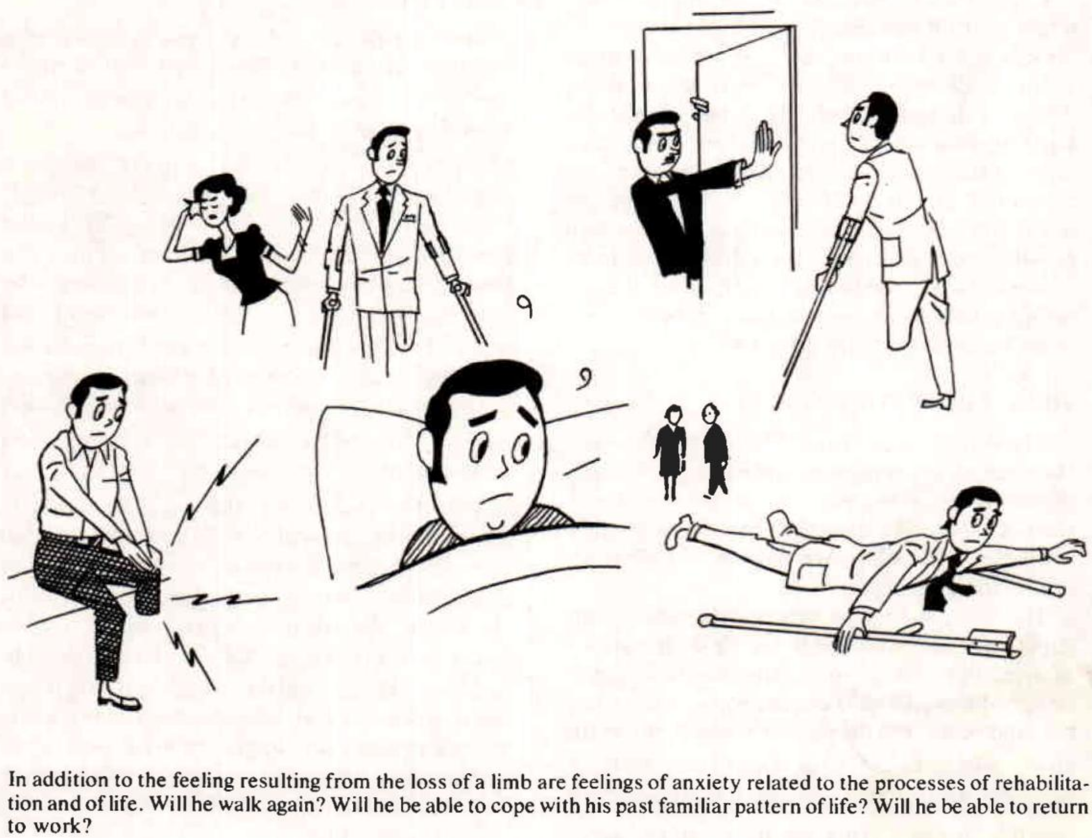
THE SOCIAL WORKER

The social worker who wants the patient's desires reflected in the treatment results can be valuable in checking home environment, work environment, social connections, and patient history so that what is done from a prosthetics point of view is a realistic reflection of what the patient wants and needs. If what the patient wants is unrealistic, the social worker can, standing apart from the mechanics involved, help bring the patient to a better understanding and acceptance of his state.

AMPUTEE PSYCHOLOGY

Obviously, an amputee is still the man he was before amputation. Amputation may, however, bring latent characteristics of significance into sharper focus. The response of a person to amputation depends in great measure on its cause. Amputation may be a warning of ebbing life. It may give relief from pain, or remove an unsightly burden. The patient, rightly or wrongly, may feel that negligence was involved in the loss of his limb. Both grief and anger will be the result. Grief and guilt will be the feelings of a man who loses his leg through his own carelessness. Loss through accident will spawn feelings of grief and mourning. Loss in this case is a tragedy like death. In addition to the feelings resulting from the loss of a limb are feelings of anxiety related to the processes of rehabilitation and of life. Will he walk again? Will he be able to cope with his past familiar pattern of life? Will he be able to return to work? To family? To friends? How will he stack up in competition with others similarly disabled? What are the expectations of those involved in his rehabilitation? And one major question seldom considered even by those who treat amputees, and this can even be a thought among the elderly, is "will I be sexually acceptable?" A castration complex has been postulated.

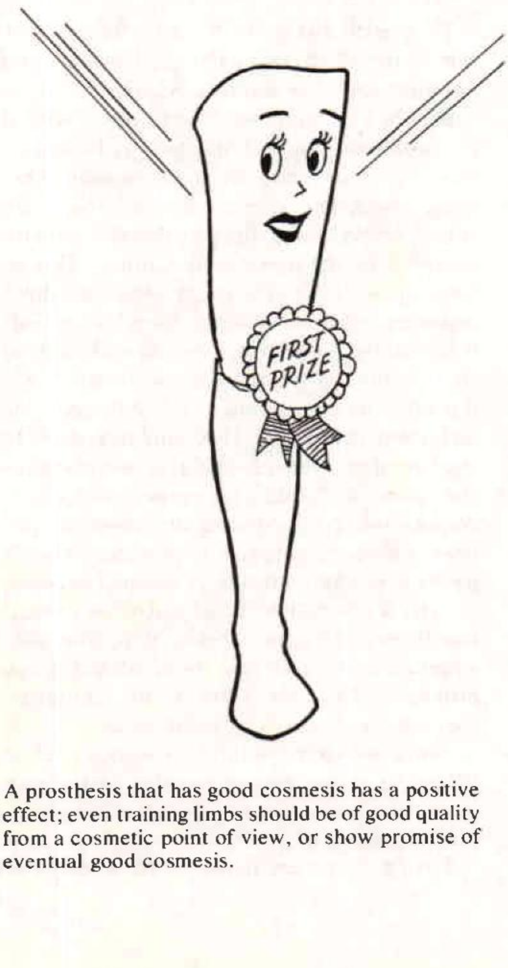
If the patient feels he is poorly dealt with during rehabilitation, an otherwise satisfactory response to amputation can be spoiled. Conversely, good handling can work against negative feelings unless they are deep and bitter. It is difficult for a



In addition to the feeling resulting from the loss of a limb are feelings of anxiety related to the processes of rehabilitation and of life. Will he walk again? Will he be able to cope with his past familiar pattern of life? Will he be able to return to work?

human being to accept that others can take lightly what he himself sees as a crisis. He is not persuaded otherwise by knowing that to the treatment staff disability is a familiar and accepted fact in their daily lives. His unique position is firmly entrenched and must be recognized by those who deal with him. The more technically competent the prosthetist is, the less stressed will the patient be. This competence of the prosthetist must be evident in care for the patient and the details of his art, including the condition of his equipment, the finesse with which he applies himself, and evidence that he himself is not hampered by psychological problems. A brazen stance will not help the prosthetist if he cannot deliver the goods. He will be found out soon enough. There are no substitutes for honesty and a genuine interest in the patient and in prosthetics.

Nothing helps an amputee adjust better than rehabilitation among his own kind. Also, knowing the prosthetist early, even preoperatively, is valuable. Quick initiation of prosthetic services is also good medicine. A prosthesis that has good cosmesis has a positive effect; even training limbs should be of good quality from a cosmetic point of view, or show promise of eventual good cosmesis.



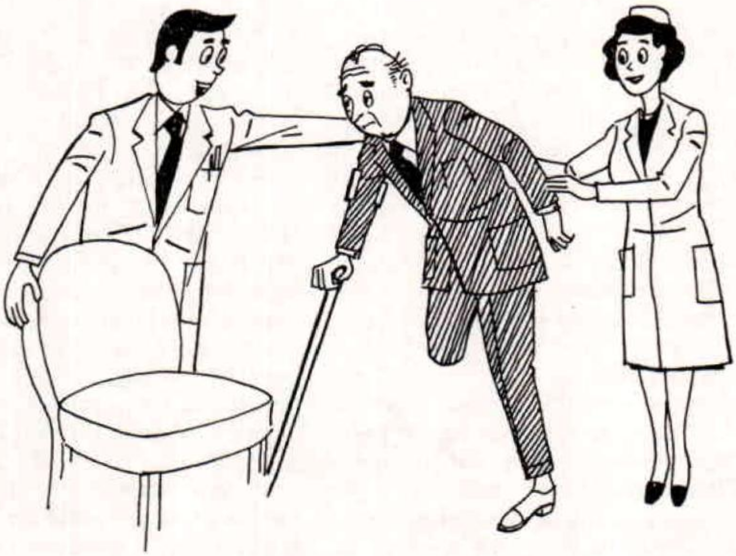
A prosthesis that has good cosmesis has a positive effect; even training limbs should be of good quality from a cosmetic point of view, or show promise of eventual good cosmesis.

With the initiation of rehabilitation, a surge of optimism usually follows. The amputee begins to see the possibilities of overcoming his loss, facing his family, going back to employment, reestablishing his social ties and activities, and returning to a familiar environment. The frustrations he has because of reduced function, and the need for learning new skills with and without the prosthesis, dampen the initial optimism if he is not well informed as to what the course of events is likely to be.

Even rehabilitated, he finds that the transition back into the stream of life is not cut and dried. The reaction of his family, especially the mate, is of crucial importance. Instances abound in which a spouse finds amputation difficult to adjust to. It often means more work, may disrupt intimacy initially, or scar a relationship deeply if difficulties preceded the fact of amputation. Over-solicitous friends and family impress the amputee with his disability when he wants more strongly to appear normal. Conversely, he may, in some instances, become a tyrant, using disability for attention and support. Firm, gentle, consistent good manners toward him are in order. He has enough to bear, unless amputation was in fact a blessing. Even then, it is surprising how often an amputee will gloss over or forget previous pain when faced with a different pain.

Among other factors which touch on the psychological impact of amputation, the amputee's expectations in lawsuits or reimbursement can affect the tone of treatment. Objectivity on the part of the prosthetist is required. The prosthetist should stick to his own business, and stick to facts. If he suspects that his best efforts are being frustrated by what some have called the "green poultice" problem, he should make this known in clinic when he has the case reviewed for help in the difficulties he experiences.

It is important for the prosthetist to recognize the state of the patient from the psychological point of view so that he can have the pertinent facts in mind as he does his own job. A complaining attitude directed toward disability and the prosthetis or the prosthetist may not involve the prosthetics service at all. Cultural factors are not without relevance. Some people tend to whine and grizzle at any setback. This reaction need not



The prosthetist must not lose his patience. He must not make the patient feel guilty under any circumstances.

be taken seriously. On the other hand, some patients are so stoical that real difficulties develop before they make a complaint. Sometimes important damage is done as a result. A wise eye as to the possibility of these factors becoming involved is needed.

By knowing the patient, the prosthetist can ease his own tasks without burdening the patient further, which should be the aim. The prosthetist is usually not much better at psychology than the patient! There is always the physician to fall back on, and beyond that the clinic team, if the going gets rough. Scheduling the patient back into clinic can give a needed breathing spell to both the prosthetist and the patient. Sometimes an impasse between prosthetist and patient becomes so severe that a different prosthetist must take over.

The prosthetist must not lose his patience. He should not make the patient feel guilty under any circumstances, or feel guilty himself, but leave the situation on as positive a note as possible, on the assumption that he will very likely become involved with the patient again. If he leaves the scene graciously, re-encounter will not be an embarrassment to either.

Struggle, whether prosthetist's or patient's, is not necessarily to be avoided since it can give satisfaction to have endured the difficulty and won through. If the patient feels that he has made a contribution to his own advance toward acceptance and achievement in the process, he will be the better for it.

OTHER PROBLEMS

The prosthetist has to deal with the established, semi-established, or new case. Each presents a different set of problems. Naturally, the more experience the amputee has the fewer should be his problems. Such difficulties as the amputee may have can arise from relationships in the home, from the community and the working situation. For some, the prosthesis is a focus for escape from the unpleasant realities. This problem is none of the prosthetist's business unless it impinges on his ability to perform his own job, or is something about which he can make a positive contribution to the patient's well-being. Sometimes the newer amputee, rehabilitated, lingers on for prosthetic care. He complains of one thing after another, often changing his complaints as he goes along, or flooding the scene with a variety of complaints, even avoiding definition of specific ones. This can be especially prevalent when he is trying a new prosthesis. A gradual increase in activity level, until he gets tired of the game, will usually save the prosthetist time and get the amputee into a different mode of attack on his problems. Here the clinic team, including the social worker, needs to be informed.

There is also the natural resistance to change. While he wants a new prosthesis, the patient wants it to feel like his old one even though he had problems with it!

Taxing the patient harder as he taxes the prosthetist more can often break a situation where the prosthesis is a poor excuse for resistance. But a prosthetist should be careful about using such a tactic, even when he is sure that the prosthesis is right and the patient is balking. The physician should be involved in an effort to resolve things quickly.

An example of using such a forcing technique may be cited: The patient was fitted with a new limb, and almost immediately complained of discomfort. (Often a patient is not aware of the degree of discomfort that must be endured as part of the process of adapting to a prosthesis. Any force on the stump is considered unacceptable.) He was asked to walk for an hour in order that the difficulty might be better defined. After an hour there were no obvious signs of stump irritation and some discussions about the application of forces necessary were carried out. The patient was less sure, but insisted he would try again, although he felt discomfort. After a second session of two hours, activity being increased in intensity, he returned for further inspection, and the process was continued. Finally, the patient indicated that the prosthesis was better than he had originally thought, and that he was somewhat surprised at just how much he could do on it. During the succession of following trials in which activity was kept high, no changes were made, nor was there any evidence that changes were needed. This episode broke a five-year history of rehabilitation on many prostheses, during which time the patient had not worked. Within two weeks he went back to work, and generally assumed a more natural routine.

In situations where the prosthesis, and indirectly the prosthetist, is the sticking point, the physician should be involved to get at the seat of the problem and get things moving.

Among new amputees in training, deterioration of socket fit due to stump changes should be anticipated and the amputee reassured. He will sometimes ask why it is that his difficulties are multiplied while he has in fact undergone considerable rehabilitation. He wonders why it is not the reverse. It should be pointed out that (a) the stump is shrinking, and (b) his activity level is increasing. Adjustments will be made at the appropriate time, and function thereby improved.

Orthotics and Prosthetics, Vol. 28, No. 1, pp. 12-20, March 1974.

VACUUM FORMING OF PLASTICS IN PROSTHETICS AND ORTHOTICS

A. Bennett Wilson, Jr.[1]

The first reference to vacuum forming of plastics applied in orthotics appeared in 1968, in an article in "Orthopaedics: Oxford" by Dr. Gordon Yates of England (14). In this well-illustrated article, he described the end products, lower-limb orthoses of polypropylene and ABS (acrylonitrile-butadiene-styrene) but left much to the imagination concerning the fabrication procedure. Included were Helfet heel-cups (similar to the University of California at Berkeley shoe inserts) (6) (7) (9), ankle-foot orthoses (AFO), and knee-ankle orthoses (KAO).

Inspired, apparently, by Yates, the Ontario Crippled Children's Centre and the George Brown School of Applied Arts and Technology, both of Toronto, Canada, began in 1970 a program in the application of vacuum-forming techniques in orthotics, at all levels, and to some degree in limb prosthetics (1) (2) (8). The result of this program was the design and development of a machine especially suited to needs of orthotists and prosthetists (Fig. 1). Eventually machines of this type were made available commercially by VAF Industries, Ltd.[2] also of Toronto.

In 1969 Snelson and Mooney of Rancho Los Amigos Hospital, Downey, California, received a grant from the Social and Rehabilitation Service, Department of Health, Education, and Welfare to develop a practical method for fabrication of a transparent socket. Methods of making clear sockets had been developed previously but none was sufficiently practical, even for use in research programs. After some experimentation, Snelson and Mooney turned their attention to vacuum-forming polycarbonate sheet stock in spite of being told by suppliers of the materials that "it won't work." The result was a method of producing plastic sockets, both clear and otherwise, using very simple equipment (Fig. 2) (10) (13). Further experience has shown that this simple method is also suitable for production of AFOs. Success with this method of production has persuaded Orthomedics, Inc.[3] to make a simple compact machine available commercially (Fig. 3).

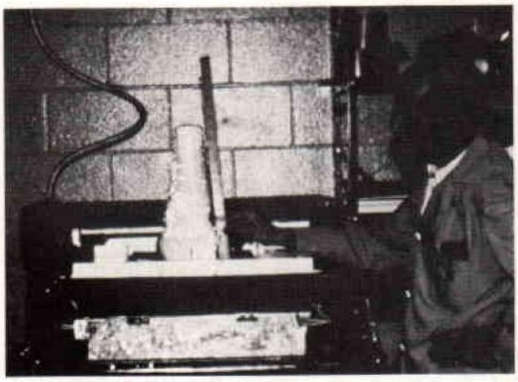


Fig. 1. Front view of the vacuum-forming machine developed at the Ontario Crippled Children's Centre. The male model is forced upward into the semimolten plastic sheet by a compressed air actuator.

