HIGHLIGHTS OF OTHER VA RESEARCH PROGRAMS

PROSTHETICS

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Specimens of skin and deeper tissue containing Vitallium mesh (which had protruded for months from the backs of the test dogs in this study of semi-buried implants) were mounted in epoxy and sliced to be stained and examined by a pathologist. Unfortunately, initial slices were not acceptable. Experts from Ford Motor Company are investigating the possibilities that heat generated during setting of the epoxy may have raised the temperature too high, damaging tissue cells adjacent to the Vitallium, or that the epoxy (chosen to support the stiff wire mesh) was too hard.

Excellent pictures, however, have been taken for electron microprobe x-ray analysis to identify each element in tissue of a larger block specimen. With this technique, the Ford laboratory found that metal ions from the Vitallium, even after being in the tissue for four years, did not appear to have diffused into the surrounding tissue.

Gilmatic, Northridge, California
Gilbert M. Motis

A motor-driven electric elbow was designed and a bench model constructed. All components, except the battery, are in a case the same size as the Hosmer mechanical elbow. Three pre-production units are now ready for amputee tests. A battery and charger are installed in the forearm near the elbow.

A variety of pad switches is being used with the above item. They are installed in the stump socket over the biceps muscle and provide a sequence of multiple contacts which is used for reversing and speed control of the electric elbow.

Mauch Laboratories, Inc., Dayton, Ohio
Hans A. Mauch

The clinical tests of the Swing and Stance Control System for above-knee amputees were completed. The results are reported elsewhere in this issue of the Bulletin. The recirculation program for the correction of oil contamination was also completed.

In view of the first production run of the Swing and Stance Control System, an effort was initiated in March 1968 with the goal to eliminate whatever minor shortcomings have become known in the past. As a result, a number of improvements were incorporated in the system. They include: provisions for keeping air contained in the reserve oil space from entering the system proper by placing a wick of open-cell polyurethane foam in the accumulator piston; reduction of the mechanical friction of the main piston seal by substituting for the Buna N O-ring a polyurethane O-ring with less interference which is possible due to the longer wear life of polyurethane; reduction of the hydraulic friction for the swing phase at minimum adjustment settings by widening a number of fluid channels in the swing-control bushing; decreasing the turning resistance of the swing-control adjustment elements by closer concentricity tolerances of the parts involved; and elimination of occasional minor noises.

A system was modified accordingly and installed in the new-type wooden setup described before. Amputee tests of the improved system and modified setup started in July 1968. Two other setups of this type and two systems which contained a part of the improvements were shipped to the Veterans Administration in New York for testing, in April 1968.

Work on the production prototype Hydraulic Ankle has been continued. Additional refinements were incorporated in the casting patterns and core box. Two sample castings each of the piston rod and the housing were received from the foundry in May. They were satisfactory. The remainder of the housing and piston rod castings was received in June. They were found to be in accordance with our drawings except for minor shortcomings which we corrected. The manufacturing of one set of parts for the assembly of the first of the eight shakedown test systems is underway. This manufacturing run and the subsequent assembly of the system will be used for checking out our drawings and assembly methods before we proceed with the remaining seven shakedown test systems.

Committee on Prosthetics Research and Development
National Academy of Sciences-National Research Council
Washington, D.C.
Herbert Elftman, Ph.D.

An annual report covering the period that would generally be reported on in this section appears elsewhere in this issue.

Committee on Prosthetic-Orthotic Education
National Academy of Sciences-National Research Council
Washington, D.C.
Herbert E. Pedersen, M.D.

An annual report covering the period that would generally be reported on in this section appears elsewhere in this issue.

New York University, New York
Renato Contini

Early in this report period, several designs for an inexpensive, expendable pressure gage were tested. The pressure gage was intended for use by clinicians and prosthetists. In concept the device was similiar to the ink-filled micro balloons developed by Southwest Research or the inked shoe insert devised by McLaurin several years ago. In principle, however, it differed since peak pressures would be determined by the permanent deformation of aluminum foil. The deformation, directly related to pressure, would be read with an inexpensive microscope or jeweler's loupe.

