PROSTHETICS

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When the Veterans Administration launched its first research programs to help elevate prosthetics from a craft to an art-science, appliances were generally hand carved of wood or made with adjustable leather sockets attached. Joints at the ankle, knee, and hip consisted mostly of single pivot metal joints poorly designed and poorly aligned. The suspension systems were crude strap and belt affairs which offered poor control of the prosthesis. The functional controls available at the various joint levels were confined essentially to those necessary to limit the range of motion. No standard methods for fitting or alignment of prostheses were in existence. Each prosthetist used his own methods which were carefully guarded secrets. Very little literature was available to guide or train new personnel. The field was totally ignorant of the biomechanical aspects of prosthetics or the physiological impact of their services upon the patient.

Few means were available for purchase of appliances through third party sources, and no funds were available for research or education in the field.

During the past 30 years, much has occurred in the way of progress due to the early government subsidies which were made available for the development of rationales for design and fitting of sockets and the alignment of prostheses. These developments, followed closely by the design and development of the suction socket for above-knee amputees and the recognition of the biomechanics involved in fitting and alignment, launched an avalanche of developments which influenced the redesign of prostheses at all levels. These changes were enhanced through the use of new materials (primarily plastics) and sophisticated componentry. Following the introduction of immediate postsurgical and early-fitting concepts, total contact and self-suspended sockets became the standard. Replacements for anatomical knee joint functions lost through amputation surgery were improved by many sophisticated knee mechanisms which provided both stance and swing controls. Functional standards for components, hardware, and softwear were
established. Prefabrication of parts and assemblies followed. Fitting and alignment tools were developed to satisfy the new demands of the interim prosthesis concepts and temporary fittings used as diagnostic tools and training devices. The clinic team concept of patient care with all disciplines involved had become a routine procedure. All persons involved were now fully trained and had ready access to up-to-date information through the various technical publications and university training centers.

Highly skilled professionals in medicine, engineering, and education were now interested in prosthetics rehabilitation. They found the field challenging and their contributions gratifying. Although these changes have favorably influenced prosthetic functions essential for acceptable mobility, they leave a great deal to be desired from the patient's point of view in terms of security, versatility, weight, cosmesis, and reliability. Various innovations have been applied to the prosthetic foot and hip to simplify their functional design. However, the net result to the stance security and function of the overall prosthesis remains insufficient. There is no doubt that the level of utility and patient acceptance demonstrated with these appliances is considerably higher in general than that with patients wearing upper-limb prostheses. However, this could be motivated by a strong desire to be mobile and the relatively low level of functional demands necessary to ambulate. At any rate, even in the presence of this seemingly high level of achievement, the following further improvements are desperately needed: 1. A voluntary knee control system is required which will accommodate the wide range of stance and swing functions. The systems should be lighter than the knee units now available and should be smaller to accommodate better cosmesis. 2. A durable prosthetic skin is required whose physical characteristics will not conflict with the functions of the underlying components. The single largest drawback of endo-skeletal prosthetic systems has been the lack of an acceptable cosmetic finish. 3. By design, prosthetic feet are not generally intended for use on one specific prosthesis nor are they sufficiently adjustable to meet the needs encountered in all situations; therefore, it is desirable to develop adjustable prosthetic feet with a greater functional capability and better cosmesis. 4. We must continue to seek better socket interface materials and techniques which will be more compatible with body dynamics.

Although upper- and lower-limb prosthetics traditionally have been considered within the province of all prosthetists, there has existed a wide separation of interests among us which has caused an inequity in the pursuit of advancement for the development of these two disciplines. There is no doubt that, of the two, lower-limb prosthetics has continually enjoyed the greater degree of patient acceptance and utility. In spite of the big push during the 1950's to update upper-limb
prosthetics with the most modern fabrication methods, utilizing new plastic materials and incorporating more sophisticated controls, the level of acceptance and relative utility of upper-limb prostheses, even in the face of these advances, has never approached the record obtained in lower-limb prosthetics.

Prior to this time, upper-limb prostheses generally used body power to position the terminal device for operation and to open it against some form of elastic resistance. Because of the power transmission systems and the harness designs used, the functional level-to-force ratios were poor. The terminal devices were typically spring-loaded hooks of many configurations, each adapted to a special function. These appliances were considered tools rather than hand replacements. To obtain a greater level of utility, to this day we often advocate the use of "hooks" in preference to the prosthetic hand. In fact, there is now a drive on to develop an externally powered "hook."

The development of the APRL hand undoubtedly signaled our first serious efforts to promote hand function in prosthetics. It also constituted the first voluntary closing device of any consequence. This functional mode is still employed in the electric and myoelectric hands of today. Although these terminals devices provide better cosmesis, their level of function, their reliability, and their weight are still subjects of great concern to those patients who use them. Perhaps during the transition in our application of external power, from the early use of gas-powered systems to the modern electric-powered systems, we have unwittingly perpetuated the traditional problems which have assailed us from the beginning.

In reviewing the current state of the art it becomes evident that: 1. Emphasis must be placed upon more sophisticated functions controlling both the positioning of the terminal device and its operation. Reliable proportional control systems coupled with feedback and coordinated simultaneous motions are urgently needed. 2. More efficient components in the electrical system are required to further reduce weight and noise. 3. Better quality, product reliability, and functional reliability must be achieved. 4. Combinations of power sources and control systems must be exploited by establishing standards which make interchangeability of components possible. 5. Less restricting and more versatile suspension and control systems should be studied which might include changeable active and inactive modes. 6. Efforts should be given to develop a new outlook on the indoctrination, evaluation, and training of patients in light of the new socio-psychological climate in which we live.

Our patients are no longer sympathetic to the assumed indifference of the developers or crushed by the implied lack of technical expertise. They are no longer content to accept our inability to provide adequate
restoration of missing function. We are challenged today as never before. Scatter-gun techniques of development cannot begin to meet this vital duty. Only through well organized coordinated effort specifically directed at the recognized problems can we begin to satisfy this commitment.