In 1969 the Arkansas Cerebral Palsy Equipment Center began the use of individually molded wheelchair-seat inserts for severely involved cerebral palsied patients (3). The first sixty units were laid up in the conventional manner using fiberglass and resin, but since 1972, the seat inserts have been produced by vacuum-forming ABS over a mold using a machine commercially available from the EMC Co.[4] for fabrication of plastic signs and other items. By use of the vacuum-forming technique, the production rate has been increased about 300 percent. In addition to the cerebral palsied patients, the Center is providing seat inserts for paraplegic and quadri-

[1] Executive Director, Committee on Prosthetics Research and Development, National Research Council, Washington, D.C.

[2] 330 Bay Street, Suite 1001, Toronto 1, Canada.

[3] Orthomedics, Inc., 8332 Iowa Street, Downey, California 90241.

[4] P.O. Box 9331, Dallas, Texas.

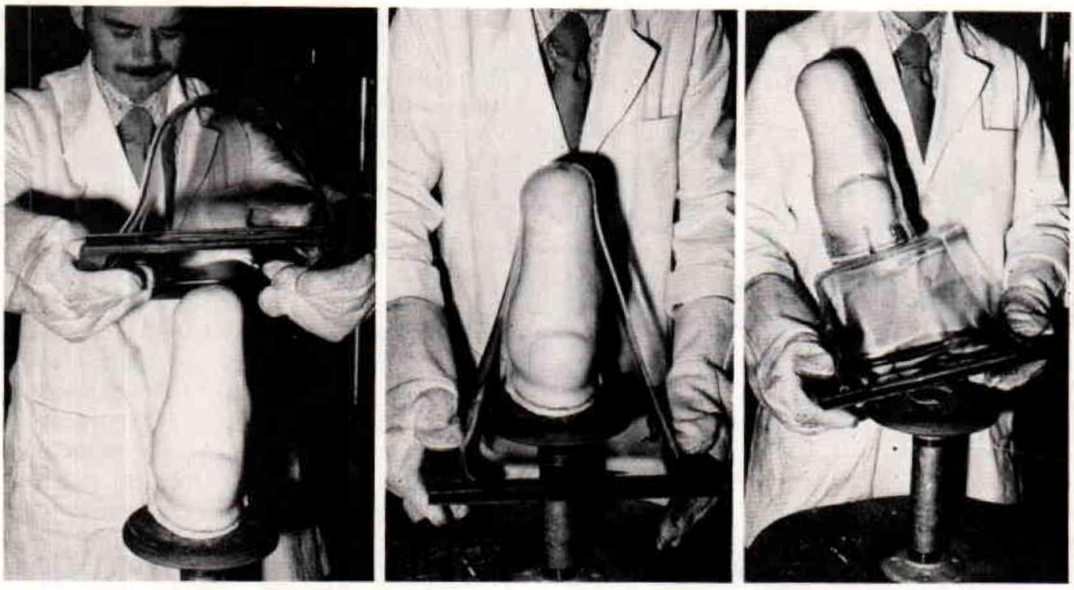


Fig. 2. Snelson's original manual technique to make transparent sockets for artificial limbs. *Left*, the Lexan sheet, placed in a metal frame, has been heated to a semimolten state; *center*, it is drawn down over the male model and, after air has been drawn out through the central pipe, the Lexan is pulled in until it conforms to the male model. *Right*, the gross casting is being removed from the machine.

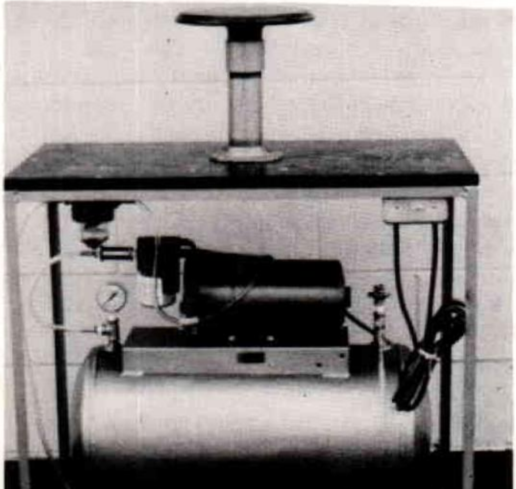


Fig. 3. The commercial version of the Snelson machine. A rectangular platen is substituted for the round one when most orthoses are to be formed.

plegic patients in order to spread the load over the weight-bearing areas when the patient is seated.

(An interesting facet of the Arkansas procedure is the method used for taking the impression, which consists of the revival of dilatancy (11), a process also employing the use of vacuum, and one which has been tried from time to time in taking impressions of amputation stumps. It may be time to initiate new experiments in dilatancy in view of the new knowledge gained and new processes developed over the years.)

As part of its evaluation program, the Committee on Prosthetics Research and Development ordered a prototype machine from VAF (Fig. 4) and sent it to the Veterans Administration Prosthetics Center for trials. Primarily because of electrical problems, it was difficult to obtain experience sufficient to evaluate either the equipment or the process. Meanwhile, Moss Rehabilitation Hospital in Philadelphia, because they could not obtain early delivery from VAF, purchased a large commercially available machine from Plastic Vac, Inc.,[5] primarily to make lower-limb orthoses (Fig. 5).

[5] P.O. Box 5543, Charlotte, North Carolina.

Fig. 4. The VAF machine. This model accommodates a 3-ft. sq. sheet of plastic.

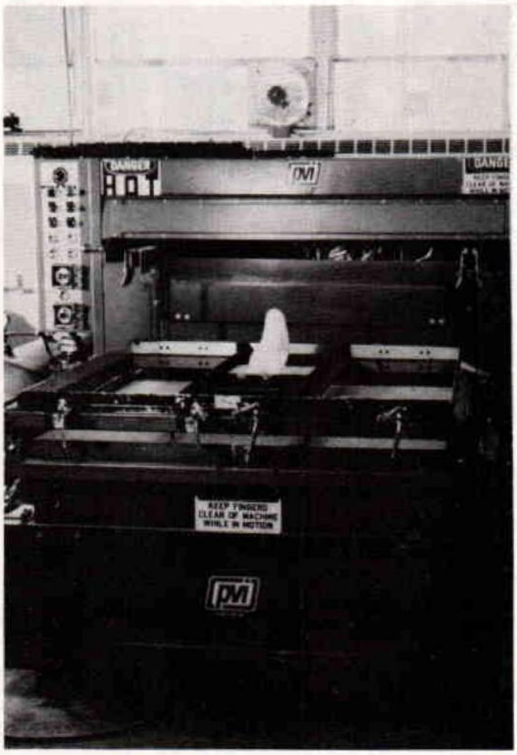


Fig. 5. The Plastic VAC machine. This model accommodates a 4-ft. sq. sheet of plastic.

Later the J.A. Pentland Co. and Rancho Los Amigos Hospital purchased VAF machines similar to one bought by CPRD.

Natresources, as a consultant to NOPCO, designed a special machine for prosthetics and orthotics practice for use in Boston, Massachusetts. Others, including a group in Winnipeg, were experimenting with vacuum forming.

Because it seemed beneficial to bring the various groups together and exchange information and then develop recommendations for future work, CPRD convened a meeting of representatives of all groups in North America known to have experience in vacuum forming of components for prostheses and orthoses at Moss Rehabilitation Hospital, June 3, 1973 (4).

It was the consensus of the participants that vacuum forming of plastics offers great potentials for improving not only prosthetics and orthotics services, but also should be very useful in educational programs.

It was also the consensus that not enough is known about materials and techniques. While general knowledge exists in industry where plastic shapes are mass-produced for a large variety of products, specialized knowledge is needed in tailoring special shapes in the prosthetics and orthotics field. In order to assure satisfactory results, there is a need to determine specifics in process variables for different materials and end products. Until the variables unique to the fabrication of prosthetic and orthotic components are documented, the process cannot be taught effectively.

The participants from educational institutions felt that equipment and processing details for vacuum-forming orthotic components such as lower-limb appliances were not well enough defined to consider opening courses immediately. Teaching the vacuum forming of larger components, such as spinal or other torso-fitting configurations, was even further off in time.

The state of the art in vacuum-forming sockets, however, appeared to be ready for use in formal educational programs. Accordingly, it was proposed that a two-day instructional course be convened in Downey, California. Orthomedics agreed to teach the course without reimbursement. It was held July 2 and 3, 1973, and was attended by representatives from New York University, Northwestern University, University of California at Los Angeles, and the University of Washington.

METHODS AND MATERIALS

There are many methods of using air-pressure differential to form heated plastics in sheet form into a given shape. In some instances, female molds are used; in others, male molds, and elaborate schemes have been developed for the mass production of items to provide uniform wall thickness and intricate shapes (Figs. 6-9). For prosthetics and orthotics, the use of the method known as "drape" molding, or forming (Fig. 9), seems to be the most appropriate, although it is

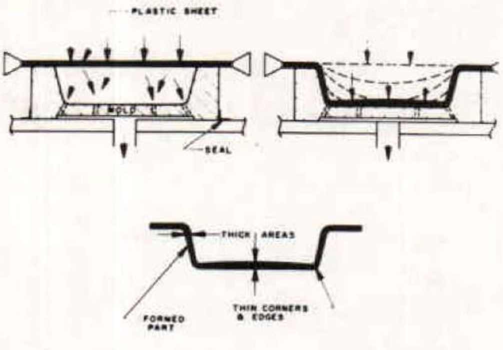


Fig. 6. Straight vacuum forming.

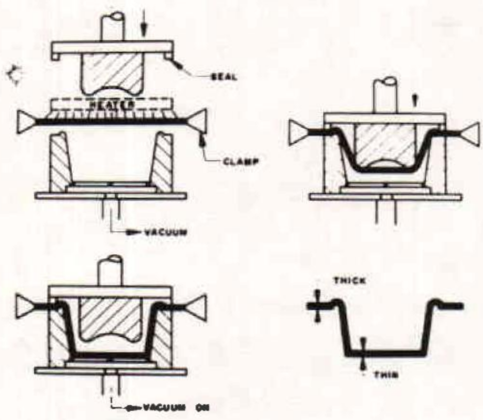


Fig. 7. Plug-assist vacuum forming.

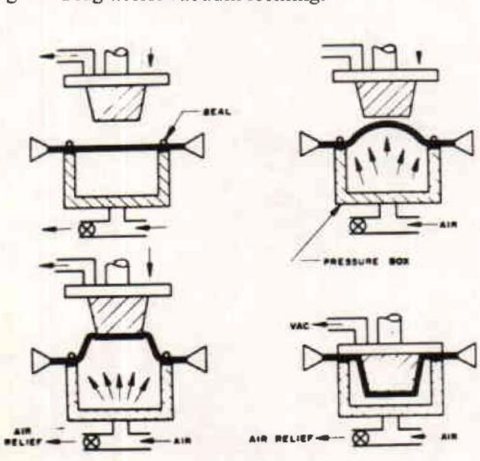


Fig. 8. Pressure-bubble immersion forming.

sometimes difficult to obtain uniform wall thickness by drape forming. All of the machines used in prosthetics and orthotics to date use the drape method.

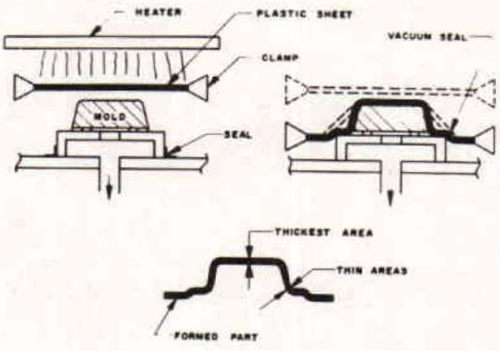


Fig. 9. Drape forming.

Five materials have proven to be useful in prosthetics or orthotics: polycarbonate, acrylonitrile-butadiene-styrene, cellulose acetate butyrate, polypropylene, and polyethylene. Their physical characteristics are shown in Table 1.

No single material has an ideal set of properties for use in prosthetics and orthotics. Polycarbonate is transparent and has high impact resistance, but its fatigue strength is low and the cost is high. ABS seems to be the preferred material for spinal supports and seats because of its rigidity. CAB is used rarely because of certain properties such as rate of elongation, but should not be overlooked for special cases. Polypropylene's resistance to fatigue and its low cost makes it very useful for limb orthoses, although it is not available in a transparent form. Polyethylene shows a lot of promise because when formed over a layer of Plastazote, which is itself expanded polyethylene, a perfect bond is formed. This readily permits the installation of a cushion between the soft tissues and the external supporting structure when necessary.

Other materials, new and old, are being tried at various places in an effort to find even more suitable materials for each application.

STATE OF THE ART

The use of vacuum forming in prosthetics and orthotics is increasing progressively. The following examples are those known to the author, but by no means include all that are being used in North America.

At the OCCC, vacuum forming is used routinely in the supply of virtually all lower-limb orthoses, back panels for orthoses, and in many seating and support devices. Polypropylene is generally used for limb orthoses, polycarbonate

TABLE 1
PROPERTIES OF PLASTICS FOR VACUUM FORMING

Characteristics	Units	Polycarbonate	Acrylontrile Butadene Styrene	Cellulose Acetate Butyrate	Polypropylene	Polyethylene
Tensile Strength	P.S.I.	8500	6000	5000	4900	4200
Elongation	%	115	15.0	75	390	500
Tensile Modulus	10^5P.S.I.	3.25	3.80	2.25	2.20	1.30
Compressive Str.	P.S.I.	10500	9000	—	7200	2900
Flexural Yield Str.	P.S.I.	12500	11000	5000	7000	—
Impact Str. (12OD)	ft.lb/in Not.	15.0	4.50	—	2.00	1.50
Hardness (Rockwell)	R.	120	110	70	95	95
Flexural Modulus	10^5P.S.I.	3.30	3.50	—	2.30	1.80
Compressive Modulus	10^5P.S.I.	3.45	2.20	—	2.10	—
Specific Heat	CAL/°C/gm-R.T.	0.29	0.35	0.35	0.46	0.55
Thermal Expansion	10^{5}/in/in/°C	6.60	7.0	14.0	7.30	12.0
Continuous Heat Res.	°F	250	200	190	230	230
Deflection Temp.	°F	270	235	220	200	200
Clarity	—	Trans.	—	Trans.	Opaque	Opaque
Transmittance	%	85	33.3	88	60	50
Haze	%	3.0	100	<1	2.0	3.0
Water Absorp. (24 hours)	%	0.16	.30	1.10	<.01	<.01
Burning Rate	in./min.	Self. Ext.	Slow	Slow	Slow	Slow
Effects of:						
Sunlight		Slight	None	Slight	Crazes	Crazes
Weak Acids		None	None	Slight	None	None
Strong Acids		Slowly	Attacked	Attacked	Slowly	Slowly
Weak Alkalies		Slowly	None	Slight	None	None
Strong Alkalies		Attached	None	Soluble	None	None
Organic Solvents		Soluble	Soluble	Soluble	None	None
Other Properties:						
Draw Ratio	Height to Base	2:1	4:1	3:1	2:1	2.5:1
Linear Mould Shrinkage	in./in.	0.006	0.006	.005	.015	.035
Specific Gravity	lb./cu.in.	1.20	1.05	1.19	.904	.940
Specific Volume	cu./in./lb.	23.0	27.0	23.0	30.4	28.3
Machining Qualities		Excellent	Good	Good	Good	Good

for back panels, and ABS for seating and support devices (Figs. 10-12).

At Orthomedics, polycarbonate sockets are used routinely as check sockets in lower-limb prosthetics, and polypropylene lower-limb orthoses are used widely (Fig. 13) (5).

At the Veterans Administration Prosthetics Center approximately 75 percent of the ankle-foot orthoses are being vacuum-formed of polypropylene. Experiments to develop practical methods of fabricating knee-ankle orthoses, orthoses for the upper limb, and limb prostheses are under way.

In Arkansas the Cerebral Palsy Center is routinely providing vacuum-formed seat inserts of ABS for cerebral palsy patients and patients with spinal-cord injuries.

