HIGHLIGHTS OF OTHER VA RESEARCH PROGRAMS

PROSTHETICS
Edited by
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Committee on Prosthetics Research and Development
National Academy of Sciences-National Research Council
Washington, D.C.
Colin A. McLaurin

For progress covering this report period, see “The Annual Summary Report on Committee on Prosthetics Research and Development” for the year ended June 30, 1970, appearing elsewhere in this issue of the Bulletin.

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


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

An abstract of an annual report, which covers the progress during this report period, appears elsewhere in this issue.

New York University, New York
Renato Contini

This project has terminated. A summary report covering activities from its inception July 1, 1958, until its termination June 30, 1970, appears elsewhere in this issue of the Bulletin.
1. Below-Elbow Polysar Prosthesis—One amputee has been fitted with a temporary Polysar prosthesis using a modified Münster socket for suspension.

The Polysar was not applied directly to the stump because in previous fittings of this type on recently amputated patients it has been found that the amputees could not tolerate pulling and stretching of tissues around the suture line. A cast was taken of the stump, and the model was modified. A plaster extension was added to the distal end for proper forearm length, and the Polysar then was formed over the plaster model.

Münster-type harness was used for control with a 5XA Dorrance hook. Lamb's wool was used to fill the space between the stump and wrist unit to give distal contact.

The amputee has been wearing the prosthesis for 3½ months with no socket problems. He is to be fitted with a conventional prosthesis by a local prosthetic facility when the stump stabilizes, with thorough healing of the suture line.

2. Self-suspended Above-Elbow Socket—Eight sockets are being evaluated for self-suspension on two above-elbow amputees, one with a medium-length stump and one with a long stump. Four sockets will also be tested on a short stump. The sockets vary in proximal trimline and socket materials.

It is felt that in making a socket of this type three factors should be considered for self-suspension: 1. contour, which is directly related to the contour of the stump (and potential changes from muscle bulging); 2. friction, which pertains to socket materials (and finishes); and 3. atmospheric pressure, which is used as an auxiliary aid.

3. Fracture Bracing—One fracture brace was fitted during this past reporting period on a 72-year-old woman. The quadrilateral shape at the ischial level was formed by hand-molding. Otto Bock polycentric joints with a lock were used at the knee center.

4. Self-Pressurizing Pneumatic Above-Knee Socket—The third patient returned after 3 weeks complaining of discomfort in the distal lateral aspect of the stump. Relieving the socket in this area punctured the flexible polyester laminate liner. A new socket was fabricated, but this time Silastic laminate was used for the pneumatic liner. The flexible polyester was somewhat stiffer than the Silastic and tended to wrinkle when inflated. When the amputee walked with the new socket, his first comment was on the increased comfort apparently related to the air chambers.

*Registered trademark of the Polymer Corporation, Ltd., Sarnia, Ontario, Canada.
2. Grahn, and

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9. Modified Münster Socket—Two amputees have been fitted with definitive myoelectric prostheses using the modified Münster socket for self-suspension. The trim line is altered to increase the range of elbow motion.

The first amputee is a 22-year-old male, acquired amputee with a 9½-in. below-elbow stump. Prior to this fitting he had never worn a

Other VA Research Programs

A diagram of the air flow in this socket appears as Appendix N of the Report of the Eighth Workshop Panel on Lower-Extremity Prosthetics Fitting of the Subcommittee on Design and Development, Committee on Prosthetics Research and Development.

5. Polyester-Cushion Below-Knee Socket—Four PTB prostheses have been fitted using this procedure. One prosthesis is of the one-piece construction; three prostheses utilize an insert of flexible polyester resin and vinyl foam. The insert method allows the prosthetist to grind reliefs in the socket without damaging or changing the liner. The one-piece construction is simpler and quicker to fabricate, but it requires careful attention and planning of the socket because it is very difficult to alter. All four amputees like their prostheses and claim them to be more comfortable than their previous conventional PTB prostheses.

6. Powered Wrist Rotator—The first prototype of a unit (Model III) which will allow through-center operation of a terminal device has been constructed. The unit will undergo laboratory evaluation to determine its operational characteristics. The noise level of this unit has been greatly reduced below that of Model I.

7. Powered Hand Splint—The eighth patient has been fitted with a unit which has a new motor and drive screw. The motor has better operating characteristics and better construction than those previously used. The only significant problem to date has been the wearing of the Teflon nut. A larger diameter screw is now being used in this unit to increase the load area and thus decrease the stress on the Teflon threads.