Development was terminated when supplementary tests showed that the use of this type of gage would be severely limited. The standard pressure transducers and recording equipment were used for these tests. The recordings indicated that in donning his prosthesis, an amputee produced pressures equal to the peak pressures encountered during walking.

The modification to the distal end of one subject's test socket has been tested on two occasions. As reported in BPR 10–9, this modification consists of a hard epoxy insert which partially fills the excess space or relief present in the socket. The insert, a heart-shaped cap, is placed in the medial distal quadrant of the socket; it extends proximally 2½ in. along the medial wall and is ½ in. thick at its center.

Generally, the pressure sites affected are located on the distal portions of the medial and lateral walls and on the brim. The insert produced a 30 percent decrease in mean pressure on the medial wall and an increase of 15 percent on the lateral wall. Three of the five sites located in the brim were affected by the insert but the results thus far are not consistent.

Additional tests of this subject have been scheduled. At least one more subject will be included in this phase of the modification program.

Northwestern University, Chicago, Illinois
Robert G. Thompson, M.D.

Electric Power Assist

The forequarter amputee has now been using the unit for 23 months. No problems have been encountered during this report period. A second forequarter amputee has been referred to us by the Veterans Administration Hospital at Hines, Illinois as a candidate for this unit. The unit will be installed as soon as his limb is finished by the prosthetic facility.

A third unit has been sent to the Veterans Administration Prosthetics Center for evaluation.

Powered Hand Splint

A quadriplegic has been using a power assist unit adapted to a flexor hinge splint for 12 months with no problems. A second unit has been constructed and fitted to another quadriplegic. This unit utilizes an inexpensive motor, probably in the price range of one to two dollars, and a simplified drive mechanism. The control consists of head-operated switches. The unit operated satisfactorily with no problems. The pinch force was low (1.5 to 2 lb.); however, the patient and his therapist found this to be satisfactory. After approximately ten weeks the patient recovered enough shoulder movement to change to a body-powered splint. This power unit will be fitted to another quadriplegic's splint early next quarter.

Two motors have been purchased which should increase the pinch force to 4 lb., but not increase the cost significantly.

Powered Wrist Rotator

The noise has been reduced by using smaller diameter ball bearings with double shields. The bilateral above-elbow was fitted with a unit and an AMBRL 2-level switch on a chest strap for control. Two problems developed: The amputee had difficulty "hunting" for the first position in the switch and the bending moment present when the hook was opened caused the Harmonic Drive unit to skip over several teeth, binding the unit, thus preventing rotation. Both problems require only minor design changes and the units will be fitted to the bilateral above-elbow and below-elbow amputees early next quarter.

Powered Wrist Rotator/Terminal Device

The design has been modified to allow the unit to accept any electric hand with an integral motor or with a remote motor operating through the mounting stud. The shop drawings are nearly completed.

Wheelchair Speed Controller

A speed controller for a head-operated wheelchair was sent to Ontario Crippled Children's Centre in Toronto for testing.

Three-Mode Controller

Design changes were made in the three-mode controller to facilitate operation of the proportional control mode. A Viennatone hand was purchased for use with the three-mode controller.

Pierced Skin Technique for Electrodes

This procedure for attaching electrodes to the skin has been abandoned. The idea was to make an attachment somewhat like that of an earring in the lobe of the ear. The skin above the biceps was used but the two tunnels did not epithelialize during the 3 months of electrode insertion.

Thigh Kicker for Hip-Disarticulation and Hemipelvectomy Prosthesis

The components for the thigh flexor have been completed. The components will be assembled using a pylon-type construction, and fitted to an amputee for evaluation purposes.