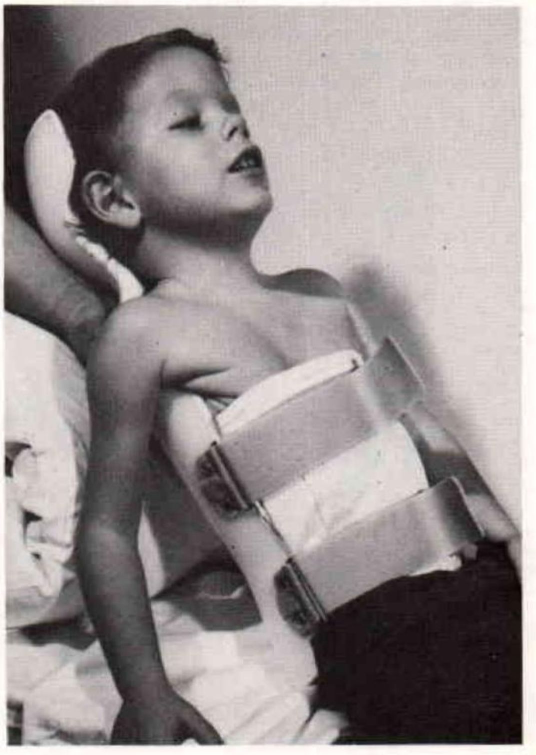


Fig. 11. Plastic back panel provided at OCCC.

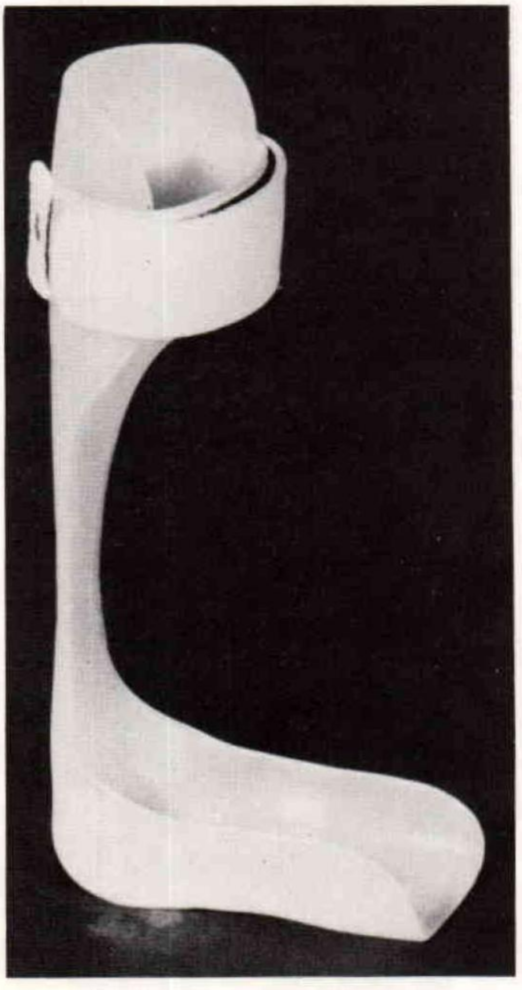


Fig. 10. Plastic knee-ankle orthosis provided at OCCC.

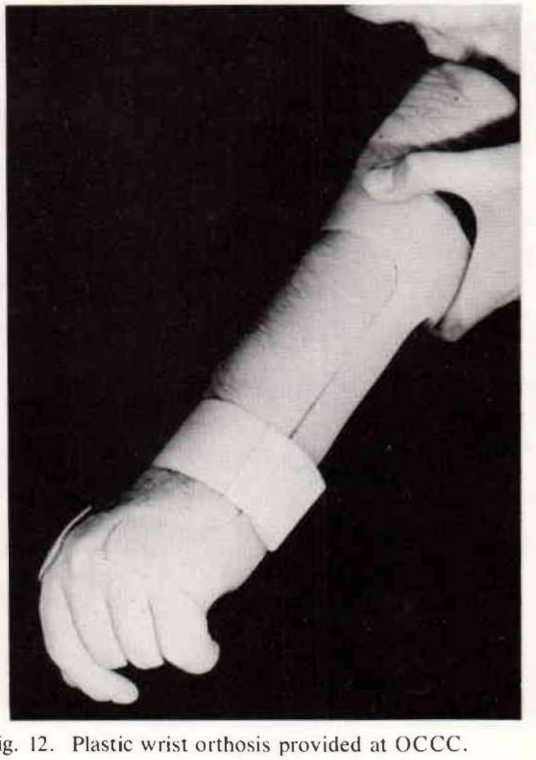


Fig. 12. Plastic wrist orthosis provided at OCCC.

Moss Rehabilitation Hospital is providing on a routine basis lower-limb orthoses molded from polypropylene and is experimenting with other materials. This group at MRH is also developing methods to check the performance of any given orthosis in order to develop a method for correlation of prescription, fabrication, and fitting (Figs. 14-16).

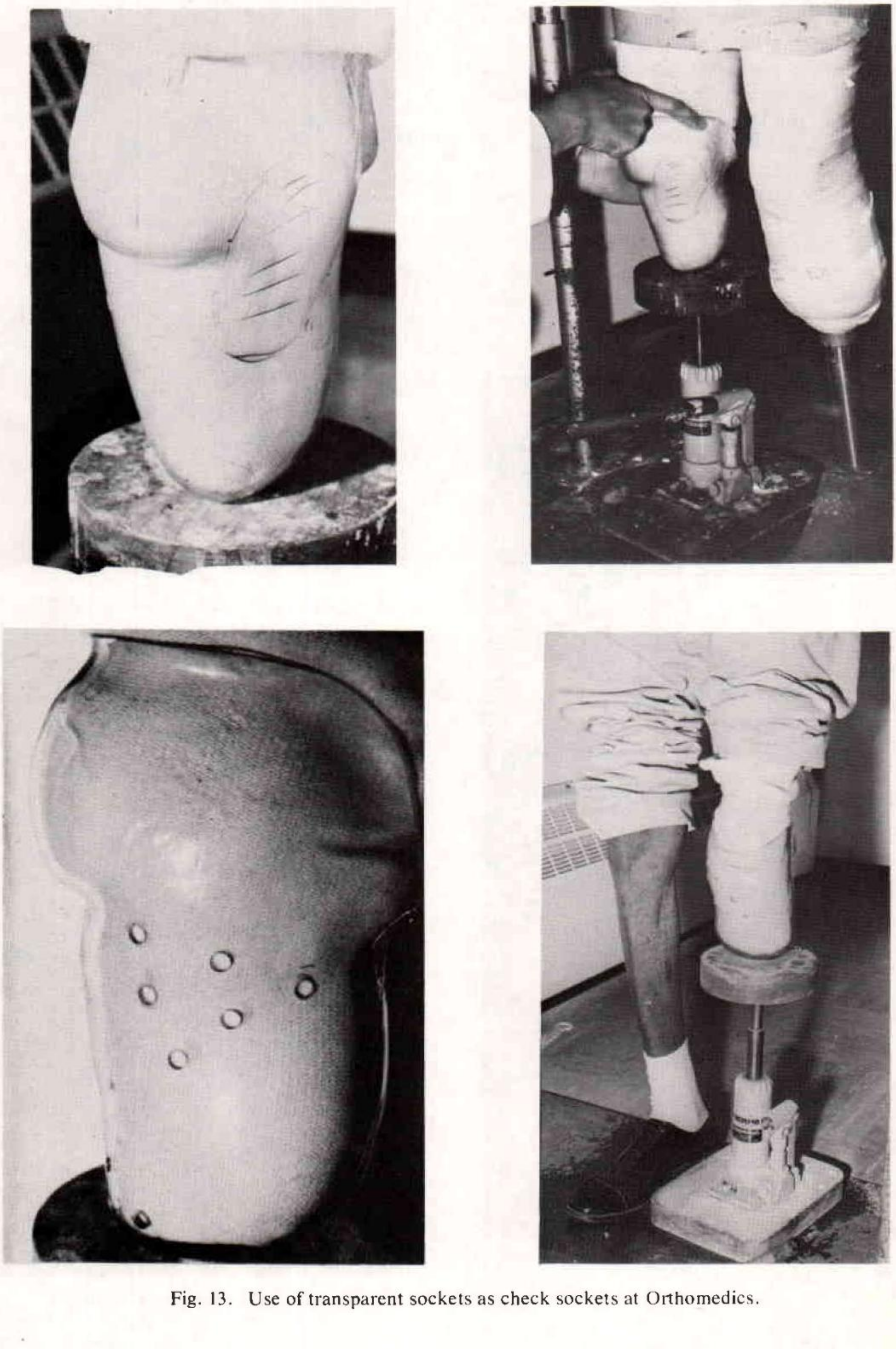


Fig. 13. Use of transparent sockets as check sockets at Orthomedics.

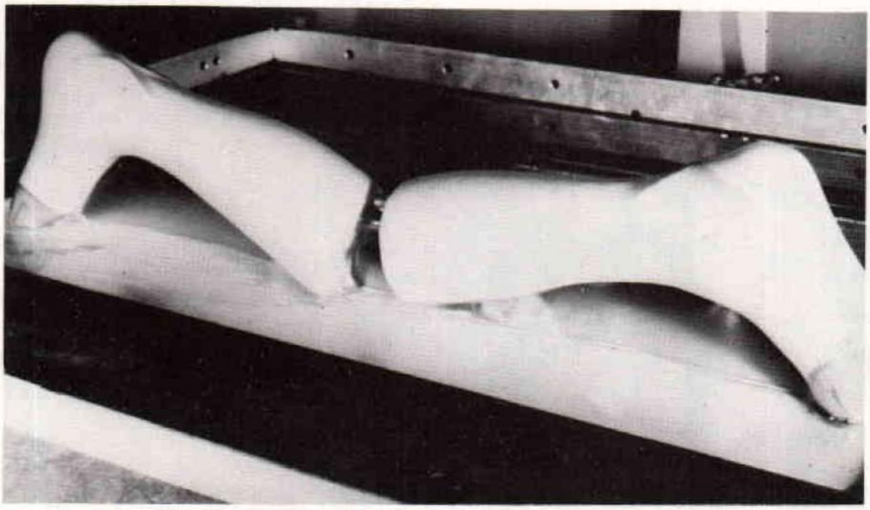


Fig. 14. Two AFOs being molded of polypropylene simultaneously on the plastic VAC machine at Moss Rehabilitation Hospital.

The Prosthetics Education Program at the University of Washington is using the Orthomedics technique in their prosthetics education program. Clear sockets have been found to be very useful for laboratory instruction.

A firm, Plasthetics, Inc.,[6] has been established to provide vacuum-forming services, especially for prosthetists and orthotists.

ADVANTAGES AND DISADVANTAGES

At this point, it appears that vacuum forming of sheet plastics offers prosthetists and orthotists an opportunity to provide improved, more functional prostheses and orthoses more rapidly than can be done with present practice. Orthoses, especially, can be tailored to fit the needs of the patients more adequately with thermoplastics than with either metal or plastic laminate. The cosmetic factors should not be overlooked. Color, even transparency, and snugly fitting orthoses provide less conspicuous devices.

Vacuum forming has the potential of providing the clinical prosthetist prompt service when required, especially for patients fitted for the first time. The use of check sockets (5) in lower-limb prosthetics becomes practical. Needed to be developed are simplified means for coupling the vacuum-formed socket to a pylon for extended use.

[6]5640 Enterprise Drive, Lansing, Michigan 48910.

For the first time now, research groups have an inexpensive way of forming sockets, transparent as well as translucent, so that extensive experiments in casting techniques, heretofore considered to be too costly, can be carried out. At the present time, just such an experiment is being conducted jointly by Rancho Los Amigos Hospital and CPRD in determining the relative differences between the conventional technique for casting a below-knee stump and two other recently developed methods.

It would seem that vacuum-formed sockets, especially transparent ones, would prove to be extremely valuable in an education program.

Present-day prosthetist students do not go to

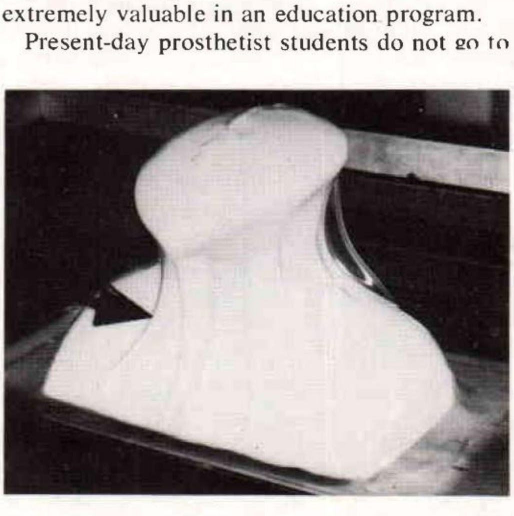


Fig. 15. Cervical collar formed at Moss Rehabilitation Hospital.

Fig. 16. Polypropylene AFO provided by Moss Rehabilitation Hospital.

school to learn lamination, yet they must laminate sockets over casts they have taken and modified in order to determine if they have taken the cast and modified it satisfactorily. The use of vacuum forming to provide sockets would permit the students to spend their time more fruitfully than making a lay-up.

THE FUTURE OUTLOOK

At this time, it appears that vacuum forming has a great future in prosthetics and orthotics. There is reason to believe that materials with even more appropriate physical properties will be emerging from the plastics industry, and ingenious prosthetists, orthotists and engineers will devise practical means of taking the maximum advantage from these new materials.

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HOW AMPUTEES FEEL ABOUT AMPUTATION[1]

James Foort, M.A.Sc.[2]

To obtain the views expressed in this report, four amputees were interviewed in depth. Two were doctors, one was a psychiatrist, and one was a prosthetist. One of the most interesting things to come out of the interviews was that, though their skills, interests, and education levels were different, the four amputees gave quite consistent responses to the questions asked. They tended to emphasize similar lines of thought, and offered quite similar solutions to the problems discussed.

FEELINGS ABOUT AMPUTATION

When amputation offers some powerful advantage, such as saving life and reducing disfigurement and pain or some other objectionable factor, its acceptance by the patient is relatively easy. When loss is due to an accident, the nature or intensity of feelings depends upon the circumstances. A bitterness is aroused that is hard to reconcile when the reason is another's negligence. If due to one's own negligence, remorse and guilt are experienced. If another was unwittingly involved, the guilt may be stronger.

One of the amputees interviewed indicated that anger rather than panic struck him when he lost his leg under a railway car on which he was working. Although such an experience would be imagined to be painful, in fact it was not especially painful, although effects of the environment at the time and cramps from shock caused discomfort.

Under circumstances which lead to a deprivation of function, the impact of amputation is very great and persists for a long time. One man indicated that, although he had been well rehabilitated, the implications resulting from the trauma took three years to overcome. Conversely, though physically deprived of function, the amputees indicated that they felt no different after amputation than before; that is, they were the same person as always. None felt that psychiatric input would have helped him. Of paramount importance, however, was the need for psychological insight on the part of the people treating them, including the doctor, therapists, prosthetists, and nurses. We hear of the importance of body image. The amputees who discussed these matters indicated the peculiarity of noting that a part of their bodies was missing. Eventually this too becomes accepted and the person may eventually reach the stage where to look whole again would seem strange, change in appearance being the important factor. Meanwhile, reduced function as evidenced by such factors as reduced capacity to keep up, limping, noises from a prosthesis, or the need to use crutches, imposes feelings of inferiority.

Given full attention, an amputee can be rehabilitated by a well-coordinated team so that the functional return and acceptance of amputation are optimal for that patient. Who can say that every vestige of psychological trauma can be erased no matter how sound the man? But it can be said with certainty that bungling the rehabilitation process through poor coordination of team members, deficient understanding or inadequate prosthetic devices will reduce prospects for success, and have a long-term effect, no matter what is done to recoup. This doesn't mean that patients need everything laid out for them. On the contrary, the amputees said that they derived satisfaction from overcoming the obstacles of disability through rehabilitation and adaptation. What they wanted was support. This support should be in the form of usable information and quite explicit instructions based on facts which they can readily grasp and follow.

The amputees indicated that they began to worry about jobs and families as soon as they were conscious. They wanted vocational coun-

[1]This article is based in part on a manuscript of a book on *Lower Extremity Prosthetics for Above the Knee Amputees*, prepared under the auspices of the Sanatorium Board of Manitoba, Winnipeg, Canada, during 1970-71. Filing in the Prosthetics and Orthotics Research Reference Catalogue is under codes: A-04-10; F-13-10; H-03; and 1-05.

[2]Director, Prosthetics and Orthotics Research, Orthopaedics, University of British Columbia, Vancouver, B.C., Canada.

seling early to allay concerns, or at least to give them something to work with. They wanted this counseling to be realistic, take into account their reduced functional capacities, and prepare them for a changed job or retraining that would save them from future stress.

INFORMATION

The plea for useful and reliable information was strong. Many questions arose which were handled variably by the treatment staff. Most important was to have a simple, realistic apprais-al of their situation. Sometimes events leading up to amputation are not clear. How did it all happen? What of their families, social associates, colleagues at work, etc.? And a fundamental question among the young is—"Will I be sexually acceptable?" This issue is seldom raised, though it is almost the first thing of concern to younger amputees. Young males frequently set out with great courage to find out.