One quadriplegic returned after using the unit for 10 months. The only problem appeared to be a discharged battery. After recharge the unit performed well.

8. Pronator Assist—This is a device to aid the quadriplegic who does not have the ability to pronate his wrist and rests with the wrist supinated and in dorsiflexion. However, if the wrist is passively pronated, the patient can actively supinate it. The criteria are to provide a device which will accomplish this with simple, lightweight hardware and with no hardware required on the patient proximal to the wrist, that is, one reaction point at the wrist and the other on the wheelchair.

The first prototype utilizing a torsionally loaded, flexible cable between the wrist and wheelchair has been constructed and fitted. The idea appears feasible and a second unit is being constructed to eliminate the problems in the first unit.

9. Modified Münster Socket—Two amputees have been fitted with definitive myoelectric prostheses using the modified Münster socket for self-suspension. The trim line is altered to increase the range of elbow motion.

The first amputee is a 22-year-old male, acquired amputee with a 9½-in. below-elbow stump. Prior to this fitting he had never worn a
prosthesis. He has been wearing the prosthesis 5 months with only the problem of atrophy at the distal end of the stump.

The second amputee is a 13-year-old male, congenital amputee with a 5-in. below-elbow stump. Prior to this fitting he wore the original Münster socket. In his opinion the new prosthesis is more comfortable and easier to don. He was able to extend to 0 deg. and flex to approximately 120 deg. He has been wearing the prosthesis for 7 months with no socket problems.

10. Self-Suspended Wrist-Disarticulation Socket—A technique has been developed for making a self-suspending wrist-disarticulation socket using a removable panel on the distal ulnar surface of the forearm. The amputee removes the ulnar panel, which is approximately one-third of the distal ulnar surface of the socket, allowing the distal end of the stump to pass through the narrow wrist area. The panel is put in place to secure the socket on the stump. Excellent suspension was maintained using the radial and ulnar styloid processes because no modification was required to allow the styloid processes to pass through the narrow wrist area.

The socket covers only the distal two-thirds of the stump. Because of the snug fit at the distal end as well as the short socket, he was able to maintain 130 deg. of supination-pronation (60 deg. supination-pronation).

He has been wearing his prosthesis for 1 month with no socket problems.

11. Upper-Extremity Prosthetic Systems—It is becoming increasingly apparent that upper-extremity prosthetics must be viewed from a systems viewpoint. In other words the developer must consider the total prosthetic system including the amputee, and not allow narrow vision to limit the view to a single prosthetic component. Just a few years ago it was thought acceptable to adapt external power and myoelectric control to standard prosthetic practices. As the systems developed, it was found that external power and neuromuscular control only begin to take on real significance when the conventional principles of prosthetic attachment and construction are altered. Thus, the self-suspended above-elbow socket (item 2 above), the modified Münster socket (item 9), and the self-suspended wrist-disarticulation socket (item 10) have all been outgrowths of the need for a better overall system when external power is employed with the self-containment of all components, including the energy source.

Not only the attachment but the assembly is important to the total system. At present the self-contained and self-suspended below-elbow prosthesis is assembled from a separate forearm section and socket. Before the socket is installed, the energy source and controller are inserted at the proximal end of the forearm. Of course, removable panels could be used to insert the components from the side of the prosthesis. The idea is not new; the device has its own suspension system. It is only a matter of approach.
ostheses 5 months with only the stump.

A male, congenital amputee with his fitting he wore the original prosthesis is more comfortable from 10° to 0° and flex to approx 70°. He is more comfortable and able to use with good control for 7 months with the stump.

ion Socket—A technique has been developed to use a custom-made wrist-disarticulation socket using an external power source. The socket is approximately one-third of the stump, allowing the distal end of the forearm to be used for suspension. This technique allows for better suspension and movement of the prosthesis without the need for modification or fitting.

Wrist unit—The wrist unit should allow passive supination-pronation of the hand, passive wrist flexion, and quick disconnect so that the terminal device may be quickly changed. Therefore, the below-elbow system has its own special needs for a wrist unit, and the possibilities of a modification of commercial wrist units for this purpose are being studied.

In like manner, the need for exchangeable terminal devices which are powered was found. Work is proceeding on the first prototype of a powered hook.

It also seems advisable to move from the crustacean type of upper-extremity prosthesis to the endoskeletal type. It appears that this approach may simplify prosthesis construction and assembly while at the same time improve cosmesis. LeBlanc and Bechtol at UCLA and the Otto Bock Co. in Germany have already shown the feasibility of this approach.