Below-Knee Sockets

a. Supracondylar wedges—Three below-knee sockets have been fabricated using the supracondylar wedges for suspension. The casting and fabrication of the sockets was done according to the Fillauer technique. This series was done for familiarization of the technique and for evaluation purposes.

b. Socket made with POLYSAR [a]—Two below-knee sockets made with POLYSAR X–414 were fabricated according to instructions issued by the Veterans Administration Prosthetics Center. In one case the proximal portion of the socket was unstable for medial-lateral stability resulting in discomfort. The socket fit seemed good initially. A second socket fabricated according to the outlined instructions resulted in too tight a fit. This tightness could not be relieved by reheating the socket. Further study of this technique will continue.

Immediate Postsurgical Fittings

a. Three below-knee immediate postsurgical fittings were carried out during this past quarter.

b. Above-Knee Suspension Belt—A modified above-knee suspension belt has been developed. The belt is a four-piece construction which provides for adaptation to either right or left amputations by rearranging the various components, and it also provides for adjustability to any waist size. The cables, housing, and buckle attachments are replaced by parachute cord run through polyethylene tubing. The belt is less bulky than those now being used, and it provides effective suspension.

Early Postsurgical Fitting

One below-knee early postsurgical fitting was carried out during this report period.

Above-Knee Fluid Lined Sockets

The pneumatic socket incorporating the input and expulsion valve has been worn by an amputee for approximately one month. Initial acceptance was very good; however, some problems are becoming evident. The amputee's stump is not making total contact distally, and there is a tendency for displacement proximally due to air pressure. The stump, after a prolonged wearing period, became edematous. Further study to eliminate these problems is being undertaken.

[a] Registered trademark of the Polymer Corporation Limited.

University of California at Los Angeles
Biotechnology Laboratory
John Lyman, Ph. D.

Research activity during the period covered by this Bulletin has been directed toward the development of upper-extremity prostheses and manipulator movement control and coordination systems. VA-sponsored work comprised both experimental and theoretical studies. The ultimate goal of each contribution has been to ease the decision load of the patient or human operator respectively as he handles prosthetic or manipulative devices.

Experimental investigations have been devoted to a comparison of various signal sources as to their suitability for generating appropriate control information. The signal sources having been selected are an EMG mean frequency system, an average EMG power level detector, and an electromechanical strain gage transducer activated by muscle displacement and force.

Also, data acquisition experiments have been conducted to study arm motions of 4 deg. of freedom. The experiments were carried out with the cooperation of Rancho Los Amigos Hospital, Los Angeles, utilizing their special orthosis permitting movements of 6 deg. of freedom. The development of a mathematical model to describe arm motions, as suggested by the test results, is in progress. Specific attention has been attracted to the time relations between arm motions according to different degrees of freedom which appear to be of critical importance for target-approach-type movements.

Theoretical efforts have been made to establish and further improve structural models of prostheses and manipulator control systems. A programed analytical procedure is being developed to determine the frequency response of human-operated control systems through evaluating triangular pulse perturbations. Finally, the utilization of artificial intelligence for prosthesis and manipulator control has become the subject of a doctoral dissertation.

Preparations are being made currently to continue experimental and analytical investigations through utilization of a general purpose digital logic control system. The system is comprised of electronic modules which permit both experimental implementation of control devices, such as movement pattern generators, and connection to pneumatic actuator systems.

University of California at San Francisco and Berkeley
Charles W. Radcliffe, Howard D. Eberhart, and James M. Morris, M.D.

After considerable satisfactory experience with the UC-BL Pneumatic Swing-Control Unit, in the San Francisco Bay area, a clinical application

study will be conducted by the Research and Development Division, PSAS, in six widely scattered VA field stations. It is contemplated that 30 subjects will be fitted with this unit, with a period of 6 months of wear for each subject. Pending completion of this study and establishment of final policies, UC-BL Pneumatic Swing-Control Units will not be furnished to veterans other than to those participating in the study.