Misinformation from ill-informed but well-meaning staff members was a strong irritant. When the information was discovered to be phony, ill-conceived, or exaggerated, there was great resentment. Those involved in the treatment of amputees should have a fund of common information that will help to ensure consistency of management from beginning to end. Further, the patients with whom these matters were discussed wanted to be in on what was being planned, not just be recipients of what was handed out. The clinic team must include the patient in its deliberations to the fullest extent possible. At least the results of clinical thinking should be summarized and presented to him in a way that informs him that his care has been thought out, and that the decisions made are considered appropriate. Further, this information should be presented so that he can amend plans in ways that touch on his own specific requirements.

Besides information about himself and relationships with family and community, work situation and recreation, he wants information about the prosthesis he will receive. He wants to know how much it costs, how long it will last, how strong it is, what he should do to preserve it and get the most out of it. He needs to know what limitations he faces—for instance, can he drive? Will the automobile have to have automatic transmission; will it be a small car, a large car? What kind of extra benefits can he get by making special efforts to engage in such activities as skating, skiing, and swimming? He wants to know what new things are coming up which might reduce his level of disability, and how relevant they are for him. Getting factual information was considered important as it gave him the chance to cooperate with those who were providing treatment to achieve a successful result.

Team members sometimes tend to leave the patient in the dark, treating him as an object rather than a person. Standoffishness was greatly resented. Two suspicions were entertained: one, that the treatment staff really didn't know what to do and were not prepared to admit it; and, two, that the treatment staff didn't consider the treatment program something the patient needed to know or should know, perhaps because they wanted to stay in control.

Some treatment staff members indulge in horseplay or flippancy in the belief that this lightens things for the patient. The patients indicated that some lightness was appreciated, but in excessive quantities it was usually not welcome. They wanted their problems to be dealt with seriously. Joking suggested that it wasn't so serious, or perhaps was something they could be jollied out of.

Humorous exchanges between themselves during rehabilitation and friendly competition were helpful. On the other hand, organized mutual support groups were only of interest as pressure groups which would solve social and other problems for the members of the group. Thus, the Amputee Association in Manitoba started out to be a social group and ended up getting prostheses and orthoses covered by medical insurance through a Brief presented to Government. When such a pressure group is formed, they felt it should be headed by an amputee who had had training as a social worker.

When all was considered, those to whom the amputee turns for information may not remain constant. As rehabilitation moves along, he finds new possibilities for obtaining information from different people. At first it is the physician to whom he looks for every sort of support. One amputee referred to his family doctor as "terrific." It was the care given not only to him but to the family at the time, and, through bringing other professionals into the scene at the right time, this doctor gained a lot of credit for himself from the particular amputee. The surgeon is all-powerful in the early stages. The therapists who spend a great deal of time with the amputee are in a strong position to give information. The prosthetist, too, has a strong position in this situation later,

Team members sometimes tend to leave the patient in the dark, treating him as an object rather than a person.

and, for many amputees, he is the most continuously seen professional to whom they come through the years for replacements, adjustments, repairs and supplies. The social worker usually has a strong place early in the process, or for cases in need of continuous support, but these amputees were not much interested in social workers except to get something needed when the situation was critical, and their own capacities to deal with such a situation were low.

ABOUT THE STUMP.

After amputation, the patient generally experiences considerable pain. Amputees want this pain explained. They tend to feel that it is a unique experience with them and that they are being childish about it. Also, they feel the stump to be vulnerable. All mentioned this concern. A common fear is that the stump will burst open if it is stressed when the amputation is new. The doctor can do much to still this fear by demonstration. He can pull up on the end using hand traction on the skin—"That's a good, strong, well-healed end!" The patient needs to be assured that the pain will gradually diminish, and that wearing a prosthesis will accelerate its reduction.

While the physician may best give information on pain, the prosthetist can reinforce this information by recounting the common experience that use of the prosthesis helps reduce pain. Although awareness of the stump is persistent, awareness of pain and the vulnerability of the stump disappears in time. The amputees questioned mentioned how even a temporary prosthesis was welcomed because of the protection it offered the stump.

AWARENESS OF DISABILITY

Immobilization was a source of great frustration. Later, the encumbrance of crutches was frustrating too, even though walking was possible. When he has a prosthesis, the slower pace he must follow while those around him speed on is a source of frustration to the amputee and brings on feelings of insecurity and inferiority until he comes to a "what the heck" position, and goes his own pace, leaving the normals around to adapt. Among the worries these amputees indi-

At first it is the physician to whom he looks for every sort of support.

cated they had was that they would not "measure up"; that is, would not be able to achieve their reasonable level of performance.

Acceptance of disability was enhanced by good rehabilitation, and especially by good prosthetics care. Considerate handling also helped. When a patient was made to feel guilty, or to feel that he was a failure, acceptance dropped off. Realistic vocational counseling also helped to improve acceptance of amputation by settling unknowns, or by helping to do so.

Failure at the social, family, or work levels, or in the rehabilitation setting, reduced acceptance. High expectations by those who asked more of the situation than was reasonable were deleterious, unless the amputee could maintain his perspective.

A poor or uncosmetic prosthesis reinforced feelings of inferiority and inadequacy, while a good prosthesis had the opposite effect. The more nearly normal the prosthesis appeared, the closer to normal their gait, the greater their feeling of adequacy. The desire was to disguise abnormality. A good gait helped accomplish this goal. At the same time, in order to avoid unprofitable effort, the amputees felt that the goals set should be realistic and not require too much energy. The need for compromise should be indicated when necessary. Realistic struggle was considered to be a positive element in that winning through was a source of satisfaction and increased the patient's acceptance of his disability.

These experienced amputees indicated that frustration and retreat from acceptance of disability did occur. The difficulty in keeping up in social activities requiring increased effort, or in standing for long periods, was mentioned. Their solution was to rest before such activities, and wind down with further rest afterwards. At such times they also took better than average care of their stumps and prostheses to increase their margin of tolerances and safety.

FEELINGS ABOUT THE PROSTHESIS

A good prosthesis becomes something approaching a part of the amputee as time goes on. It protects his stump, returns some function, and gives him a more normal status. He may claim that what it looks like is not important but, in fact, if it is comfortable, he will look for improvements in its appearance. All stressed that they preferred a good-looking prosthesis, including one that was noise-free and dependable. Things they wished for in addition were softness,

Feelings of anxiety which relate to the prosthetist taking the prosthesis away for adjustments occur. Often the patient fears that the prosthesis may be spoiled and wants information about what is to be done.

a more normal color, and some adjustability so that they could relieve flare-ups of discomfort by shifting forces.

They all felt that further design improvements were possible, and some were interested in trying new things.

Feelings of anxiety which related to the prosthetist taking the prosthesis away for adjustments were discussed. They feared that it might be spoiled, and wanted information as to what was going to be done, and why. This probably accounts for the frequency with which amputees will follow the prosthetist into the shop if permitted to.

Any malfunction that creates an embarrassment to others is an embarrassment to the amputee. Such things as a foot dropping off are funny enough to recount, but not so funny when they happen. The horror of losing suction was referred to, and some safety method to forestall the occurrence of this catastrophe would be desirable.

REHABILITATION STAFF AND NEEDS

Meeting the prosthetist early, even preoperatively, was reassuring to the amputees. When this preoperative contact was followed by the immediate or early fitting of a prosthesis, the impact was greater. Early provision of a prosthesis cut short brooding and gave the amputees something positive to think about. They considered getting the prosthesis the highest form of psychotherapy. It kept the focus on real things even when there were other challenges to be dealt with.

Seeing other amputees at various stages of rehabilitation was a very positive thing. They needed to understand the differences between themselves and others so that their expectations for themselves were kept realistic. An above-knee amputee cannot be compared to a below-knee or a hip-disarticulation amputee. The subjects felt that the amputee needs to know from the start that work on his part is involved if the best results are to be achieved. For optimal gait, extra effort is required.

Demonstration by another amputee in their category was rated as desirable. He should be straightforward about it, not showing off. They also considered it important that the amputee be shown a temporary prosthesis, and, at the same time, a finished prosthesis so that he would be able to see that one was a "stepping-stone" to the other, and that each had a place in the process of rehabilitation. This exposure to other

The prosthetist and therapist should be wary so that no setback occurs as a result of unbridled activity in the early stages of walking training.

amputees, and to prostheses, should be as soon as possible after surgery.

LOCOMOTION

Therapists tend to explain normal locomotion to amputees, and to urge them toward walking in a normal manner. The subjects felt that such explanations do not convey to an amputee how he should walk. Demonstration by an amputee who has the same category of disability is considered to be the better course. They found that their gaits deviated from normal, and that there was little they could do about it, unless they were willing to tolerate discomfort and increased expenditures of energy. It was their feeling that therapists also tend to move in and take over too readily. The first standing-walking experience on a prosthesis was rated as having the most fantastic impact. It was agreed that at this stage the prosthetist and therapist should be wary so that no setback occurred as a result of unbridled activity. Nevertheless they should be careful not to blight this keenly felt experience. Because sensitivity to pressure is low initially, the amputee can easily overdo it during this first experience.

Treatment staff members tend to see the amputee as his disability relates to their own specialties. There should be an integrated approach to rehabilitation so that the members who most nearly meet the requirements of the amputee in the psychological sense lead the team. If there is someone outside the team who has a strong position with the disabled person, he should be included. Similarly, in dealing with the home situation, the strongest member in the home should be used in support of the amputee and the rehabilitation effort. For one, his small son was a source of strength; for another, the wife. The clinic team must include the amputee or his spokesman in their deliberations. Dictatorial treatment or rifts within the team were resented. The amputees wanted to be recognized as having a point of view and a strong interest in what went on, and they wanted team members to give evidence of mutual support to one another.

The prosthetist has a very polarized relationship with the amputee. This is because he intervenes between the amputee and pain, and pain is a very strong factor in the acceptance or rejection of a prosthesis. The amputee expects his prosthetist to have the highest degree of knowledge in his field. He wants him to have a polish similar to that of the doctors and therapists and other professionals with whom he deals. Good handling by the prosthetist was highly appreciated, and poor handling deplored in very strong terms: "The prosthetist was poor; turned me off. His manners were poor. He was rough. There was no communication. I hated him. I accepted what he had to offer, but I was not happy, and did everything I could, including fixing my own leg, to avoid him." Another said: "He really knew his business. He explained everything to me just the way it happened. What a difference it made compared to previous experiences. I knew I could trust him."

Handling the patient doesn't mean pandering to him. The amputees indicated that when the prosthetist is not sure whether a change should be made, he need not feel vulnerable. He need only be definite about the situation. Making fake changes to appease the patient was considered bad because, sooner or later, the prosthetist would be found out and his reputation affected. What the amputees wanted in their prosthetists was competence as indicated by actual results. When amputees raised questions which the prosthetist could not answer, the prosthetist should say so. If it seemed to warrant it, or the patient had strong feelings about it, he should be directed to someone who has the answer, or the answer should be found for him.

For most amputees, the therapist came next to the prosthetist as the most influential person ultimately. This was because of the long periods of time she spent with the patient. She was often his avenue of communications to all the other professionals.

While social workers rated low in these amputee discussions, many social problems were discussed. This probably indicates that the best use of social workers is not realized when amputees are being dealt with, or at least in the areas from which these amputees came. They expected the social worker to know what was available to them in the community—medical services, financial support, written material, organizations, other amputees from whom they could get information, etc. They felt that the social worker could be important to the family, and in bridging the gap for the amputee in the community and at work.

They indicated that amputation is a crisis for everyone involved in the work, and in family and social environments. There is a strong desire to get things sorted out and to close the action. The hospital was seen as a refuge to which an amputee might cling if things were not going well. In the event of dire stress, his wish was to get back to it. Thus, going home was a highly charged experience often anticipated. However, they needed to come back to the hospital to recoup spent energy, with a mixture of feelings, and give the family a similar "breather."

The forces at work were the reaching out toward more independence within his new status as an amputee, and the need for protection from too much stress. Spouses were strong supporters while the crisis was hot. Later, reaction set in. They became physically and emotionally exhausted. The amputees considered that the social worker, or some other competent persons, needed to be there to support the family under these circumstances. The reactions of friends and colleagues usually depended on the amputee's own acceptance of the situation. Some were squeamish, and couldn't overcome it. Some gave very active support through money collections, looking after the family, and engaging socially with the amputee. These endeavors were highly appreciated. Amputees want to be socially acceptable, and such support is reassuring. On the other hand, all admitted that at times they had used the fact of amputation and the prosthesis as a power lever at every level.

Financial deprivation was discussed. One said that it was a great relief to know that he was covered by insurance. They all felt that prostheses should be part of a medical insurance scheme. They said that such coverage relieved the amputee of concerns about costs, and gave him the feeling that he would be rehabilitated to optimum levels at a time when he had strong financial worries. There were other important needs. Most amputees need a car. Special parking arrangements were needed because of the longer time it took them to walk from one spot to another, and the effect distances had on their total performance. Also, just being an amputee is more expensive because of such factors as getting off work to obtain medical and prosthetics attention, greater wear and tear on clothes, the cost of prostheses and special supplies, etc. Tax relief is considered to be only fair.

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THE FITTING OF THE ABOVE-KNEE STUMP

Rudolf Poets[1]

The fitting of the above-knee stump is a subject unto itself. After the alignment of the artificial leg, the fitting is the next most important factor that influences the usefulness of the prosthesis. In contrast to the problems of alignment, for which certain rules and regulations have been established, the effectiveness of fitting of the stump cannot be measured or proven by scientific data. For this reason, there are probably as many shapes of sockets as there are prosthetists. Each of them is convinced that his socket is the best and fervently dislikes making any changes.

The shape of the socket is, generally speaking, only the so-called ischial-bearing ring, i.e., the upper 5 cm of the socket where the tuber ossis ischii meets the socket. What happens below those 5 cm is often neglected or overlooked. Several shapes of sockets are shown in Figure 1. Although the upper part of these sockets is formed very effectively, at the lower end they are all circular and without a purposefully designed profile. I assume that the reason for this is the historical development of the sockets for above-knee stumps. In Germany the material most often used for AK prostheses, until well after World War I, was leather. Occasionally, a plaster-of-Paris mold was taken of the stump, over which the leather was formed, but generally wooden molds were used. Most prosthetics workshops owned an assortment of these molds and used them again and again for their prostheses. If the mold had been a little too large, or if stump shrinkage had taken place after some time, the difference in circumference was compensated for with an appropriate piece of felt.

Missing, of course, in those sockets or "stump pipes" was any kind of contour designed to meet the individual needs of the patient. Since the muscles of the stumps atrophied more or less into the shape of a cone, contours in the socket were not judged to be necessary. It should be pointed out that the cone-shaped stumps were a result of the amputation techniques used at that time as well as of the prosthetics fitting.

After wood had replaced leather as the material most often used for artificial legs, the demands which were made on the fitting technique rose considerably, since the consistency of wood caused the patient to feel pain in pressure areas more readily than was the case with leather. Some prosthetists thought they solved the problem by fitting the socket so tight that the amputated limb would soon ride on a bulge of soft tissue. This kind of fitting does not give rise to complaints at first, but the method definitely has to be rejected firmly because of the severe problems that will occur later.

Naturally, the wooden sockets at first were shaped like the leather sockets; that is, funnel-shaped, into which the stump, usually covered by a wool sock, was placed. Because no amount of suction could be achieved in this way, cumbersome harnesses and other suspension methods had to be used. It was hoped that inadequacies in alignment and fitting of the prosthesis would be made up for by such harnesses.

About 1930, the suction socket was introduced by Oesterle but did not come into general use until after the beginning of World War II when many soldiers with war injuries had to be fitted with prostheses. The suction socket makes much higher claims on the art of fitting of the stump because, to create a vacuum within the socket, the uppermost part of the stump has to seal off the socket at the top. At the distal interspace about 5 cm will be left between stump and the bottom of the socket. This space is sealed off by a suction valve. Since no more air can enter the socket, the vacuum produced keeps the stump in close contact with the socket. However, this kind of fitting easily leads to stump edema, particularly after the prosthesis has been worn for some time.

Favored by the existing vacuum below the stump, tissue fluids and blood are drawn into the lower part of the stump. Any counteraction which presses out the fluids and the blood is missing, and painful congestion of the stump is seen. This often leads to reamputation.

