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Artificial Limbs

A Review of Current Developments

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT

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Artificial Limbs

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Surgeons and Sockets

ANTHONY STAROS, M.S.M.E.[1]

An apt, alliterative appellation for this introduction to the Spring 1967 issue of ARTIFICIAL LIMBS might have been *Wilson's Way with Words*, for the writings of A. Bennett Wilson, Jr., Executive Director of the Committee on Prosthetics Research and Development, comprise much of the issue. Mr. Wilson's literary talents are documented—and acknowledged—but the primary concern of this editorial is with surgeons and prostheses.

Mr. Wilson has set himself a continuing task. The difference between *Limb Prosthetics Today* and *Limb Prosthetics—1967* is four productive years of the Research Program. Many new items are covered. But the Program can be expected to continue to produce significant developments that should be made known to the world, so that four years hence that which is published as representing the state of the art in 1967 will require updating.

Comprehensive summaries of prosthetics technology are an essential part of an efficient information-dissemination system. Typical articles reporting developments in prosthetics research assist the day-to-day practitioner with technical details of design, fabrication, and fitting. They serve an important purpose. But also needed is comprehensive, accurate, nontechnical information in a form that is readily understandable to amputees and their families and the large number of clinicians who are too busy to digest all the detail underlying prosthesis design. The summary coverage is appropriate; as one would attempt to highlight important and even complex matters for a busy Board of Directors, so must there be occasional briefings for those concerned with prosthetics. Not only busy clinicians but equally busy and technically deprived administrators currently or newly responsible for prosthetics programs in the United States and abroad can also obtain an excellent overview from Mr. Wilson's offering. For those surgeons who have never attempted to gain such an overview—and, unfortunately, there are too many—this article represents a real opportunity.

Significant developments of recent years are reported in the other two articles of this issue. The total-contact concept represents a major contribution to improved socket design. Founded upon the very sound principles of the quadrilateral and PTB sockets, total-contact sockets became accepted

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early in this decade. Beneficial results, particularly in patient satisfaction, have certainly accrued.

Dr. Georg Bakalim of Finland has conducted an interesting survey. Especially stimulating were the replies to an inquiry about skiing. "Only" 23 of the group surveyed (more than 15 per cent) tried to ski with their new prostheses. The Finns are a hardy people.

Also noted are the problems of perspiration (in Finland!). But the advantages of the total-contact principles are brought out quite clearly from the survey. It is refreshing to see surveys of this type conducted on the products of the North American Research Program; even if the results had been less favorable, such follow-ups are welcome. The Finnish survey exemplifies a very desirable evaluation in what may now properly be called the International Program.

Dr. Bakalim points out that the problems that do occur may be attributable in large part to factors other than use of the total-contact principles. How true! The importance of careful attention by the prosthetist and the significance of stump hygiene would be replicated in surveys of fittings elsewhere in the world. But perspiration in Finland!

Total contact means total support of tissues. Support and control forces are present all over the stump; some are low, and some are necessarily high. But all tissue is subjected to pressure. Various external portions of the body can take higher pressures than others, and there is a time dependency. There may also be ambient temperature effects on the response of skin and tissue to pressure. Moreover, not only the forces applied perpendicular to the surface but shearing force must also be considered in the stump-socket interface. It is gratifying to report that studies of the forces acting on the stump are under way at several projects. Eventually, more will be known about the interface between stump and socket in current types of socket fittings. Also needed is a better understanding of the effects of force application on skin and tissue, with due consideration to other variables such as time.

It would be gratifying to report innovations in surgery, also. Total contact, with uniformly low pressures distally, is the present prosthetic answer for stumps resulting from "conventional" amputation surgery. Myoplasty and "tension myodesis" may permit higher pressures to be applied distally, reducing further the proximal share of the load and accruing less constriction in fit. Bone plugs and osteoplastic procedures may permit major changes in pressure distributions on stumps. Total contact will, nevertheless, still be needed, but the distribution of the forces required at the interface will be a function of surgical results and of the reaction of tissue to pressure.

Recent concepts of lower-extremity amputee management, as described in Mr. Wilson's second article, present some unanswered questions. A multipart technique produces a certain result, in this case apparently positive. The several *major* parts of this procedure are the surgery, the rigid dressing, and early weight-bearing and ambulation.