It is apparent that all portions of the prostheses influence its prosthetic acceptability, and it is not enough merely to design a single item which is technically excellent but which is not well integrated with the function, construction, assembly, and cost of the total unit.

12. Self-suspended and Self-Contained Above-Elbow Prosthesis—This prosthesis has an electric elbow furnished by the Veterans Administration Prosthetics Center and an Otto Bock electric hand. The arm is controlled by myoelectricity which is detected by two sets of electrodes. The standard procedure is to use biceps activity to flex the elbow with the rate of flexion proportional to the degree of activity. The triceps control the elbow in a similar manner for extension. The simultaneous activity of the two muscles is used to control hand function. The prosthesis has been fitted to a congenital above-elbow amputee, who is quite enthusiastic about it. At present the socket is being altered to allow for better suspension and to take into account the movement of the electrodes which occurs between the conditions of the arm hanging freely as opposed to being supported by an external object.

The long-term medical problems which may develop with the stump being under prolonged tension will be watched closely. The arm including battery weighs 2 lb. 14 oz. which ironically was the weight of the amputee's conventional prosthesis.

A long stump necessitated placement of the battery in the forearm. Electronic controls are divided between the upper arm and the forearm. Only a short wire across the elbow joint is visible externally.

13. Self-Suspended and Self-Contained Below-Elbow Prosthesis—Although this laboratory firmly believes in the so-called three-state myoelectric control where only one muscle group controls the two active
(forward and reverse) and one quiescent states of an electric motor, it is believed that the two-state, two-site systems have some advantages over the three-state, single-site systems currently in use. If only one function is to be myoelectrically controlled and if two muscle sites are readily available, this two-site system seems quite appropriate. Therefore, such a myoelectric system has been designed. The unit makes use of the most recent integrated circuit amplifiers. These may now be used conveniently since the quiescent current has been greatly reduced and the units are available at reasonable prices. Thus, no good reason remains for not using them and they have the advantage of reducing assembly costs since they permit a significant reduction in parts.

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

VA-sponsored activities have been directed toward the following objectives: design of an electro-hydraulic actuator system, learning system, and studies of relationships between arm motion and myoelectric activity during elbow flexion-extension.

Continuing work on development of a high-speed, highly accurate actuator and control system for prosthesis/orthosis application concentrated on development of prototype devices. As reported last year, it was indicated that a digital control system driving a stepper motor which in turn provides a signal to a pneumatic or hydraulic valve system would result in a system light in weight but powerful enough to perform necessary tasks for the wearer. Control logic was developed during the report period using standardized laboratory modules, and the control loop was completed. Feedback from the joint is provided by a potentiometer, analog error is computed, and the error is converted to a digital command through a sample/hold network. An actuator was developed which uses a pilot valve to drive a hydraulic ram. Command signals from the control logic are transmitted to the pilot valve via a differential linkage system. The system has just been assembled, and “debugging” operations are underway.

Electromyographic output from the flexor muscle group (biceps and brachialis) of the upper arm of several subjects was measured with skin electrodes during rapid point-to-point voluntary elbow flexion and extension. This output was compared to elbow angular position from rest. Elbow position was recorded via a lightweight electrogoniometer using a high precision “infinite resolution” potentiometer. The desired result was the determination of individual muscle activity patterns as a function of elbow displacement. Location of electrodes was such that cross talk was not present. The experiment covered several different
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if two muscle sites are readily appropriate. Therefore, such The unit makes use of the most may now be used conveniently easily reduced and the units are a good reason remains for not age of reducing assembly costs in parts.

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target sizes and initial-point-to-target distances. Results show that synergistic control is not apparent in rapid point-to-point tasks. Instead, the effort required to position the forearm is provided completely by prime mover modulation. Antagonist deceleration is insignificant on the rare occasions when it occurs. This is supported by a linear relationship between required mean velocity and subtended travel arc. Further research is required to determine whether synergistic activity occurs if the arm is preloaded and for other types of motion such as adduction of forearm about humeral axis—“turntable” motion in prosthesis—or circumduction about the shoulder.

Research efforts of the Biotechnology Laboratory have for some time focused on the development of a patient-aiding system which can assist his control action and unburden his decision load. These efforts led to the design, realization, and experimental evaluation of an adaptive aiding system. The system concept utilizes machine learning techniques and decision-making algorithms to form a man-machine control loop.

