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Preamble

Stimulated by the President of ISPO, Anthony Staros, I have, in my capacity as Chairman of the Research Committee, persuaded Newton McCollough to publish this most interesting paper in our Journal. Newton McCollough is Chairman of the Centre of Orthopaedics and Rehabilitation in Miami, Florida, with a wide experience in the dynamic field of prosthetic rehabilitation. He has written his paper on Orthopaedic Research in Amputation Surgery, Prosthetics and Orthotics, looking ahead at different future possibilities of evolution. It contains his evaluation of the important areas requiring research effort. It makes most stimulating reading of basic importance to all who are concerned with the creation of better methods for the treatment of the increasing number of amputees, and for those who seek a better understanding of the categories of amputees in relation to different causes, ages and environments.

A number of distinguished practitioners from the different professions have been invited to comment on, and supplement, the views expressed by Professor McCollough. Their comments will be published in forthcoming issues. Readers are also invited to comment so that we may create a stimulating discussion on the priorities for the 1980's.

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Orthopaedic research in amputation surgery, prosthetics and orthotics

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Amputation surgery

A number of advances have been made in amputation surgery over the past 15 years. These include the development of new surgical techniques for the Syme amputation, below-knee amputation, knee disarticulation and certain upper limb amputations. The techniques of myodesis and myoplasty have been introduced along with the concepts of immediate postsurgical fitting and emphasis upon the salvage of the knee joint has resulted in a complete reversal of the old 2 to 1 ratio in favour of the above-knee amputations to below-knee amputations in vascular disease. Postoperative care of the amputee has also been improved through the use of specialized postoperative dressings and early return to functional activity. The areas for continued research are as follows:

1. Development of a system to obtain current data base on amputations performed in the United States including cause, level, age of patient, healing information, time to discharge and incidence of rehabilitation.

2. Continued research into the accuracy of level selection in the dysvascular amputee which will permit healing in the vast majority of cases and eliminate the necessity for revision. Most promising in this area are the use of Doppler Ultrasound techniques as well as Xenon Clearance studies.

3. Continued research into the area of postoperative stump management including controlled environment studies which are already in progress at the Veterans Administration Prosthetic Study in Seattle.

4. Improved methods of management of the congenital limb deficient child including reconstruction of the hip in proximal femoral focal deficiency, lengthening of short stumps through the use of microsurgical techniques, and new methods of lengthening of congenitally short femurs through epiphyseal distraction, a re-evaluation of epiphyseal stimulation and other methods. Also investigation of procedures

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to prevent bony overgrowth in amputations in children should be pursued including further evaluation of capping the bone ends with inert materials as advocated by Swanson and Meyer as well as osteochondral transplants advocated by Marquardt.

5. Continued investigation should be encouraged into the direct skeletal attachment of prostheses as advocated by Mooney of the University of Texas and Hall of the Southwest Research Institute. Particular problems in this regard are bone interfacing with the prosthetic component and overcoming the cutaneous interface between the body milieu and the external environment.

6. Research into the provision of sensory feedback of the upper extremity amputee by the use of implantable radiofrequency receivers as advocated by Clippinger et al.

7. Further refinement of myoelectric control, particularly in upper extremity amputations would be desirable with the possibility of utilizing more definitive muscle activity to provide control of the prosthetic fingers to allow manipulation of objects within the grasp of the terminal device.

Lower limb prosthetics

Significant advances in the area of lower limb prosthetics which have been made in recent years include the advent of immediate postsurgical and early postsurgical fitting of temporary prostheses to allow earlier functional recovery as well as new designs of permanent prostheses including the endoskeletal design for improvement of cosmesis and decrease in weight, and new designs for Syme prosthesis as well as the new disarticulation prosthesis. The latter developments have encouraged the more frequent utilization of amputations at the Syme and knee disarticulation level which provide a superior prosthetic performance. Also the utilization of energy studies being conducted primarily at Rancho Los Amigos and Tufts University have shed new light on the energy requirements for various levels of lower extremity amputation and prosthetic fitting.

Important research areas to be supported in the area of lower extremity prosthetics include the following:

1. Continued support of energy studies in various levels of amputation, including multimembral amputations to determine efficiency of use of various prosthetic designs in the management of the amputee.

2. Continued work in the area of ultra-lightweight prostheses which further reduce energy consumption particularly in the geriatric amputee. Work in this area is currently being done at Rancho Los Amigos Hospital, Moss Rehabilitation Center and the University of Texas in Dallas.

3. The development of simpler and yet more accurate measurements of prosthetic alignment for the lower limb should be encouraged such as the laser display of the weight line being developed at Moss Rehabilitation Center and the clinically applicable objective alignment techniques being developed at Rancho Los Amigos Hospital.

4. Work should be encouraged in the area of development of adjustable prosthetic sockets for lower limb amputees to continuously accommodate to the changing volume of the amputation stump following surgery or following chemotherapy. Some work along this line has been done at the Veterans Administration Prosthetic Center in New York and at the University of Miami.

5. The application of myoelectric control to control the prosthetic knee in the above-knee prosthesis should be further investigated and refined from the standpoint of producing increased stability and decreasing energy requirements in the above-knee amputee.

6. Investigation of possible self-adjusting sockets to accommodate for growth in the child amputee should be undertaken. This would result in a considerable cost saving to child amputees by reducing the number of prostheses necessary during the growing period.

7. Further refinement of technology in the area of hydraulic control of above-knee prosthetic knee joints to permit both stance and swing phase control in the geriatric patient. Present designs prohibit the use of such a unit due to the relative stiffness of operation.