There are various hypotheses as to which part is the most essential, and even about which element of a particular part is significant. There appears to be general agreement, based upon nothing more than "clinical" or "professional" judgments, that the rigid dressing is the most important part. The greatest significance, many state, is in the reduction and control of edema. Other advantages cited are reduction in pain, acceleration and improvement in healing, reduced time in the hospital, and—most significantly—the possibility that many more knee joints can be preserved in amputation surgery on cases with peripheral vascular disease.

Clinical data indicate that the immediate postsurgical fitting procedure provides some of these advantages. Precisely which elements or subelements are truly significant is not entirely clear.

Is the control of edema related to the reduction of pain?

Is early weight-bearing and ambulation related to success in cases with marginal circulation?

Is the control of edema related to improvement in circulation?

From these several causes and their effect on circulation, can more knees be saved?

Are there disadvantages to immobilization of the knee, as most techniques prescribe for the below-knee amputee?

Does mobility of the knee improve circulation and in turn reduce edema?

Does the "tension myodesis" method affect the effectiveness of circulation?

Does an immediate prosthetic experience foster an amputee's sense of well-being and feeling of early recovery?

Are the habits of walking disturbed minimally by immediate fittings?

What effects do variations in the design of rigid dressings have on the control of edema?

How significant to success is the special attention now being given by the surgeon in this procedure?

These and other questions on the significance of the new concepts in the management of lower-extremity amputees still remain. It would be most gratifying if talented researchers could be encouraged to explore the physiological and psychosocial aspects of this revolutionary approach to surgical-prosthetics treatment. Surely, some new ideas would accrue.

More research is needed on socket design for the lower-extremity amputee. Total-contact concepts are beneficial but no cause for complacency. Surgical experimentation and parallel studies of pressures and their effects on tissues should be encouraged to develop even better fitting concepts, short of direct skeletal attachment. There is no more logical place to begin than in conjunction with research on the immediate postsurgical prosthetics fitting procedure.

If nothing else, the introduction of immediate postsurgical fitting procedures has stimulated the interest and concern of surgeons in prosthetics management. Now their possible interest in related research problems is commended to their attention.

Limb Prosthetics—1967

A. BENNETT WILSON, Jr., B.S.M.E.[1]

Because of the large demand for reprints of "Limb Prosthetics Today" *which originally appeared in the Autumn 1963 issue of ARTIFICIAL LIMBS, the article has been revised to reflect the numerous advances that have been introduced into limb prosthetics since 1963. To distinguish this revision from the original we have chosen the title* "Limb Prosthetics—1967."

Loss of limb has been a problem as long as man has been in existence. Even some prehistoric men must have survived crushing injuries resulting in amputation, and certainly some children were born with congenitally deformed limbs with effects equivalent to those of amputation. In 1958 the Smithsonian Institution reported the discovery of a skull dating back about 45,000 years of a person who, it was deduced, must have been an arm amputee, because of the way his teeth had been used to compensate for lack of limb. Leg amputees must have compensated partly for their loss by the use of crude crutches and, in some instances, by the use of peg legs fashioned from forked sticks or tree branches (Figs. 1 and 2).

The earliest known record of a prosthesis being used by man was made by the famous Greek historian, Herodotus. His classic "*History*," written about 484 B.C., contains the story of the Persian soldier, Hegistratus, who, when imprisoned in stocks by the enemy, escaped by cutting off part of his foot, and replaced it later with a wooden version.

A number of ancient prostheses have been displayed in museums in various parts of the world. The oldest known is an artificial leg unearthed from a tomb in Capua in 1858, thought to have been made about 300 B.C., the period of the Samnite Wars. Constructed of copper and wood, the Capua leg was destroyed when the Museum of the Royal College of Surgeons was bombed during World War II. The Alt-Ruppin hand (Fig. 3), recovered along the Rhine River in 1863, and other artificial limbs of the 15th century are on display at the Stibbert Museum in Florence. Most of these ancient devices were the work of armorers. Made of iron, these early prostheses were used by knights to conceal loss of limbs as a result of battle, and a number of the warriors are reported to have returned successfully to their former occupation. Effective as they were for their intended use, these specialized devices could not have been of much use to any group

Fig. 1. Mosaic from the Cathedral of Lescar, France, depicts an amputee supported at the knee by a wooden pylon. Some authorities place this in the Gallo-Roman era. From Putti, V., *Historic Artificial Limbs*, 1930.

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