Based upon experience with the prototype model, production-type drawings for the UC-BL Polycentric/Pneumatic Knee unit have been prepared. As part of the production engineering, an improved system of socket attachment has been developed which allows socket flexion adjustment in the finished prosthesis. The system of shank fairing attachment allows for use of either flexible or rigid foam cosmetic covers.

An improved mold for the rigid foam preforms used with the single-axis/pneumatic knee was fabricated and delivered to Hosmer who will produce covers for the 50 pneumatic swing-phase control test units previously delivered to the Veterans Administration for the clinical application study noted above.

A series of digital computer programs have been prepared for use in reduction of locomotion data at the Computer Center, University of California, Berkeley. Available accessory equipment includes a digitally controlled automatic drafting machine which is being used to plot results. Additional programs are being prepared which will allow digital computer simulation of locomotion of amputees wearing various types of lower-extremity prosthetic knee mechanisms.

A magnetic tape data acquisition system has been made available by the Department of Mechanical Engineering, University of California, Berkeley; accessory units are being developed which will allow tape recording of locomotion data in analog form. Subsequent conversion to digital form and calculations will be done on a PDP–7 computer, also made available by the Department of Mechanical Engineering.

The program in immediate postoperative fitting of prostheses, established in cooperation with the Veterans Administration Hospital, Fort Miley, San Francisco, has been very successful and is continuing.

VA Hospital, Seattle, Washington
Ernest M. Burgess, M.D., and Joseph H. Zettl

Twenty-one new cases were managed by use of immediate postsurgical prosthetics procedures. These included: 1 Syme, 16 below knee, 3 above knee, and 1 knee disarticulation.

Polyurethane foam pads have been used successfully. Three densities and four sizes have been utilized.

In cooperation with the VA Prosthetics Center in New York, a program has been undertaken to study pressures applied by rigid dressings used in

the immediate postsurgical fitting procedure. Pressures between stump and socket are being measured. The EMG activity of the stump musculature is being studied. Temperature studies are being utilized to chart the course of inflammatory response to trauma.

Under consideration is a revision of the publication "Immediate Postsurgical Prosthetics in the Management of Lower Extremity Amputees," published in April 1967.

VA Hospital, San Francisco, California
Wesley L. Moore, M.D., and Albert D. Hall, M.D.

In the last quarter of 1968 the Veterans Administration Hospital, San Francisco, has initiated a study to evaluate immediate postoperative fitting of prosthesis in patients undergoing below-knee amputation for vascular insufficiency. The purpose of the study is twofold. First of all, we will evaluate the applicability of the immediate fitting technique to a large volume of patients undergoing amputation for vascular insufficiency. The secondary purpose of this study will be to establish quantitative criteria to aid in preoperative determination of level for a successful lower-extremity amputation by evaluating the skin blood flow necessary for successful healing following amputation.

At this time we have performed 25 lower-extremity amputations with immediate postoperative fitting of prosthesis. Twenty-three of these were below knee and two were above knee. The initial results of this study have been summarized in a paper presented at the International Cardiovascular Society in June of 1968 and will be subsequently published in Archives of Surgery in December of 1968.

Work has been started on constructing the various equipment required for performing skin blood flow measurements, including radioisotope techniques utilizing xenon 133 and a capacitance plethysmograph.

SENSORY AIDS

Howard Freiberger, A.M.

Electronics Engineer, Research and Development Division
Prosthetic and Sensory Aids Service, Veterans Administration
New York, N. Y. 10001

Fabrication of Obstacle Detectors for the Blind
Bionic Instruments, Inc., Bala Cynwyd, Pennsylvania 19004
Thomas A. Benham, J. Malvern Benjamin, Jr., D. Ridgeley Bolgiano, and E. Donnell Meeks, Jr.

There is no new research activity to report on for this period.

The manufacture of ten C–4 laser canes is nearing completion at this time. Demonstrations of the cane have been made to approximately ten individuals and organizations during the past three months.