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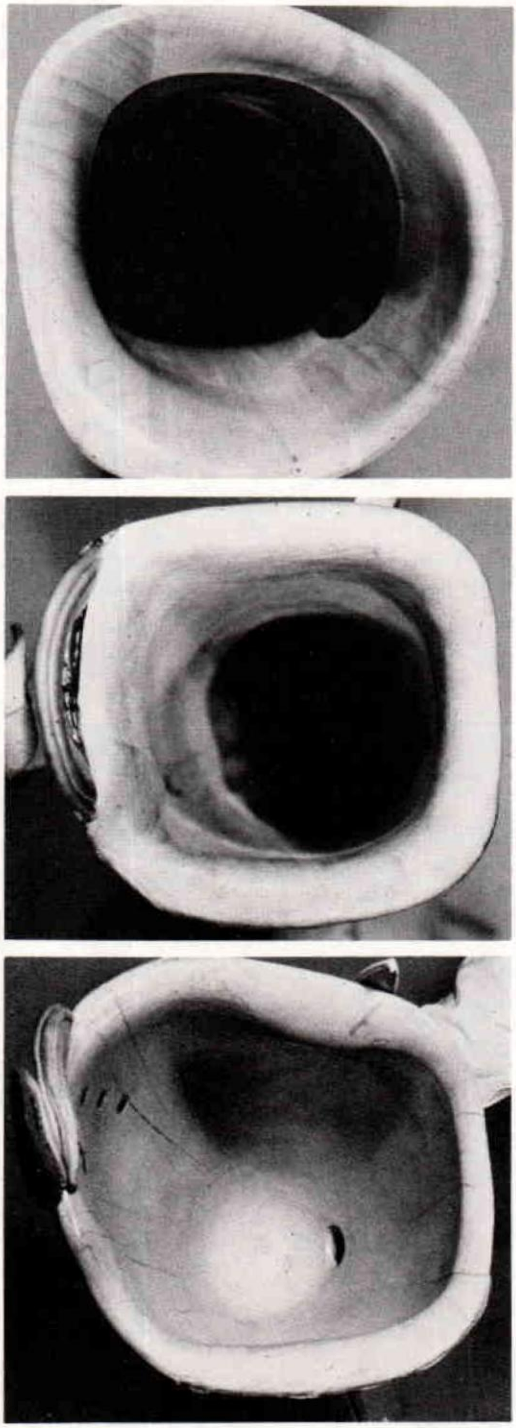

Fig. 1. Variations in the shapes of above-knee sockets.

To counter this problem the total-contact socket was developed in Münster in the late 1950s, based on the work done by Canty and in California at the Biomechanics Laboratory, University of California at San Francisco and Berkeley. The main criterion of the total-contact socket is the entire contact between stump and the wall of the socket. Although the pressure will be distributed unevenly, the contact with the socket must be 100 percent, including the distal end of the stump, enclosing the tip. Therefore a suction valve which conforms to the shape of the lower end of the socket must be used. Because of the complete contact with the socket, a pumping action is created in the stump which pulls tissue fluid and blood into the stump when the prosthesis is lifted, and squeezes it out when weight is put onto the prosthesis.

The total contact, however, is not the only criterion for the optimal fitting of the stump. First, we have to ask ourselves what is meant by "optimal fitting." In my opinion, the following points must be considered:

1. The fitting should not obstruct blood and tissue-fluid circulation.
2. The stump should be fitted in such a way that a stabilizing action of the muscles of the stump against the wall of the socket can take place, and, when the sound leg is lifted, the pelvis can be held in a horizontal plane above the prosthesis.
3. The bone of the amputated leg must be grasped by the socket in such a way that the prosthesis can be well guided in flexion and extension.

CIRCULATION

Besides the total-contact element, a shape of socket has to be found which allows the musculature of the stump to stabilize itself within the socket without obstructing blood flow. To Prof. Dr. Oskar Hepp goes the credit for developing a socket shape which fulfilled these requirements, namely, the so-called undercut socket (Fig. 2). It shows that the diameter of the socket enlarges below the entering point. The undercuts are more pronounced at the medial and dorsal aspects while at the anterior wall they are only required to a small degree. They are not necessary at the lateral wall and here can even be a disadvantage. Because the musculature of the stump corresponds more correctly to the shape of the socket and clings to it, adherence in this type of socket is considerably better than in a funnel-shaped socket which would be pulled down by the contracting muscles.

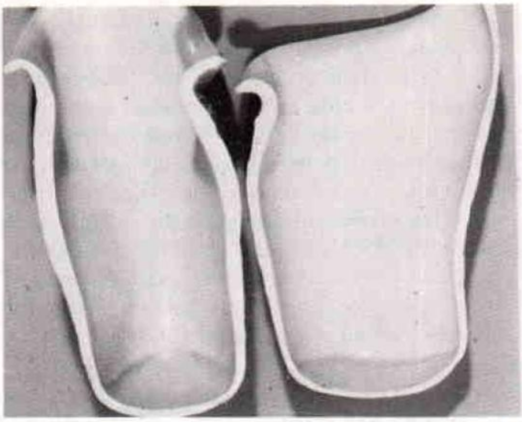

Fig. 2. Cross sections of the "undercut" socket developed by Professor Doctor Oskar Hepp of Münster.

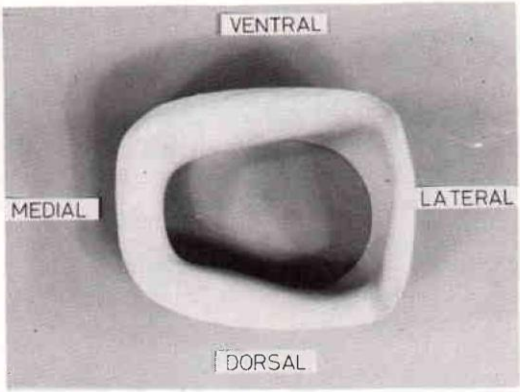

Fig. 3. Top view of socket designed to provide optimal stability.

STABILITY

It is general knowledge that, to obtain the maximal strength of a muscle, the origin and insertion must be as far from each other as possible; that is, the muscle has to be extended as much as possible. To translate this to our conviction: those muscles which keep the pelvis in a horizontal plane over the weight-bearing leg (the gluteus medius and the gluteus minimus) have to be put in tension. This can be achieved by adducting the stump. Therefore, the stump should always be fitted in adduction. But, more: the adduction has to be maintained when weight is put onto the prosthesis and, in its upper part, must not be allowed to tilt medially. The shape of the ischial weight-bearing ring plays a decisive role here. To bring the hip joint and the upper part of the femur into the socket as far as possible laterally, we must allow as much room as practicable in this area. Conversely, to prevent the tendency of the proximal end of the stump to move toward the medial side, we must fit the socket as tightly as possible medially. One can picture it in this way: the distance of the ischial support to the anterior brim should be smaller than the total distance at the lateral part of the socket (Fig. 3). In this way the desired stabilization of the upper part of the stump can be achieved and the pressure on the perineum and the adductors (with the vessels saphena magna and vena femoris) can be avoided. Better conditions for return of the blood are thus achieved at the same time.

ANTEVERSION AND RETROVERSION

Conversely, the stump has to brace itself in adduction in the distal area of the socket. To grasp the bone snugly, the distal end of the femur has to be given a reaction area that can be provided by the shape of the lateral wall of the socket (Fig. 4). To fit the femur at the ventral and dorsal aspect at the same time, the distal-lateral part

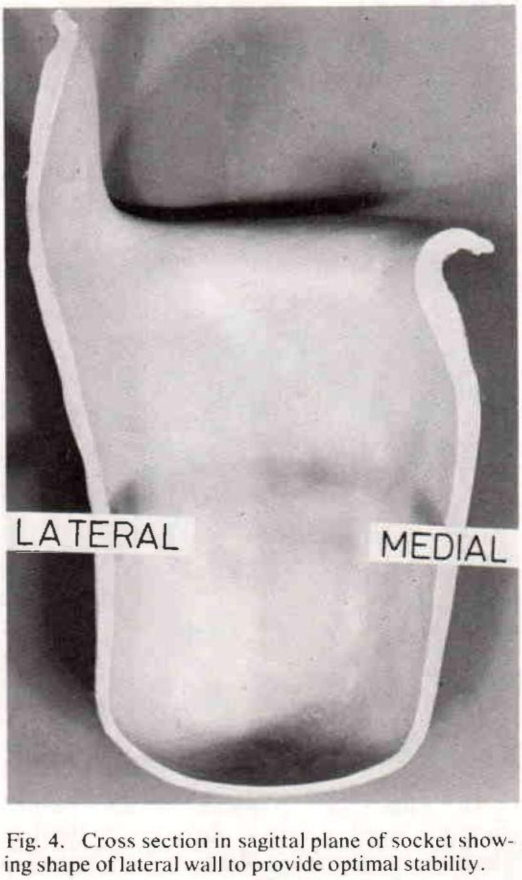

Fig. 4. Cross section in sagittal plane of socket showing shape of lateral wall to provide optimal stability.

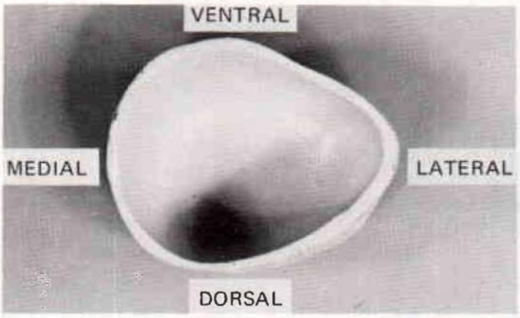

Fig. 5. Horizontal cross section in distal portion of socket that provides optimal stability.

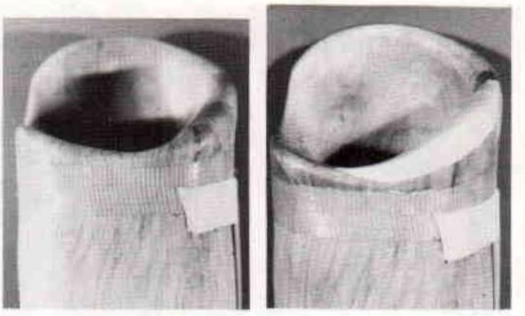

Fig. 7 (left). Unsuccessful fitting caused by lowering the height of the anterior brim.

Fig. 8 (right). Photograph showing build-up on brim of unsatisfactory socket shown in Figure 7.

of the socket is molded, as recommended by Burger, like a clasp (Figs. 5 and 6). Because of this, the prosthesis can be well guided by the femur. If the socket is not shaped in the described way, and is allowed to end in a circular pattern instead, the femur can escape toward the front and toward the back and thus create an unnecessary space which makes the guiding of the prosthesis more difficult.

FURTHER CONSIDERATIONS

I would like to mention one more point, although it is debatable if the shaping of the brim belongs to the fitting of a stump. In my opinion this is true owing to the many difficulties that are encountered especially about the brim. Often there are complaints about pressure in the area of the tendons of the adductors (on the brim on the anteromedial side). Because it seems logical, one is easily tempted to solve such complaints by cutting away some material in the anteromedial area. But this rarely meets with success. A possible cause for this can be that the anterior brim opposite the ischial support is too low. The anterior brim should be 2-3 cm higher if the tuber ossis ischii is to remain on its supportive area. If the anterior wall is lower, the tuber ossis ischii will slide forward and will create considerable pressure on the opposite side. The patient with the socket shown in Figure 7 complained about pressure on the anteromedial side and relief was attempted by cutting away, which proved to be a failure. Only by building up the brim—this piece is clearly visible on Figure 8—could the complaints be obliterated. Another cause for these complaints may be a gluteous maximus which is fitted too tightly. When contracting, the stump is pulled forward and is pressed against the anterior brim. This can easily be determined when a finger is placed in the area of the gluteus maximus. The patient then contracts the muscle and the pressure felt will tell the experienced prosthetist what to do. The same holds true for the medial brim of the socket: one again is tempted to relieve localized pressure by localized measures and also mostly without success. If the patient reports pressure in the area of the perineum, the cause most often is that the prosthesis tilts medially when weight is put onto the prosthesis. Therefore too much pressure is put onto the upper medial part of the stump. The cause for this may be that the upper-medial distance of the socket is too great and at this place some material should be added. One should definitely not cut away in this area. The medial brim of the socket should only be a little lower than the ischial weight-bearing point and should lead in a shallow curve to the anterior brim (Fig. 9).

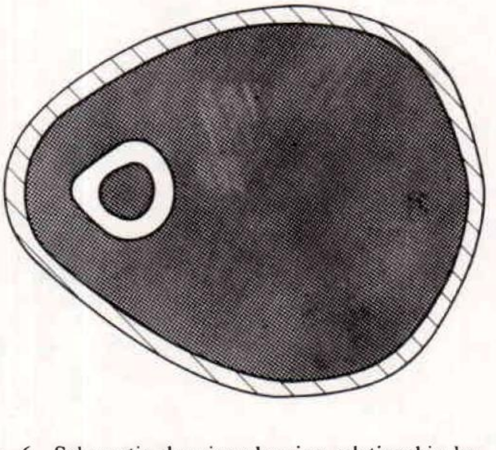

Fig. 6. Schematic drawing showing relationship between femur and socket design shown in Figures 4 and 5.

Because I believe that difficulties in fitting an AK amputee do not only exist in Germany, and because we have had such good results with the socket described, I have tried to point out some of the experiences we have had in our clinic. I have not mentioned any connection between fitting and alignment of AK prostheses, although this of course is important.

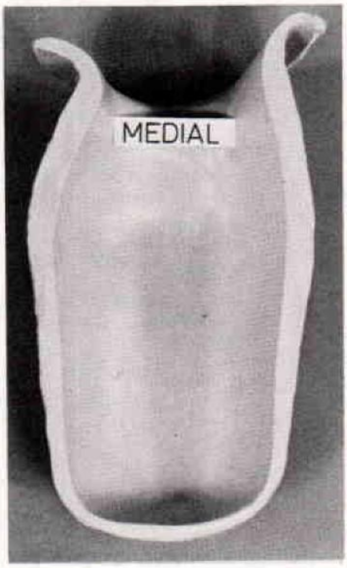

Fig. 9. Sagittal cross section of above-knee socket showing the relationship of the medial brim to the anterior and posterior aspects of the brim.

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POST HOSPITAL FOLLOW-UP OF THREE BILATERAL UPPER-LIMB AMPUTEES

Richard A. Sullivan, M.D.[1], and
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In a recent period of one year, we admitted to the Kessler Institute for Rehabilitation three married white males, ages 37, 38, and 41, all with a history of sudden onset of traumatic bilateral upper-limb amputations. They were all admitted for their rehabilitation training between two and four months after their injuries, and none had been exposed to prosthetics or training in their use. All three were of working-class backgrounds with rural or small-town educations and working experiences. In addition, their interests and hobbies were similar.

One of the patients had bilateral above-elbow amputations, and the other two had bilateral wrist-disarticulation amputations. Each was fitted with a standard upper-limb prosthesis with a figure-eight, O-ring harness. The terminal devices were Dorrance hooks and hands of different varieties depending on their needs and future vocational goals. Each, during their stay at the Institute, achieved a significant level of independence with their prosthetic hooks. This independence included a completed course in driver education with re-licensure following retesting by the motor vehicle bureau. Every attempt was made to interest the patients in future reemployment, either with their former employer or in a position more compatible with their present disability. This was successful in one instance, partially successful in the second, and a failure in the third.

We thought that it would be interesting to visit them in their home environments two years after their discharge from the Institute to ascertain their level of prosthetics use and independence. The visit was made by the co-author of this article, a person who had been personally involved in the prescription, fitting, and training of each of the patients as their occupational therapist. She also worked in close liaison in each case with their activities-of-daily-living nurse in their functional retraining in the vital area of self-care. She had a personal concept in each case of what they had accomplished and was thus able to better assess their losses and their gains over the intervening two years since they had been trained.

The primary objective of the visit was to assess their levels of independence both with and without their prostheses. She would also determine their dependency on the prostheses as well as their present level of prosthetics skill. Of interest also was the follow-through towards the vocational, avocational, and self-help goals that had been set for each individual patient at the time of his discharge. An attempt was made in two of the cases not to provide the patients with the Dorrance hands because it had been our experience that, in most instances when hands were prescribed for bilateral amputees, the patients found them to be useless items which decreased their functional ability and therefore ended up unused, on the shelf. It had always appeared to us that it was the exceptional bilateral upper-limb amputee who developed a skill in the operation of the prosthetic hands. The usual response was rejection. In both cases, however, the patient insisted on being fitted with the hands as well as the hooks in spite of our counsel, and they were accommodated. We were interested to learn the level of hand use after two years.

Each of the patients was contacted and expressed delight in our interest and in the impending visit. They were then visited for two days each in Pennsylvania, Virginia, and Tennessee at their homes and places of employment. Interviews with their families, friends, and employers were carried out when feasible. The following report is a summary of the results of these visits:

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[2]Director, Occupational Therapy, Kessler Institute for Rehabilitation, West Orange, New Jersey

CASE REPORT NO. 1

J.M., a 41-year-old white male, sustained third-degree electrical burns on July 1, 1970, while working as a journeyman lineman. Bilateral below-elbow amputations were performed initially, but subsequent revisions were necessary which left J.M. with bilateral above-elbow amputations (Fig. 1).