An autonomous control subsystem, which operated parallel with the patient, together with the patient, constituted the system. It was successfully tested on control of a simple three-degree-of-freedom manipulator capable of picking up, moving, and releasing small objects on a flat work surface. The autonomous subsystem was implemented on an IBM 1800 process control computer, connected directly to the manipulator mechanism. Its behavioral characteristics were formed by a “training” process which consisted of refining a conditional probability matrix on the basis of experience with block-moving tasks. The system (ACS) acted as a passive observer trying to “understand” how the patient controlled the prosthesis and to develop an “awareness” of the environment of the operation. At this phase the autonomous subsystem defined the relationship between the operator’s responses and the external world. Upon acquisition of some “experience,” the internal loop participated in the control of the prosthesis. It observed the successive prosthesis states and generated a future state. In this next phase the operator acted mainly as an action initiator, letting the internal loop control the motion of the arm. Finally, the function of the operator was reduced to that of action initiator and inhibitor. Under such a configuration, as expected, the decision load associated with controlling the manipulator was substantially reduced.

Feasibility studies with regard to the application of a learning system to aiding the patient in the control of an arm prosthesis are in progress. The studies involve a set of experiments in which subjects use a transducer control harness to perform manipulative tasks.
Fundamental Studies

The first stage of the new locomotion studies which were initiated in fiscal year 1967 has been completed. This project has been concerned with the development and trial application of measuring devices and computer data processing procedures for efficient collection of reliable kinematic measurements of walking subjects. Extensive measurements have been made of lower-extremity motions in a single subject walking on a treadmill over a wide range of speeds. A detailed description of the principles applied, the procedures developed, and the results obtained in this project can be found in a Ph.D. dissertation entitled “Experimental Kinematics of Human Walking,” by Larry W. Lamoreux, which is available in microfilm or Xerox form from University Microfilms, Ann Arbor, Michigan.

On the basis of the results of this development project, a continuation project is planned which will use improved data collection and data processing techniques to examine numerous subjects during both floor walking and treadmill walking. A new, minicomputer-based data acquisition system has been specified and ordered, with delivery expected late in 1970. Data will be recorded in digital form on IBM compatible magnetic tape for processing either in the minicomputer itself or in any large computer center. Preliminary efforts with the new system will be directed toward the development of improved, quantitative techniques for gait evaluation.

Pneumatic 4-Bar Polycentric Knee

A structural failure in the rear link of the knee mechanism has delayed the preparation of production drawings. Design modifications will be undertaken to eliminate the stress concentrations in the rear link, which we consider to be responsible for the failure. These modifications will require a redesign of the pneumatic damper to make it narrower.

Pneumatic 6-Bar Polycentric Knee

The 6-bar knee mechanism exhibits most of the functional advantages of the 4-bar mechanism, plus the added advantage that the proximal attachment points of the linkage lie distal to the 90 deg. rotation pole of the knee. This feature allows the mechanism to be used with a very long stump and still appear to bend in the right place during knee flexion. The first working prototypes of the 6-bar knee has been completed. Amputee trials will be undertaken as soon as possible to determine not only the durability of the mechanism but also the effectiveness of the polycentric action and the pneumatic swing-phase control.
studies which were initiated in This project has been concerned cation of measuring devices and for efficient collection of reliable subjects. Extensive measurements in a single subject walking speeds. A detailed description of developed, and the results ob- n a Ph. D. dissertation entitled Valing,” by Larry W. Lamoreux, ox form from University Micro-
deropmental project, a continuation proved data collection and data erous subjects during both floor minicomputer-based data acqui- ered, with delivery expected late gital form on IBM compatible he minicomputer itself or in any orts with the new system will beproved, quantitative techniques the knee mechanism has delayed ts. Design modifications will be atractions in the rear link, which ailure. These modifications will imper to make it narrower.

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

To continue surgical-prosthetic research and development in immediate postsurgical prosthetic fitting 33 new patients presented themselves for treatment under this form of management. The various levels of amputation included 23 below-knee amputations, nine above-knee amputations, and one upper extremity; below-elbow amputation was also performed using the immediate postsurgical prosthetic fitting concept.

The basic research program which involves instrumentation of amputation stumps to record pressures at the stump-socket interface including studies relevant to the EMG activity of stump musculature were temporarily suspended due to the unavailability of the electronic equipment. These studies are carried out with the cooperation of the VA Prosthetics Center in New York and will be continued as newly improved and more compact equipment is made available to Prosthetics Research Study.