8. Further research into developing a hydraulic ankle unit such as that being developed at Mauch Laboratories. Such a unit ideally would allow motion in the transverse, saggital and coronal planes and reduce shear and friction forces upon the stump within the socket.

9. Research into the area of utilizing myoelectric control to provide voluntary

dynamic push off at the foot and ankle should be considered.

10. Further refinement of endoskeletal design prostheses to ensure comparable durability to the exoskeletal prosthesis. This would require investigation of new materials and attachments. Particularly promising would be the graphite epoxy materials which are light in weight and strong and durable.

11. Further research into a better prosthetic "skin" for lower limb endoskeletal prostheses which would be more durable and more cosmetic than the present applications.

Upper limb prosthetics

Significant developments in recent years in upper limb prosthetics have included utilization of immediate postsurgical fitting for early return of function, particularly in the bilateral traumatic amputee and the development of myoelectric control systems as well as the utilization of external power sources to control prosthetic joints.

Research objectives in upper limb prosthetics are suggested as follows:

1. Further refinement of current myoelectric prosthetic designs to improve their durability and maintenance. These designs would be in particular applicable to the high upper limb amputee.

2. Further research into the area of sensory feedback in upper limb prosthetics to provide greatly enhanced function in the utilization of these devices.

3. Research should be undertaken to permit manipulation of objects within the grasp of the terminal devices of upper limb amputees in combination with sensory feedback techniques.

4. The use of self-suspending sockets to eliminate harnessing should be further developed to include designs for the below-elbow amputee as well as the above-elbow amputee. Work in this regard has already been conducted at Northwestern University and self-suspending sockets are currently available for wrist disarticulation and elbow disarticulation amputees.

5. Research into designs of upper limb prosthetics which would provide improved cosmesis compared to current standard designs. Such an effort must incorporate further refinement of exoskeletal designs, improved prosthetic skin, utilization of external power and/or myoelectric control so that harnessing may be eliminated.

Lower limb orthotics

Advances in lower limb orthotics over recent years have included the utilization of new materials such as polypropylene to improve cosmesis as well as enhance weight reduction and at the same time provide continued optimum function. The reduction of weight in newer designs, both in plastic and metal, has enabled many children with muscular dystrophy, myelomeningocele and other paralytic disorders to achieve useful ambulation.

Areas for research support in lower limb orthotics should include the following:

1. Development of a self-locking knee joint in stance phase for the ankle-foot orthosis so that normal swing phase can be permitted and energy consumption can be reduced.

2. Energy studies should be further undertaken to ascertain the relative energy requirements in walking with various types of lower limb orthoses so that design evaluation can be more objective.

3. Continued research into new orthotic materials, namely the graphite reinforced epoxy and plastic materials to provide superior strength, adjustability and lightness of weight should be pursued.

4. Research should be undertaken to interdigitate myoelectric control with orthotic joints in higher levels of paralysis including the hip and knee joints.

5. In upper motor neuron lesions further investigation of internal orthotic devices which are physiological such as the use of radio frequency peripheral motor control should be encouraged. Multichannel computerized peripheral motor control through radio-frequency signals to muscles affected in upper motor neuron lesions could effectively permit a paraplegic patient to walk with appropriate computerized programming.

6. Further evaluation of biofeedback techniques to enhance control of the lower limb in conjunction with orthotic applications.

7. Continued refinement of orthotic devices for fracture bracing should be encouraged. Present methods are not applicable in the private practice clinical setting. Research in this area should be in new materials as well as new designs and the utilization of prefabricated components.

Work in this area is ongoing at the University of Miami, University of Southern California and the University of Texas at Dallas.

Upper limb orthotics

Relatively few advances have been made in the area of upper limb orthotics due to the complexity of function of the upper limb and the difficulty in providing a truly functional orthosis as compared to a supportive type of brace.

Areas for further research include:

1. Possible development of myoelectric control in conjunction with upper limb orthotic devices.
2. The development of sensory feedback in combination with upper limb orthotic devices.
3. The utilization of biofeedback techniques in conjunction with upper limb orthotic devices in the stroke patient.
4. Continued investigation into the use of functional electrical stimulation in both the stroke patient and the quadriplegic patient such as is being carried out at Rancho Los Amigos and Case Western Reserve University.

Spinal orthotics

Recent advances in the area of spinal orthotics have primarily been confined to the area of scoliosis management and have included many new designs which have come to replace the Milwaukee brace in many instances. These designs have been made possible by the utilization of new materials and improved fabrication techniques to permit bracing of the scoliotic spine with underarm types of orthotic appliances.

Areas for research activity in the area of spinal orthotics include:

1. The development of a modular spinal orthosis which could be adjustable in the control of motion in all three planes, depending upon the particular type of motion restriction desired.
2. Further research into spinal orthoses which provide an unloading effect to the spine such as have been developed by Dr. James Morris at the University of California at Berkley and at Newington Children's Hospital principally in the treatment of myodysplasia.
3. Possible utilization of biofeedback techniques in conjunction with orthotic devices to correct posture and thereby reduce low back pain.
4. Further evaluation of the utilization of functional electrical stimulation in the correction of scoliosis either independently or in conjunction with orthotic devices.
5. Research and development in the area of emergency orthotic devices for use in traumatic injuries of the spine to reduce the neurological complications in such patients who must be moved from the scene of the accident to the hospital.
6. Clinical and laboratory investigations should be encouraged to determine the effect of bracing on the scoliotic spine including the various types of new braces. Forces required, length of time required and the effect of exercises in conjunction with bracing as well as night bracing should be investigated.