He was first admitted to Kessler Institute for Rehabilitation on September 17, 1970, and remained until December 16, 1970, participating in a program of pre-prosthetics and prosthetics training. During this period, he was trained initially in the use of a temporary prosthesis for the left arm only, and later with a right temporary prosthesis after resolution of an infected sebaceous cyst on the right stump. He was discharged with a temporary right and a permanent left prosthesis, and returned in February to receive his permanent right prosthesis. He was readmitted on February 10, 1971, and remained until February 23, 1971. At discharge, he had been fitted and trained with two permanent prostheses.

THE PROSTHESES

J.M. was provided with bilateral conventional, above-elbow prostheses with spring assists for elbow flexion bilaterally. Hosmer wrist-flexion units, two #555 Dorrance hooks, two Dorrance #7 hooks (farmer's hooks), and Dorrance hands. He received an extra single-harness attachment which allowed either prosthesis to be worn independently of the other. The terminal devices were interchangeable.

SOCIAL HISTORY

Mr. and Mrs. J.M. and their teenaged twins live in Knoxville, Tennessee. There is also a married daughter living nearby and his wife's mother lives next door. It appears to be a closely knit family.

Fig. 1. J.M. without prostheses.

While at the Institute, J.M. presented himself as an emotionally stable, outgoing individual who related easily in a straightforward manner. He showed excellent control of the underlying reactive depression. He appeared to expect unrealistic goals from the prostheses and failed to realize the effort that would be required on his part to operate them. Throughout his stay, he made mention of ideas he planned to try out at home related to adapting carpentry tools and self-care devices, suggesting an enthusiastic desire to increase his independence. His vocational goals appeared to be minimal since the compensation and disability pensions from his place of employment would be sufficient for his and his family's financial needs, thus rejecting other types of employment. He did talk of opening a furniture shop in partnership with a friend, but this never developed into a firm vocational goal.

VISIT TO PATIENT'S HOME—SUMMER 1973

Mr. M. was asked for his thoughts and criticisms of his prostheses. He felt that they were too hot and heavy. He did wear them for at least 6½ to 7 hours daily but he removed them more frequently during the hot summer months. He felt they were a definite necessity, feeling lost without them. The #7 hooks (farmer's hooks) and the functional hands had been discarded; he found them both too heavy. The farmer's hooks had been prescribed with the belief that they would be useful for his anticipated carpentry work. Most annoying to him was the fact that the cable on the left prosthesis had broken about every two to three months. This left side had become his dominant extremity because it was the longer stump and therefore received the greater work load. He had had a second prosthesis fabricated in Tennessee since his discharge using these as a spare. He wears seven rubber bands on the left and three on the right to improve his tension of grasp.

It was clear that Mr. M. had developed more skillful use of his prostheses in the interval since discharge. Strength of shoulder and scapular musculature had increased and he could now activate each individual prosthesis independent of the other with relative ease. He did not have spring assists put on this second pair of prostheses, because they tore his clothing and were of little functional value. It was our feeling that he no longer needed them because of the increase in strength in both stumps and his improved expertise in their use.

Self-Care Activities

It became clear during the interviews with the patient that in spite of his increased strength and his improved functional performance with the prostheses, the patient was actually less independent in some areas of activities of daily living than he had been at the time of his discharge from the hospital. The most glaring lack was in the area of the self-help innovative equipment which he talked about so often during his hospitalization. There was none in evidence.

Dressing: In the hospital, by using a dressing pegboard frame with hooks, with the board attached to the foot of the bed, the patient had been independent in dressing. At home he had never completed the construction of the dressing frame. His dressing activities were very slow and he requested and received a great deal of assistance from his wife. He had specially tailored Banlon shirts which fit higher and more snugly in the axilla, reducing the restrictions of movements which the regularly available shirt caused by its looseness in axillary fit. He wore specially made T shirts with stump-sock sleeves and he found these to be of great value, alleviating the need for manipulation of additional stump socks. He needed assistance donning his prostheses.

Feeding: At discharge, he was independent in eating and cutting his food, and he could handle sandwiches with a "sandwich holder" with which he was provided. He now needs his food cut and no longer uses the sandwich holder, but is otherwise independent.

Personal Hygiene: He was independent in bathing and talked about having a soap dispenser, rotating brushes, and an overhead heating lamp placed in the bathroom. He did none of these things and is dependent in bathing, being fully bathed by his wife.

Toilet Function: He managed cleaning after toilet independently but with effort, and he used a hook attached to the wall to assist with the replacement of shorts and pants. He remains independent. He wears nylon shorts which he finds easier to adjust. He cleanses himself by wrapping the paper around the left hook, flexing the wrist unit with the hook in the mid-position, and unlocking the elbow. Upon reaching back, the elbow locks and remains stable for the task.

General Activities: He was and still is independent in managing faucets, turning keys in locks, turning most doorknobs, operating light switches and in using the telephone. He keeps money in his shirt pocket and asks the cashier or salesperson to reach for the money needed and to replace the change.

Top Priority Activities for Mr. M.

Driving: He had had the ignition key and signal control adapted (Fig. 2) and has a knob on the steering wheel (Fig. 3). He can use the tractor lawn mower (Fig. 4), and has a foot-control choke on it (Fig. 5). He can hook up and release the trailer, which is used to transport the tractor, to his car independently. Mr. M. does a great deal of mowing for the church and also for his neighbors whom he charges.

Carpentry: He does some refinishing of old furniture and has constructed simple pieces. He can use the power saw, sander, and planer but not the hammer.

Church Activities: He has continued to be active in his church, especially with children. During the summer he was principal of vacation Bible School, and last fall he led the exercise group for football training.

Fig. 2. Switch-key control on car.

Fig. 3. Steering-wheel control knob.

Fig. 4. J.M. on his tractor mower.

Fig. 5. Choke control on J.M.'s tractor.

CASE REPORT NO. 2

J.S. is a 37-year-old male who sustained severe crushing injuries and subsequent amputations of both hands on May 28, 1970, while operating a press at work. He was admitted to Kessler Institute on September 28, 1970, with a diagnosis of bilateral wrist disarticulation and was discharged on November 6, 1970 (Fig. 6).

He participated in a pre-prosthetics and prosthetics training program and, while he waited for the permanent prostheses to be fabricated, a temporary prosthesis was provided. He was fitted with a Viennatone myoelectric hand on this temporary prosthesis—purely on an experimental basis. He soon became proficient in control of this hand. He became most proficient in the use of his prosthetic hooks and rejected the hands because of their weight and operational noise.

THE PERMANENT PROSTHESES

Conventional bilateral wrist-disarticulation prostheses of laminated plastic were provided. J.S. received two Dorrance #555 hooks and two #7 Dorrance hooks and Dorrance hands. No difficulties were encountered in training.

SOCIAL HISTORY

Mr. and Mrs. J.S. live in the village of Goode, Virginia, with their 3 children ages 11, 9, and 7. They live next to his brother-in-law's 400-acre farm and Mrs. S's parents also live in the same town. This is also a very close-knit family.

Mr. S. showed good adjustment to his disability. He was quiet, straightforward, and even-tempered, However, he also came to Kessler Institute with great expectations regarding prosthetics function. His vocational goals were to return to his former occupation as a machine operator.

HOME VISIT—SUMMER 1973

J.S.'s Thoughts and Criticisms of the Prostheses

The prostheses were a part of him and were worn all day. The hands were rarely worn. . . "only to a wedding and a couple of funerals." He found they were too heavy and clumsy. The Dorrance #7 hooks were used occasionally; he found them most useful for house painting, but they were of no value for driving. He favored the #555 hooks and used them almost exclusively. The cables frayed frequently but he had them replaced with heavy-duty cable and has had no repairs since. He uses four rubber bands on each hook.

Self-Care Activities

J.S. is almost completely independent in self-care, although this is not surprising in view of his levels of amputation. However, he too finds dressing the most frustrating activity.

Dressing. He still requires help with buttons because he finds it takes too long. He continues to don and remove his prostheses but does need help with T shirts. His wife has sewn stump socks to the sleeves.

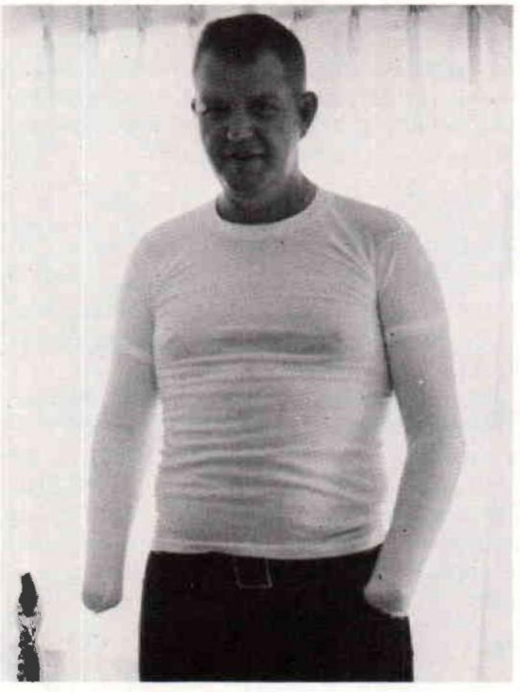

Fig. 6. J.S. without prostheses.

Feeding. He remains independent. He can cut food but most times it is done for him by a family member. Sandwiches are a problem.

Personal Hygiene. He remains independent. He uses a sponge mitt over his stump for bathing. An electric razor is held between his stumps for shaving. He uses a cuff on the stump to hold his toothbrush.

Toilet Functions. He remains independent.

General Activities. He can still manage faucets, most doorknobs (round slick ones are difficult), can manage keys, light switches, and the telephone. He uses a wallet and can reach into his shirt pocket for money. He also cooks simple meals.

Top Priority Activities for Mr. S.

Farming. Mr. S. has not returned to employment but helps his father and brother-in-law on the 400-acre farm. He can use the tractor and can even lift bales of hay weighing 50 to 70 lbs.

Driving. He needs only a ring on the steering wheel and is independent.

Carpentry. He does furniture refinishing, and has made night tables and sold them. He is able to use the power saw and sander, can manage the electric drill and, although he finds the regular screwdriver impossible, he can use the screwdriver attachment with the power drill. Hammering is not a success except for light taps.

Gardening. Planting, using a hoe, and mowing the lawn can all be accomplished.

Sports. Hunting is very important to Mr. S. Friends and his wife helped him design a special shotgun harness and anterior metal piece for stabilization of the gun (Figs. 7-10). These adaptations make hunting possible. Mr. S. is now president of the local gun club.

Social Activities. He enjoys square dancing during the winter months.

Fig. 7. J.S. shooting specially adapted rifle.

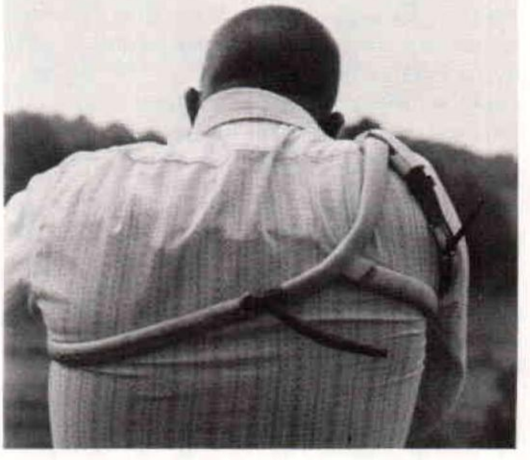

Fig. 8. Special harness for rifle shooting.

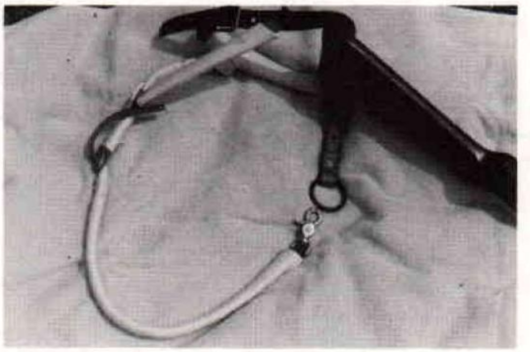

Fig. 9. Another view of the special harness designed by J.S.

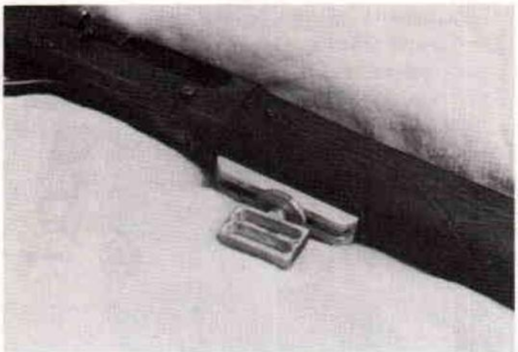

Fig. 10. Close-up view of special stock fitting for J.S.'s rifle.

CASE REPORT NO. 3

G.B. is a 38-year-old white male who was injured in an explosion while at work in a chemical plant on April 19, 1971. Bilateral amputations were necessary leaving him with a left wrist disarticulation and a right transcarpal amputation (Fig. 11). He was admitted to the Kessler Institute for Rehabilitation for pre-prosthetics and prosthetics training on June 21, 1971, and remained until August 13, 1971. A temporary right prosthesis was provided so as to allow him more function during the pre-prosthetics training period.

THE PERMANENT PROSTHESES

Conventional bilateral wrist-disarticulation-type prostheses with a Dorrance 88X hook for the right and a #555 hook for the left and two Dorrance hands were provided.

SOCIAL HISTORY

Mr. B. and his wife live in Tamaqua, Pennsylvania, with their three children ages 16, 15, and 11. This is a small, practically one-industry town where Mr. and Mrs. B. were born and raised. Mr. B's parents live nearby.

Mr. B. presented himself as an extremely quiet individual who never initiated conversation, though he was extremely cooperative and hard working as a patient.

PRE-VOCATIONAL EVALUATION

This patient was closely followed by this department of the hospital since it was possible, in this instance, to make contact and visit with his employer. He showed good potential for desk work, using calculators, typing (12-15 wpm), writing, and handling papers.

Two months after discharge, he was reemployed and given a position as a driver for a van-type truck which he used to taxi employees and transport mail from building to building within the grounds of this large plant. He was also equipped with a one-way radio.

HOME VISIT—SUMMER 1973

Mr. B's Thoughts and Criticisms of the Prostheses

Mr. B. is the most independent of these three cases, probably because help is not so readily available.

The prostheses are worn all day and there is no question in his mind that he could ever be without them. He wears four rubber bands on the right dominant hook and three on the left. The hands have been worn only "three or four" times since his discharge because he found them "cumbersome." The cables fray every four to five months.

Work

Mr. B. is content with his position and is employed full time. His employer is well pleased with him, finds him dependable, and stated he has proved to be a safer driver during the winter than other employees (Fig. 12).

Self-Care Activities

Feeding. He remains independent; his wife cuts meat when they eat out.

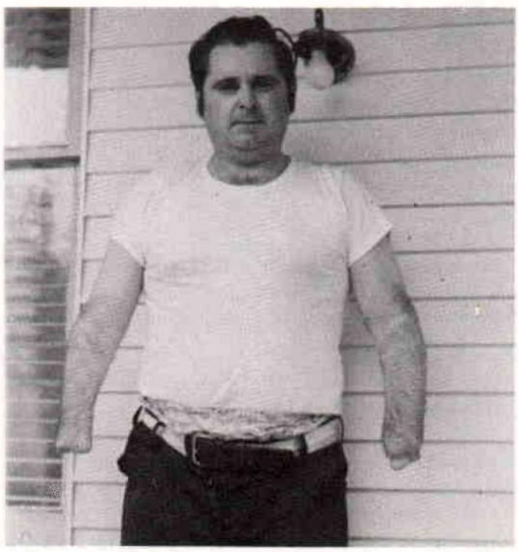

Fig. 11. G.B. without prostheses.

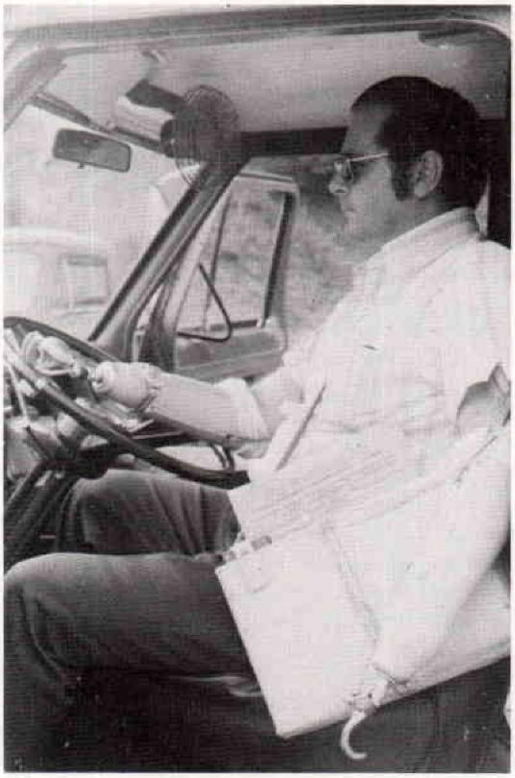

Fig. 12. G.B. at the wheel of the company van.