The principles of direct molding of below-knee sockets using Polysar,* a synthetic balata, have been expanded to include “Lightcast,” a new orthopedic casting material. The advantages of the resulting fiber glass socket lie in its inherent characteristics of porosity and extreme lightness. Furthermore, the material itself remains unaffected when submerged in water. Lightcast is also applicable for a variety of splints. More fittings and work with the material are planned in an effort to widen our experience.

Several patients, including multiple amputees with severely burned, scarred, and/or skin grafted stumps, have been evaluated and fitted with the knee mechanism has delayed specially modified, experimental and/or standard type of prostheses.

January 1, 1970—June 30, 1970

<table>
<thead>
<tr>
<th>Total Number of Patients:</th>
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<td>Levels of Amputation:</td>
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<td>Above Knee</td>
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<tr>
<td>Below Knee</td>
<td>23</td>
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<td>Below Elbow</td>
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<td>ETIOLOGY—Above Knee:</td>
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<td>Vascular with Diabetes</td>
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<td>Vascular without Diabetes</td>
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<tr>
<td>Trauma and Post Trauma</td>
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<td>Tumor</td>
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*Registered trademark of the Polysar Corporation, Ltd.
Bulletin of Prosthetics Research—Fall 1970

ETIOLOGY—Below Knee:
Vascular with Diabetes.................................................. 8
Vascular without Diabetes............................................... 10
Trauma and Post Trauma............................................... 5

ETIOLOGY—Below Elbow:
Trauma and Post Trauma................................................ 1

AGE GROUP IN YEARS:
80+ ................................................................. 1
70–79 .................................................................. 4
60–69 .................................................................. 8
50–59 .................................................................. 13
40–49 .................................................................. 1
30–39 .................................................................. 4
20–29 .................................................................. 2
Under 18 ................................................................ 0

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

The San Francisco Veterans Administration Hospital continues to study two major areas, the first being evaluation of the immediate fitting technique in clinical practice and the second the development of techniques to predetermine the lowest level at which successful amputation can be performed.

In the first area, 51 amputations with immediate postoperative fitting have been performed on 43 patients. Forty-two operations at below-knee level, four knee disarticulations, and five above-knee amputations comprise this group. The high rates of primary healing and patient rehabilitation, and the low incidence of complications continue to be the hallmarks of this technique. Recent experience with knee disarticulation using immediate postoperative fitting has been very encouraging. The applicability of knee disarticulation would be limited to those patients in whom a high below-knee amputation was not feasible, such that a knee disarticulation would be a much better alternative to above-knee amputation.

The next major area of interest has been the study of skin blood flow at the proposed site of amputation. These measurements have been done using washout times of Xenon-133 radio-isotope as an index of capillary blood flow. In the deep arterial blood flow and in those patients who had anterior skin blood flow rates of 0.55, 0.56, and particularly the 11 patients who had anterior skin blood flow rates of 3.54 cc./100 gm, the incidence is being increased in being able to permit primary reconstructive surgery.

Construction and work at this unit are so that this may be arriving at the

Harvard Med School
Boston, Mass.
Richard Wa

The activity of the data project is a Principal Investigator. These have

Follow-Up...will not be able to

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Cambridge, Mass.
Richard Wa
Hall, M.D.

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blood flow. As others have suggested, the skin blood flow (rather than the deep arterial flow) is presumed to be the primary factor determining wound healing. Fourteen patients have been studied prior to amputation and in those 11 patients proceeding to primary healing, the preoperative blood flow rates have ranged from 0.9 cc./100 gm. tissue to a high of 3.54 cc./100 gm. tissue. In this group of 14 patients there were three patients whose amputations failed to heal due to ischemic necrosis of the anterior skin flap. The blood flow rates in these three patients were 0.55, 0.56, and 0.59. The three failures all seemed to cluster at a particularly low level well below the lowest flow rate found in any of the 11 patients who went on to primary healing. This additional evidence is beginning to add confidence to the accuracy of this technique in being able to predict patients whose blood flow is so low as not to permit primary healing at the level of measurement.

Construction of a capacitance plethysmograph has been completed, and work at the present time is in progress to attempt to standardize this unit and compare measurements with Xenon technique. It is hoped that this may become a relatively simple and inexpensive means of arriving at the same data secured from the isotope studies.

Harvard Medical School
Boston, Mass.
Richard Warren, M.D., Ronald B. Kihn, M.D., and Leon Sheplan, M.D.

