

Advances In Artificial Limbs

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For this reprinting, the author has prepared a postscript, which appears at the end of the article.

Because of accidents, warfare, disease, and congenital abnormalities, the human population since the earliest recorded history has included a substantial proportion of amputees and cripples representing every conceivable level of disability—many unable to help themselves. Perhaps because these people represented an economic drain upon the balance of the population, the history of the treatment afforded them by society and by otherwise responsible government has, until very modern times, been largely a long and more or less disgraceful example of man's inhumanity to man.

But we live now in an enlightened age. The social reforms of the 19th and 20th centuries brought with them an expanding public consciousness of many responsibilities not theretofore recognized. Among these has been a growing public acceptance of responsibility for providing appropriate assistance for the less fortunate in the community of men. In this favorable intellectual climate, there has been an increasing tendency to apply public funds in support of modern scientific research and development aimed at the solution of some of the problems of disease and disability. This changing picture, which is now to be seen in almost every field of public welfare and in institutions both public and private, comes, in the area of amputations and artificial limbs, at the end of a long series of sporadic and largely unsystematic empirical attempts at the development of suitable limb substitutes.

Because periodic warfare tended to produce periodic contingents of new amputees, and doubtless also because of the emotional recoil that besets people after every major conflict, war has always generated an increased interest in the problems of amputees and has been followed by a flurry of impetuously conceived inventions relating to artificial limbs. History records, for example, a distinct rise in interest and achievement on the continent of Europe after the Napoleonic Wars, again in the United States after the American Civil War, and still again after World War I, notably in Germany, Belgium, and England. But in every instance these efforts have subsided to the previous peacetime level soon after hostilities had ceased and the wounded had been absorbed into civilian life, their residual problems largely forgotten.

For almost a quarter of a century after World War I, systematic efforts toward genuine improvement in artificial limbs, particularly in the upper extremity, lay almost dormant. It was World War II that was responsible for still another revival of interest in the problem of amputee rehabilitation.

even though by that time, in our highly mechanized society, disease and accidents—in the home, on the farm, in the factory, on the highway—were accounting for many, many more amputees than were produced in the military campaigns.

In any event, servicemen who had suffered amputations during World War II displayed keen disappointment with the artificial limbs provided them upon their return to the United States. Since they were now all familiar with extremely intricate mechanical, electrical, and hydraulic mechanisms, it was incomprehensible to them that a country so adept at turning out efficient weapons of destruction had seemed to have failed so miserably in providing substitutes for limbs lost in battle. Fortunately, in those days there were both the will and the wherewithal to establish a systematic investigation of the whole field of limb prosthetics.

When the problem came to the attention of The Surgeon General of the Army, he turned to the National Academy of Sciences with a request for assistance. An investigation by the Academy early in 1945 revealed that no sustained scientific approach had ever been made to the development of artificial limbs; that virtually all devices in use had been developed without the benefit of adequate design criteria, usually by amputees to fill partially their particular needs and who then made these devices available to others; and that the industry supplying limbs, serving a comparatively small and relatively impecunious segment of the population, was not prosperous enough to support a systematic research and development program of any consequence. In view of these findings, the Academy, using funds supplied first by the Office of Scientific Research and Development, then by the U. S. Army and the Veterans Administration, organized and operated by subcontracts with universities and industrial firms a research and development program in the field of prosthetics which has since come to be known as the Artificial Limb Program. This organizational structure prevailed until July 1, 1947, at which time the program was reorganized so that the Academy became the coordinating agency for projects sponsored by the Veterans Administration, the U. S. Army, and the U. S. Navy.

In mid-1948, the 80th U.S. Congress, recognizing the need for continuity in a program of this kind, initiated and passed Public Law 729,¹ which authorized the expenditure of \$1,000,000 annually for prosthetics research. The Veterans Administration was designated as the appropriate agency for the administration of the funds thus made available, and the Administrator of Veterans' Affairs was directed to make the results of such a program available to all, veteran and civilian alike.