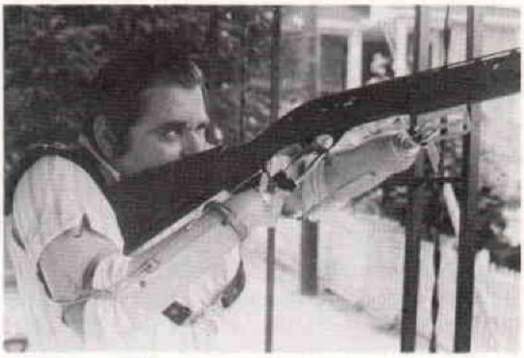

Fig. 13. G.B. shooting his rifle with adaptations suggested by J.S.

Fig. 14. G.B.'s "shooting" harness.

Fig. 15. Fishing rod with rings.

Grooming. He remains independent.

Personal Hygiene. He uses a sponge mitt over his stump when bathing.

Toilet Functions. He remains independent.

Dressing. Buttons are still a problem; he needs assistance.

General Activities. He remains independent except for some doorknobs. He has surgical tubing on the fingers of the right hook and this helps increase traction. He keeps his wallet in his shirt pocket and can manage it independently.

Sports

Hunting. This was very important to Mr. B. so when Mr. S. from Virginia wrote us about his shotgun harness, his address was passed on to Mr. B. and he had a harness fabricated for himself from photographs received from Mr. S. They continue to correspond with one another and exchange ideas (Figs. 13 and 14).

Fishing. Mr. B. was given a body harness with a fishing-rod support while he was a patient at Kessler Institute. He has since discarded this harness and has rings only, taped to the fishing rod. He gets assistance in placing the hook; the reel is automatic (Fig. 15).

DISCUSSION

The problems of the traumatic bilateral upper-limb amputee are necessarily great, affecting every aspect of living. Each patient presented here was faced with the need for emotional adjustment, first to traumatic injury and amputations, and then to the alien world of prosthetics. Within a matter of months, they had to adjust to these new worlds and develop a new pattern of independence within the confines and framework of present-day prosthetics. They did not have the advantage of "growing up with their disability and their prostheses" as do children with congenital deformities. They were and still are fully aware of what losses they have suffered as a result of the loss of hands and elbows and what limitations the prostheses offer even at their most functional level.

As was expected, the bilateral above-elbow amputee had the greater prosthetic and emotional adjustments to make and was the least skilled in activities of daily living and in independence. However, his level of functional ability is high and, taking into consideration his educational background, one must reach the conclusion that he is doing well. If the need for more independence were there, we feel that he could achieve a higher level. The compensations of our social system to the injured worker have taken away his need for employment and he therefore has not pushed to achieve any type of vocational goal.

He is functioning in his family unit, partially dependent but adequately self sufficient, and able to aid in some of the chores and tasks. His dependent areas are primarily in self-care. With improvisations and some simple additional devices he could achieve a more independent status. He knows this but for some undetermined reason prefers his partially dependent role. This may, in a way, justify his failure to seek employment.

The two patients with the wrist disarticulations have achieved an admirable level of physical, social, recreational and work independence. This again could be prognosticated. Each was trained in prosthetics use and independent living in a relatively short time and has maintained or improved upon this since discharge from the hospital. Each was given the benefit of a full program of rehabilitation in addition to their prosthetics fitting and training.

All three amputees were exposed to the atmosphere of the rehabilitation center with a full team effort. Medical supervision, psychological counseling, social service evaluation and assistance to both the patient and his family, and training and testing in the vocational area to assess their vocational skills for the future, were provided in addition to their prosthetics needs. Each patient adjusted to his new problem in his own way and took advantage of the rehabilitation team as his needs required. The results were considered uniformly satisfactory and still are two years later. These patients are three severely disabled individuals who have returned to their homes, their families, their social milieu and to full- or part-time employment. Each in his own way can be considered a successful case.

Each accepted his prostheses with little problem and quickly became aware of their positive and negative aspects. As each paraplegic wishes to walk and rejects the advice against it for medical reasons and demands his chance, so here each one rejected the advice against the prosthetic hand, insisted on his chance to try, and in the end rejected the device. Each has developed a dependence on the prosthetic hooks to the point that functionally they are lost without them. Each continues to use the prostheses every day stressing once again the value of proper preparation and training to develop success for prosthetics use.

SUMMARY

We have presented three cases of upper-limb traumatic amputees who received their prostheses and training by the same rehabilitation team. Each man was visited in his home environment two years later and found to be dependent on his prostheses with the functional hook attachment, and to have rejected the functional hand and specialized farmer type of hook. Each still maintained a significant level of independence of self-care, with the bilateral above-elbow amputee, as expected, showing the most dependency. Their success with their prostheses and ease of acceptance, in our view, bear out the positive aspects achieved when the patient is exposed to the full team rehabilitation approach in a rehabilitation center. Their treatment consisted not only of prosthetics prescription and training in use, but also psychological preparation and counseling, social service assistance to both the patient and his family, and vocational exploration and assistance. The results to date are most encouraging.

Orthotics and Prosthetics, Vol. 28, No. 1, pp. 41-42, March 1974.

TECHNICAL NOTES

A NEW MEASURING DEVICE

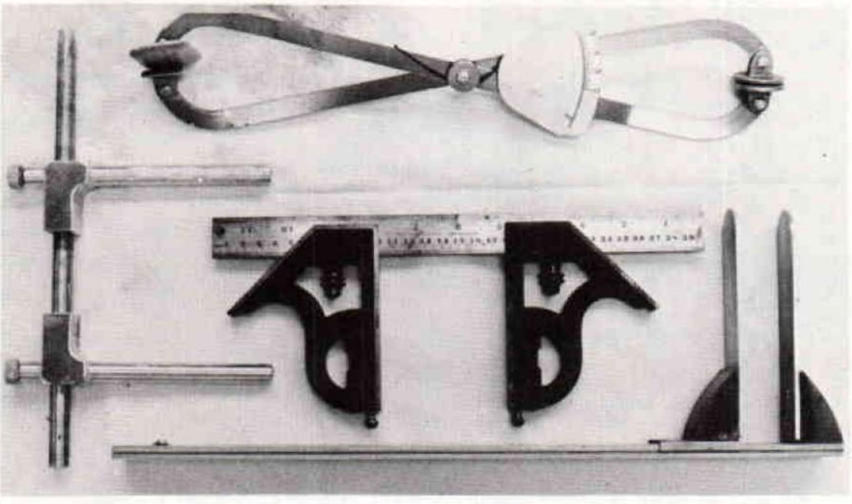

Fig. 1. Various tools for measuring the below-knee stump.

Central to the process of fitting a below-knee prosthesis is the matter of measuring the stump. Over the years, a number of different devices for this specific purpose have been developed, such as the VAPC spring-loaded caliper and the special square of Nitschke and Marschall (Fig. 1). The double-headed combination square is in common use in the teaching programs. The device described in this article is an outgrowth of our experience and dissatisfaction with all of these devices.

The new tool consists of a modified combination square with a fixed post at one end, and a rivet at the other end to prevent loss of the movable head (Fig. 2). The head is stripped of unnecessary parts and modified to permit attachment of a transparent vane of Plexiglas or Lucite (Figs. 3 and 4).

The transparency of the vane allows the prosthetist to determine easily the amount of soft tissues being compressed at the end of the stump. All edges are rounded and smoothed to prevent possible injury to the patient. However, the portion of the movable head directly on the rule is not touched so as to avoid any possible loss of accuracy.

An inexpensive combination square is usually more desirable than the more expensive ones, not just for reasons of economy, but because the finer graduations found on the more expensive devices are not only unnecessary but a hindrance in prosthetics and orthotics work. The fixed post should be mounted on the end of the rule that has a scale starting from zero on each side. Once the fixed post is welded to the rule the two should be checked to make certain they are square. The transparent vane is held onto the head by four sheet metal screws set on each side of the central slot. Two notches are cut into the body of the head to allow passage of the screws. Of course, care should be exercised in the fabrication process so that the finished product will present a neat and professional appearance.

This device has been in general use here by various members of the staff for over a year, and has proven itself to be quite satisfactory. Obviously, its utility is not confined to the below-knee stump since it can be used to obtain many of the various measurements necessary in prosthetics and orthotics. Quite unexpectedly, it was found that if the set screw on the movable head is left just loose enough to allow the head to move, the tension exerted on the square by the patient's flesh when the device is firmly applied will automatically lock the movable head in position. The head can then be released by pressing the outermost portion of it towards the fixed post.

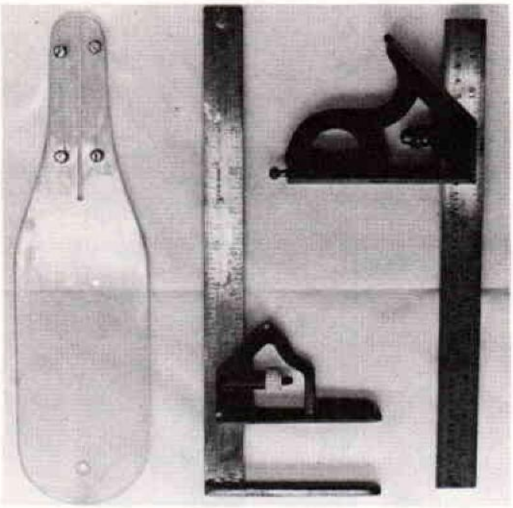

Fig. 2. Unmodified combination square and end result with detachable transparent vane.

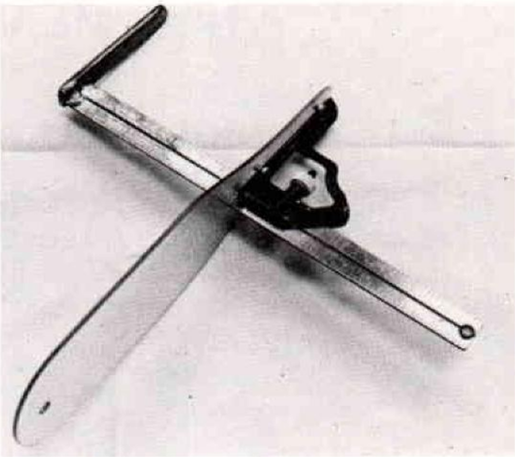

Fig. 4. Close-up showing method of attaching vane.

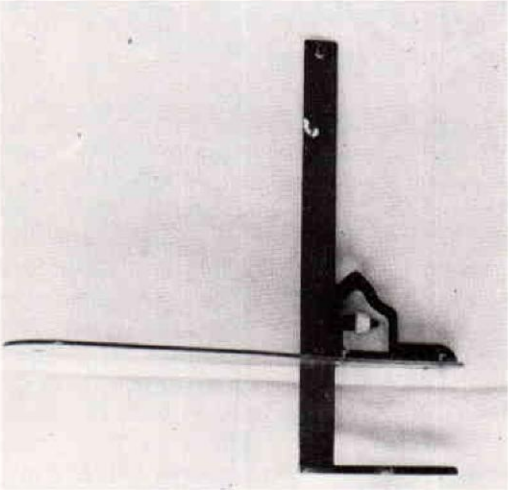

Fig. 3. Modified square with vane attached.

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University of Virginia

Orthotics and Prosthetics, Vol. 28, No. 1, pp. 43-44, March 1974.

A "SLIP" CUFF FOR ANKLE-FOOT ORTHOSES—A PISTON-ACTION ABSORBING POLYPROPYLENE ORTHOTIC CUFF

Relative motion between the cuff and the posterior aspect of the leg is a problem common to all posterior "leaf spring" orthoses, except in the case of the shoe-clasp orthosis[1].

When the patient takes a short stride and ankle action is minimal, this feature is not of clinical significance, particularly when an interposing material, such as a long stocking, is worn between the orthosis and the skin. However, in the case of the patient who takes a long stride, with the associated increased range of ankle motion, the relative motion can be significant.

DESIGN PRINCIPLE

To eliminate relative motion between the AFO and the patient, the authors have adapted the principle demonstrated so well by extensive experience with the Veterans Administration Prosthetics Center shoe-clasp orthosis[2], in developing a cuff which effectively eliminates the problem.

The basic technique requires that a separate polypropylene cuff be fabricated to nest within the cuff of the orthosis in such manner that the inner cuff will remain stationary on the calf and the orthosis itself will glide vertically on the inner cuff during the gait cycle.

FABRICATION TECHNIQUE

The inner cuff is formed over the positive model of the patient's leg. It is 3 in. in height and horizontally it covers about two thirds of the circumference of the calf, going considerably beyond the mediolateral borders of the cuff of the standard polypropylene AFO (Fig. 1).

A vertical slot, 1½ in. x 3/16 in. is cut in the posterior mid-portion of the outer cuff (the calf portion of the conventional polypropylene orthosis), and a ⅛ in. x ½ in. Nyloplex rivet is passed through the slot and fixed to the inner cuff. A separation of ⅛ in. is maintained between the inner cuff and the outer cuff. To reduce friction a ¾ in. strip of Teflon to provide a bearing area is applied around the slot (Fig. 2). The inner cuff is padded, on the calf aspect, with ⅛ in. foam rubber, and a Velcro strap is attached to provide closure.

When the device has been fabricated in this manner the outer shell will move relative to the stationary inner cuff (Fig. 2), thus eliminating detrimental shear forces on the soft tissues of the calf. Figure 3 shows the action of the orthosis just prior to heel-off, and Figure 4 shows its action as the foot has passed from heel strike to foot flat.

Because the stop is riveted to the inner cuff rather than to the upright (in contrast to the

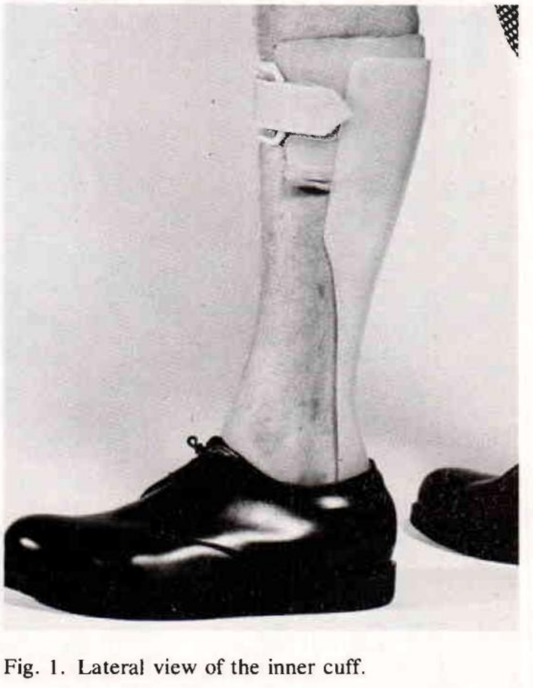

Fig. 1. Lateral view of the inner cuff.

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[1] Greenbaum, Werner, Draft Manual, *VAPC Equinus Control Ankle Foot Shoe-Clasp Orthosis*, Veterans Administration Prosthetics Center, New York.

[2] More than 300 shoe-clasp orthoses have been prescribed by the VAPC Clinic Team. When properly used this is one of the simplest and yet most effective ankle-foot orthoses available.

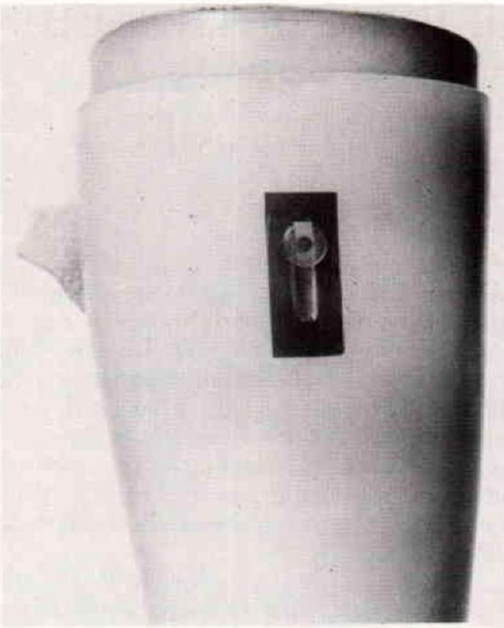

Fig. 2. Rivet and slot arrangement to provide for relative motion between inner and outer cuff.

Fig. 3. Action of orthosis just prior to heel-off.