The activities at Harvard Medical School have consisted of collating the data procured from the four forms completed by the 21 Hospital Principal Investigators during the calendar years 1967, 1968, and 1969. These have provided a 2-year postamputation followup on the 380 survivors of 427 patients receiving 559 lower-extremity amputations. The main effort on this project during the named 6 months' period has been exerted by the statistical team of Dr. Gilbert W. Beebe of the NAS/NRC Follow-Up Agency. The final collation and organization of the material will not be finished until the end of 1970.

The second activity has been the reporting and publication (in July 1970, Archives of Surgery) of the 2-year (1967 and 1968) experience of eight VA hospitals with the immediate postamputation prosthetic fitting technique. This involved 182 patients, 154 of whom (84 percent) represented "rehabilitation successes."

Cambridge Hospital
Cambridge, Mass. 02139
Richard Warren, M.D.

The activities at Cambridge City Hospital have consisted of organiza-

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project. It is to assay the breadth of applicability of the immediate post-
amputation prosthetic fitting technique to amputations done throughout
a community. The personnel have consisted of a Prosthetic Specialist, a
Physician Coordinator, and a part-time Secretary. The contract is with
the Cambridge Hospital, Cambridge, Massachusetts, where space has
been provided. The equipment has been partly supplied by the VA
Prosthetics Center in New York.
Between January and July 1970, announcements were sent to 88
surgeons in Boston. Four talks were given by request in various parts
of the community and 13 amputations were seen in consultation.

The Johns Hopkins University
Silver Spring, Md. 20910
Woodrow Seamone and G. Schmeisser, M.D.

During this period, fabrication of three myoelectrically controlled
external power units for upper-limb prostheses was completed. These
power packs interface with conventional upper-limb prosthetic compo-
nents and provide for proportional control of the terminal device or
elbow. External power transmitted through a Bowden cable replaces
body power and is controlled by myoelectric sensors built in the socket
of the prosthesis. Two powered systems have been fitted to amputees
for evaluation.

Unit # 1—This unit was fitted to a wrist-disarticulation amputee. The
motor, electronic control unit, and battery pack are worn on the waist.
The EMG sensor is built into the stump socket in a floating arrange-
ment. Proportional opening of the terminal device is controlled by
varying the EMG signal in the desired manner. The unit was evaluated
in three phases.

During the break-in phase, which lasted several weeks, the amputee
wore the prosthesis for graduated periods while performing increasingly
demanding manual skills. Design features causing wire breakage and
other mechanical and functional problems were identified and corrected.
By practicing various manipulations the amputee attempted to develop
maximum dexterity.

In the comparison phase, various physical and functional measure-
ments were made comparing the new prosthesis to the amputee's pre-
existing body-powered prosthesis. These include the span, force, velocity,
and fine control characteristics of terminal-device grasp, the range of
terminal-device placement, the bi-manual work envelope, and the degree
of grasp-placement coordination as well as stability, weight, comfort,
M.D.

three myoelectrically controlled prostheses was completed. These upper-limb prosthetic components control of the terminal device or through a Bowden cable replaces electric sensors built in the socket. These have been fitted to amputees amputeadisarticulation amputee. The mp socket in a floating arrangement terminal device is controlled by manner. The unit was evaluated used several weeks, the amputee ds while performing increasingly ures causing wire breakage and ms were identified and corrected. A amputee attempted to develop physical and functional measures of the prosthesis to the amputee’s pre- include the span, force, velocity, device grasp, the range of al work envelope, and the degree of stability, weight, comfort,

and speed of application. Test activities were recorded on movie film for review and further analysis.

In the final phase arrangements were made for the amputee to wear the new appliance as his primary prosthesis for all of his activities for several months in order to reveal undiscovered problems and to determine mechanical endurance and ultimate amputee preference.

Unit #2—This unit was fitted to an above-elbow amputee. Outside locking hinges were utilized so that the power unit could be physically located in the elbow and connected to the terminal device by means of a cable. The single EMG sensor site is mounted in the stump socket and is located over the biceps muscle. The 12-oz. battery pack is retained on the waist. A photograph of this prosthesis as worn by an amputee is shown in Figure 1.

This control/power unit will operate either the elbow or terminal device as a function of locking or unlocking the elbow similar to a conventional body-powered prosthesis. Initial tests indicate that the powered system is easily controlled and improves the amputee’s functional capability. The plan for evaluation of this prosthesis is similar to that conducted for Unit #1 with modifications appropriate to inclusion of a prosthetic elbow.

A total of eight amputees are to evaluate the power pack concept to provide quantitative data on system performance.

Other VA Research Programs

1970

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