Until 1955, the majority of the work was supported by the Veterans Administration through contracts with universities, industrial laboratories, and the National Academy of Sciences under the provisions of Public Law 729 (80th Congress), while the Army and Navy cooperated by maintaining laboratories within their own organizations. Although Public Law 729 authorizes the Administrator of Veterans' Affairs to make results of research available to civilians, use of funds is for the most part restricted to research and development for adult cases. The Office of Vocational Rehabilitation, in addition to supporting the education program originally started with Veterans Administration funds, supports a number of research projects in prosthetics and orthotics under the provision of Public Law 565 (83rd Congress); the Children's Bureau has made available, through grants to

¹ Public Law 729, 80th Congress, was superseded June 17, 1957, by Public Law 85-56, 85th Congress, with essentially similar provisions.

several states, funds for research in the prosthetic problems of children, and the National Institutes of Health has awarded grants to cover part of the necessary medical research.

At the beginning of the Artificial Limb Program, it was the general feeling that the solution to the problem lay in developing new devices, and rapid advances were made by applying new materials and methods. It soon became apparent, however, that much more needed to be known about the functions provided by normal limbs before realistic design criteria could be developed. As progress was made, it later was shown that medical and surgical research, some of it of an extremely basic nature, was just as necessary as device development. Thus the program became one of interdisciplinary research.

As new concepts, introduced through the efforts of the Artificial Limb Program, were proven to be valuable in the rehabilitation of amputees, the need for essentially the same type of program in orthopedic bracing, or orthotics, became apparent. Because much of the fundamental data found necessary for progress in prosthetics was applicable to a program in orthotics, it was only natural that orthotics be added to the program of artificial-limb research. This was done beginning, in a limited way, about 1957.

At the present time in the United States there are 33 separate groups engaged in some phase of research and development related to artificial limbs or orthopedic braces, or both. Some are responsible for studies of a very fundamental nature, such as the biomechanics of human locomotion, in order to develop design criteria. Others are engaged in the design and development of devices. Still others are responsible for the development of methods of fitting limbs and braces. An evaluation laboratory has been established for testing each new item or idea as it progresses from one phase to the next.

In an effort to maintain a well-balanced program, the various activities of the research and development units engaged in both prosthetics and orthotics are correlated and coordinated by the Committee on Prosthetics Research and Development (CPRD), Division of Engineering and Industrial Research, under the chairmanship of Howard D. Eberhart, Professor of Civil Engineering, University of California, and supported by funds from the Veterans Administration, the Office of Vocational Rehabilitation, and the National Institutes of Health. CPRD also publishes the journal *Artificial Limbs* in order to ensure a broad dissemination of the results of research.

To bring results of the research program to the medical profession and its ancillary services, the Committee on Prosthetics Education and Information (CPEI) was organized in 1957. Originally established within the framework of the Division of Engineering and Industrial Research, CPEI now operates as a unit in the Division of Medical Sciences. C. Leslie Mitchell, Surgeon-in-Charge, Division of Orthopaedic Surgery, Henry Ford Hospital, and long associated with the Artificial Limb Research Program, is the present chairman. A close liaison between the two committees is maintained.

As a result of work done during the past 16 years, virtually every aspect of limb prosthetics has undergone dramatic changes. Because of new devices and methods of fitting, it has been possible to eliminate the old concept of "ideal" sites for amputation, thus preserving in many patients more function than was the case in the past. The "synergistic" action produced by physicians, engineers, prosthetists, and psychologists has been

carried forward into the general practice of prosthetics by the formation of clinic teams for management of amputees. Improved devices permit more function, and newer fitting and alignment methods based on biomechanical data have resulted in improvement in both comfort and function. At the same time, in many instances use of the new devices and techniques has permitted economies, not only by reducing fabrication time but also by reducing the time required for the rehabilitation process. Short-term courses are offered at three universities to physicians, therapists, prosthetists, and rehabilitation counselors so that results of research can be disseminated to the field rapidly.