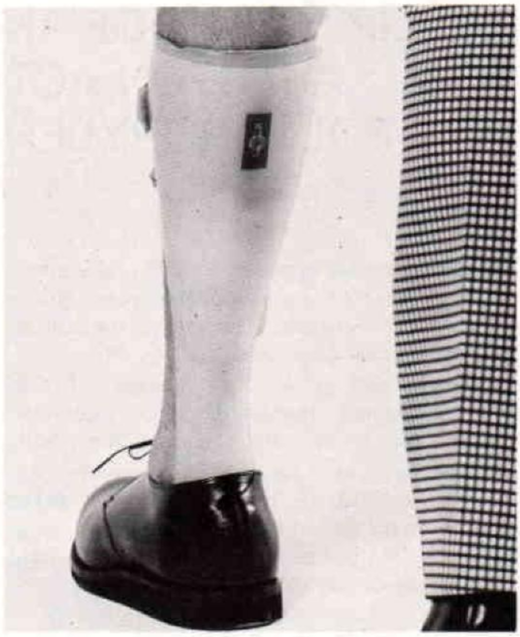

Fig. 4. Action of orthosis at the beginning of the foot-flat part of the stance phase of walking.

method employed in the fabrication of the shoe-clasp orthosis), the inner cuff must be raised before the patient takes his first step, otherwise the stop becomes effective immediately, and compensation for the relative motion will not occur. In the case of the shoe clasp the cuff is lowered initially for the same reason.

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VA Prosthetics Center

Orthotics and Prosthetics, Vol. 28, No. 1, pp. 45-46, March 1974.

PROSTHETIC SHEATHS

The Prosthetic Sheath per se is not new. For many years it has been the practice of some amputees to wear a lady's silk or nylon stocking over their stump leg, and it has not been uncommon for prosthetists to recommend this practice. However, it is only within recent years that this type of hosiery has been knitted and sized especially for use by amputees. The DAW Prosthetic Sheath was first introduced in the United States in the 1960s, but it was not until the late 1960s and early 1970s that prosthetic sheaths began to gain in popularity, along with increased interest within the prosthetics community.

Information on the function and advantages of the prosthetic sheaths is rather limited and subjective. This information is basically in the form of comments and testimonials from a limited number of amputees who have worn the sheath. There have been some who found no particular advantage, and there have been some who have stated that their comfort in wearing their prosthesis with the prosthetic sheath and prosthetic socks has been markedly increased. Generally, the benefits of wearing a sheath seem to be more for below-knee amputees than for above-knee amputees.

Apparently the sheath performs one, two, or all of three basic functions:

- Reduces friction on the stump
- Provides a perspiration barrier
- Serves as a "filler" sock

The sheath is most commonly worn next to the stump under the stump socks. When worn in this manner, the sheath tends to protect the stump against friction by absorbing any movement between the sheath and stump sock. It will also provide a perspiration barrier. The sheaths are knitted of nonabsorbent synthetic material such as stretch nylon and/or polyamid fibers. This allows the perspiration to pass through the sheath and be absorbed by the stump socks, thus giving the amputee a greater feeling of dryness.

When used as a filler the sheath is sometimes worn next to the stump; sometimes worn over the prosthetic socks; and on occasion an amputee will wear two sheaths, one next to the stump and one over the sock.

Some of the testimonial-type comments from amputees run as follows:

"My first experience in wearing a prosthetic sheath was during the hot summer months. Frequently I have to wear two sets of stump socks changing midday due to excessive perspiration. I found that when I wore the sheath, that I most often could wear my socks the full day without having to make a change. I did not seem to perspire near as much."

"With any activity at all, my stump often became rather sore and sensitive. This is especially true in hot weather. I find that by wearing the sheath my stump is much less sore."

"I have been a BK amputee for many years and have always had problems of comfort and soreness. Since I started wearing the sheath, one next to my stump and one over my stump socks, I have known much greater comfort and far less soreness when active."

The Veterans Administration reports that amputee beneficiaries are requested to return a statement of effectiveness:

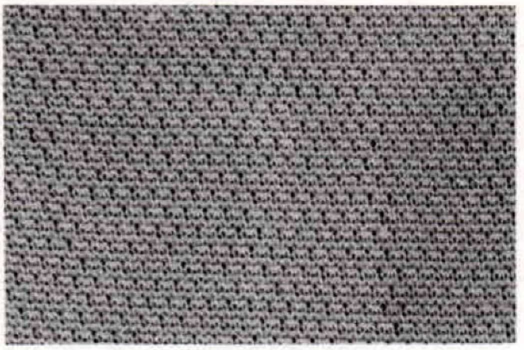
"From these statements, it appears that those with stump problems such as excessive perspiration, stump sores, or abrasion caused by friction, find the Sheath Sock to be beneficial in about 60% of the cases. The other 40% have noticed no particular improvement.

For those veterans who had no stump problems, very few continued to request them after the initial issue. We also found the benefits for AK amputees were minimal.

From the reports received, it would appear that the Sheath Sock will wear longer than the regular cotton or wool sock providing they are properly cared for.

To summarize, the Sheath Socks appear to be most beneficial in those cases of excessive perspiration for the very active wearers. Some advantages for those bothered by stump sores or abrasion caused by the so-called piston action between the regular sock and the prosthesis."

There are only two brands of prosthetic sheaths known to us that are presently available. The DAW SHEATH is imported from France by Otto Bock Orthopedic Industry, Inc. It is white in color and knitted from nonstretch polyamid fibers utilizing a special open mesh weave.



Weave structure of the Daw nylon sheath.

The KNIT-RITE PROSTHETIC SHEATH is a beige color and knitted from "stretch" nylon with comparatively close stitches. Each of the brands has its own features. DAW emphasizes the open weave and better ventilation; KNIT-RITE emphasizes the comfort and fitting qualities of the "stretch" nylon fibers. Both manufacturers emphasize that the sheath and prosthetic sock(s) complement each other as a system to provide greater comfort.

Thus it would seem there are certain indications, perhaps some contraindications, for the use of the sheath. It seems that this could be helpful to amputees who have problems during hot weather; to amputees who have soreness when they become more active; to amputees who have excessive scar tissue; to amputees who want to wear a thin filler-type sock. Amputees who found no particular advantage to the prosthetic sheaths generally have little in the way of problems on comfort and soreness. Above-knee amputees seem to find fewer advantages using the sheaths than below-knee amputees.

William B. Smith, C.O.
Knit-Rite, Inc.

Orthotics and Prosthetics, Vol. 28, No. 1, pp. 47-49, March 1974.

NEW PUBLICATIONS

Bulletin of Prosthetics Research, BPR 10-19, Spring 1973, U.S. Veterans Administration, 254 pp., 149 illus., available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; $2.05* (payable in advance).

FEATURED IN THIS ISSUE:

Editorial—We've Come a Long Way—W.M. Bernstock

Ischial and Patellar-Tendon Weight-Bearing Braces: Function, Design, Adjustment, and Training—J.F. Lehmann and C.G. Warren

The Modern Ankle-Foot Orthoses (AFO's)—G. Rubin and M. Dixon

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Summary of Activities of the Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education for the Period July 1 to December 31, 1972

VA Prosthetics Center Research Report—A. Staros and E. Peizer

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COMPREHENSIVE MANAGEMENT OF MUSCULOSKELETAL DISORDERS IN HEMOPHILIA, Committee on Prosthetics Research and Development, National Academy of Sciences, 1973; Edited by Newton C. McCollough, III, 214 pp., $6.95.

This publication is a report of a symposium held in October 1972 sponsored by the Committee on Prosthetics Research and Development to provide an environment for interchange of information among clinical and research personnel involved in care of hemophilic patients, and then to develop recommendations for future action in both research and clinical application.

The first two-thirds of the report consists of 22 papers prepared especially for the symposium, while the remainder of the report is devoted to recommendations for future action. This seems to be the first time that a symposium has produced a comprehensive document on the subject of management of orthopaedic disorders of the hemophilic patient. It should be read by all who are responsible in any way for the care of patients suffering from hemophilia—orthotists, therapists, physicians, and administrators.

Editor

CHILD AMPUTEES: DISABILITY OUTCOMES AND ANTECEDENTS, Final Report—December 1972. G.E. Sharples, Ph.D. and R.L. Crawford, Ph.D.[1], University of Michigan.[2] 121 pp., 248 tables.

This report presents the results of a long-term follow-up study of 185 prosthetic patients who were or had been patients at the children's orthopedic facility at the Area Child Amputee Center, Grand Rapids, Michigan.

This is the second part of a research study done in two steps. The first study[3] involved a review of 159 unilateral upper-limb amputees, whereas the group reviewed in this report (part 2) includes 29 bilateral upper-limb patients and 156 unilateral lower-limb patients. Statements in the report often seem to imply comparisons between these two groups which can be misleading due to the obvious extreme differences of the disabilities. The reason why the authors excluded bilateral lower-limb patients is not given.

The authors state in the preface that they "have sought in this report to provide something, in fact a great deal, for everyone." They have accomplished this goal; there is so much information provided that a few shorter reports on specific topics might have been more readable.

Information was acquired by means of questionnaires and home interviews and then categorized and presented in 248 tables, which are all included in addition to the 119-page text. All of the questionnaires are also included.

Drs. Sharples and Crawford have presented their material in a well-organized, informative manner. Topics include family and environment characteristics, prosthetic experiences, social developmental experiences, and financial considerations, and recommendations are given in each area.

Some of the statements that I found interesting were:

- ". . . 40% of upper bilateral congenital amputees (in this study) were not fitted until the fifth grade level or later, age 10 through 17."
- Concerning the lower-limb congenital patients, ". . . more than ⅔ had had five limbs or more." Sixty percent of each group needed some prosthetic adjustment at the time of the interview, usually fitting.
- Problems concerning the effect of temperature change on comfort and concerning length of prostheses were most common among all of these patients.

I would recommend this report to anyone involved in providing services to these patients through clinics (and other social services) and particularly to vocational and rehabilitation counselors. Physicians, prosthetists, and therapists would also be provided with a deeper insight into management of the child prosthetic patient by reading this objective report.

Michael Quigley

[1] Members of the Disability Research Group, School of Public Health II, Ann Arbor, Michigan

[2] Project supported by the Maternal and Child Health Service, Health Services and Mental Health Administration, Department of Health, Education and Welfare, through grants PC-1003 and MC-R-260044-05

[3] Child Amputees: Disability Outcomes and Antecedents, Final Report—July 1969 (PC-1003) (PC-1003 C1)

LOWER LIMB MODULAR PROSTHESES: A REPORT ON AN INTERNATIONAL CONFERENCE ON SPECIFICATION, Department of Health and Social Security, London; Her Majesty's Stationery Office, London, 1973, 170 pp., £2.45 net.

This document is a report of an international meeting convened in England late in 1972 by the Department of Health and Social Security, London, for the purpose of refining the prime clinical and functional requirements of lower-limb "modular" prostheses with the hope that some standardization among the Western nations might be effected. This meeting was a follow-on of one on the same subject that was held by the Committee on Prosthetics Research and Development in San Francisco in March of 1971.

There were 41 full-time participants from nine countries. Medicine, prosthetics, and engineering were well represented. Leading administrators in the English Department of Health and Social Security also participated. Representing the United States were Alvin Muilenburg, Robert Klebba, Cecil Benton, Anthony Staros, Joseph Traub, and A. Bennett Wilson, Jr.

It was the consensus that modular prostheses have the potential to improve the time factor in service and also to improve cosmesis, but none available to date is truly satisfactory. Further work was encouraged, a plan for the development of specifications on a cooperative international basis was developed, and a number of other recommendations concerning service to lower-limb amputees were made.

The report is quite detailed, is well written, is printed in a very nice soft-back edition, and should be read by all who are engaged in research and development in the area of lower-limb prostheses. It also contains information that is worthy of attention by administrators concerned with providing amputees with services.

A. Bennett Wilson, Jr.

NEURAL ORGANIZATION AND ITS RELEVANCE TO PROSTHETICS. W.S. Fields and Lewis A. Leavitt, eds. International Medical Books Corporation, New York, 1973.

This book is a collection of selected papers and discussions given at a symposium sponsored by the University of Texas Health Science Center and the Houston Neurological Society which was supported by the Social and Rehabilitation Service of the Department of Health, Education, and Welfare and the Committee on Prosthetics Research and Development of the National Academy of Sciences in the U.S.A.

Its subtitle might mislead some into thinking it is another publication on myoelectric or other controls of powered limb prostheses, with which in fact it has no connection. The purpose of this meeting in Houston was to study the use of electrical stimuli to give substitute, or prosthetic, function through physiological pathways. It was multidisciplinary, the participants being physicians, physiologists, and bioengineers making contributions to the fundamental studies and their application in many clinical areas.

The papers presented at the meeting covered a wide field but make no claim to be complete. The majority of participants were from those centers in North America which have been active in research in the use of electrical stimulation. There were also members from the University of Ljubljana, Yugoslavia, and from Köhn-Merheim, West Germany.

It would be invidious to select any specific paper for comment for the quality of all is high. The subjects discussed were the Fundamentals of Neuro-muscular Stimulation, Stimulation for the Control of Extremities, Sensory Feed-Back Systems, Alleviation of Pain, Auditory and Visual Prosthetics, Control of the Urinary Bladder, and New Applications, such as its use in epilepsy.

The papers on each aspect are of particular importance and cannot be ignored by those with interests in that specific subject. This book, by gathering together in one volume varied applications of electrical stimulation for many disabilities, gives an opportunity for cross fertilization for the mutual benefit of all since the nature of the stimulus and many of the problems arising from its use are common to all, whatever function is being sought.

Neural Organization is an important addition to the growing literature on the subject.

E.E. Harris, F.R.C.S.

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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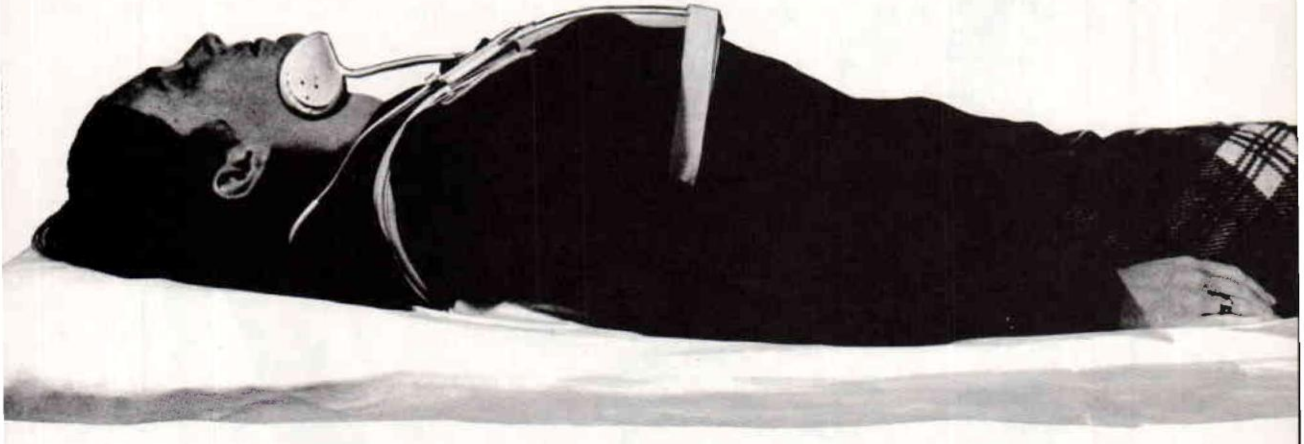

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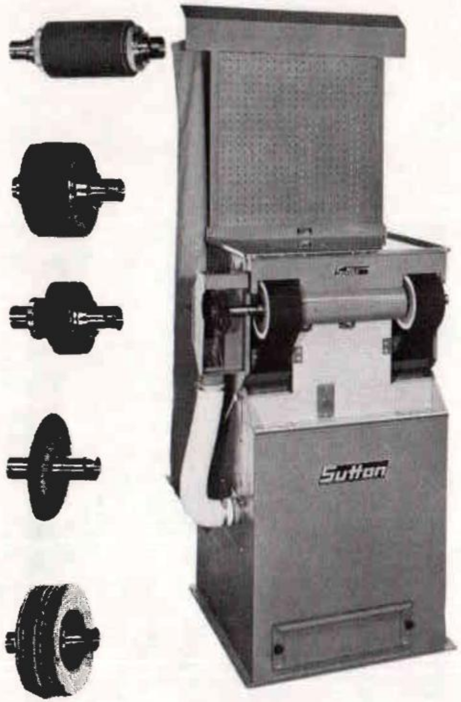

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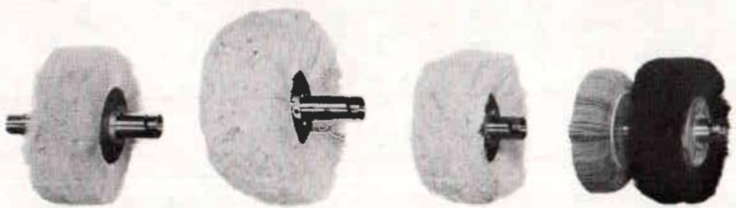

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