The time required for results of fundamental research to reach widespread use in the form of practical devices is much longer than is realized generally. Often more than 20 years elapse between fundamental discovery and practical application. By carefully coordinating the work required in the various phases between fundamental research and application, and with the cooperation of several universities in offering short-term courses as new concepts are developed, the Artificial Limb Program has been able to reduce this time to between 5 and 7 years. Thus there has been evolved a method whereby the results of research rehabilitation can be translated into general use quickly and effectively.

Unlike the interests developed as a result of previous wars, that stemming from World War II has been kept very much alive largely because through the cooperation of several Federal agencies, universities, the medical profession, the prosthetics profession, and others, the organized, interdisciplinary, scientific approach has given useful results which have reached the amputee in a relatively short time. Although progress to date has been most gratifying, some areas of the problem have hardly been entered and whole new avenues need to be opened.

POSTSCRIPT TO "ADVANCES IN ARTIFICIAL LIMBS"

Without the cooperation and assistance of the American Orthotics and Prosthetics Association the progress made by the Artificial Limb Program would have been impossible. From the beginning members of the Association have been included in the membership of the various committees, panels, and conferences set up by the National Academy of Sciences to guide and coordinate the work of the research groups. The role played by the Association (then OALMA) in conducting the Suction Socket Schools during the period 1948-51 was a major factor in the success of that venture, which not only established a pattern for the present day Prosthetics Education Courses at the University of California at Los Angeles, New York University, and Northwestern University, but also demonstrated so well the advantages that are to be had by close cooperation between physician and prosthetist. Members of the Association have continued to assist in the Prosthetics Education Courses by serving as instructors in the established courses and participating in pilot courses.

Many facilities have devoted a good deal of time to assisting in evaluation of experimental devices in the various field studies conducted from time to time on a nationwide basis by New York University and the Veterans Administration, and in evaluations on a local basis by some of the individual research groups.

In 1958 the Association established the Committee on Advances in Prosthetics under the chairmanship of Carlton Fillauer to follow closely the research program in order to assist in the introduction for general use of the results of research and development. The Association has recently completed, with financial assistance from the Office of Vocational Rehabilitation, a Survey to determine the State of Services Available to Amputees and Orthopedically Disabled Persons which reflects the general pattern of prosthetics as practiced across the United States. A similar study will be made in reference to orthotics. Both studies should prove very helpful to the Research Program and AOPA by pointing out those areas in which further study and action should be emphasized.

BOOK REVIEWS

GEHSCHULE FUER BEINAMPUTIERTE: EIN HANDBUCH FUER BEINAMPUTIERTE, FACHAERZTE FUER ORTHOPAEDIE, ORTHOPAEDIE-MECHANIKER, KRANKENGYMNASTINNEN UND UEBUNGSLEITER IM VERSEHRTENSPORT (*Gait School for Leg Amputees: A Handbook for Leg Amputees, Orthopedic Specialists, Orthopedic Mechanics, Physical Therapists, and Directors of Sport for the Disabled*). By Herbert Kersten.

Stuttgart, Georg Thieme Verlag, 1961. Price: DM 16.50.

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The long-standing controversy of who should be in charge of gait training of amputees—the artificial-limb fitter or the physical therapist—may become resolved, at least in part, through use of this systematic presentation of the subject. As well as its coverage of gait training, as such, for amputees with all levels of amputation, this monograph deals with pre-prosthetic care and preparation of the patient, activities of daily life, sports, a variety of stump problems, and stump hygiene.

With the increasing number of geriatric amputees, the problems of prosthetic rehabilitation are becoming more involved than limb fitters are usually equipped to handle. They need the help and cooperation of the physical therapist; for adequate rehabilitation of the amputee, team efforts are required. Professor Witt, in the introduction to this book, states that there will be differences of opinion regarding certain questions presented in it. These differences will persist until detailed knowledge of the biomechanics of normal human gait becomes available. In the meantime, this attempt to analyze the deficiencies of common rehabilitative procedures helps fill what has been until now a gap in concepts of amputee care and training.

When the latest advances in surgical techniques and fitting procedures become widely applied, there will no doubt be modifications in gait training. However, such modifications will be easier for the rehabilitation worker who is familiar with the principles outlined in this monograph.