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REPORT
PANEL ON UPPER-LIMB ORTHOTICS

Membership:
Chairman for the first day: H. Richard Lehneis
Chairman for the second day: Maude Malick
Recorder: Gary Fields
Members: Thorkild Engen
Steve Reger
Terry Supan

Currently upper-limb orthotics requirements have included a broad spectrum of upper-limb disability areas. The orthotist has been called upon to supply orthotic devices in two primary areas—temporary orthoses (as required in acute care) and permanent long term orthoses.

The upper-limb orthoses required for temporary or short term use are most frequently needed in traumatic arm and hand injuries (involving skeletal, soft tissue, and nerve damage) pediatric splinting when growth spurts require frequent splint changes, and progressive splinting such as needed for the burn patient. The majority of splinting for this group individuals is done with low to moderate temperature thermoplastics. They are predominantly used because of ease of fabrication directly on the patient. Orthoplast, Polyform, and Aquaplast are most frequently used for low temperature requirements. Because these materials do not require either a positive or negative mold, orthoses can be made and fitted within minutes instead of hours. Progressive serial plaster splinting has also been used for temporary and short-term applications.

The majority of these orthotic requirements are static in nature, while dynamic splinting is used primarily for support while allowing joint excursion. Often occupational therapists have supplied these orthotic needs. The orthotist fabricates similar orthoses with moderate to high temperature thermoplastics for heavy use requirements.

Numerous assistive self help devices for activities of daily living (ADL) are available commercially which fulfill the short term orthotic need. Fred Sammons, Inc., Cleo, Zimmer, and OEC are a few of the specialty companies who supply the majority of these items. Permanent long term orthoses of a sophisticated nature are required for the spinal cord injured patients. These patients pose a challenge to all orthotists and occupational therapists who must train the patient to use the orthoses. Between 8 and 10,000 new spinal cord traumatically injured patients occur each year. Of these 5,500 are quadriplegics, all of whom require orthotic devices to regain some degree of independence. According to Dr. John Young of the National Spinal Cord Injury Data Research Center in Phoeniz, Arizona, only 10 percent of the quadriplegics are treated in regional spinal cord centers. The remaining 90 percent are treated in acute care hospitals, rehabilitation centers, and U.S. Military facilities.

Currently five basic orthotic systems are available for use by quadriplegic patients: The Engen (Houston), IRM/NYU (Institute of Rehabilitation Medicine—New York University), Rancho (California), Engel (University of Wisconsin) and RIC (Rehabilitation Institute of Chicago) models. The IRM/NYU, Rancho, and Engel models are now currently available in kit form and must be constructed basically from flat stock

which involves a maximum amount of professional labor until all the splint adjustments are completed.

The RIC model can be constructed more quickly of either low or moderate temperature plastics. The RIC system is used in the early evaluation and training stages. It has limitations however, as special modifications and external power cannot be added easily and thus economically.

The modular system offered by Engen is the only readily assembled orthosis with a wide range of application.

The IRM/NYU orthosis now uses Nyloplex (high temperature thermoplastic) as the splint material which is a great improvement in appearance and allows interesting design solutions. Thus the availability of new thermoplastics as well as anatomical and biomechanical considerations have reflected some advances in design and fit.

Upper-limb orthotics for the arthritic has not shown any new advances though many orthoses are being constructed daily. One reason could be the lack of agreement by the medical profession in the efficacy of orthotics in relation to medical and surgical management of the arthritic patient. Little definitive research work has been done and certainly should be pursued. The work at the University of Michigan and that by Dr. Robert Bennett is a start. Investigation in the use of orthoses in rheumatoid arthritis requires active and comphrehensive action. In spite of the recommendations of the workshop sponsored by the Committe on Prosthetics Research and Development in 1973 at Hot Springs, Arkansas, no significant research has been done. A comprehensive research and development program for functional orthotic devices was recommended by the Workshop Panel especially because of the large number of arthritic patients that need help.

The following nine areas are listed in an approximate order of priority as needing further research and development:

1. *Review prehension patterns for quadriplegics.* Traditionally, the three-point prehension pattern has been stressed for quadriplegics. It is believed however, that this prehension pattern may not be best suited for this type of patient in view of the lack of sensory feedback and an interruption of the normal pattern of the kinetic chain. For example, a lateral pinch prehension pattern would permit the patient to use visual cues better in grasping objects. At the same time, this might prove useful in transfer activites and in propelling a wheelchair as it would leave the thumb "out of the way" for these activities. It is believed that this could be investigated by identifying certain necessary activities of daily living expected of a quadriplegic patient, and testing his ability in these tasks with various prehension patterns. The results could then serve as an aid to the design of the orthoses which provide a prehension pattern best suited for the quadriplegic patient.

2. *Control systems for the high quadriplegic.* At present, most externally energized systems are controlled by electromechanical transducers. It is recognized that the use of electromechanical transducers is limited by the availability of an adequate number of control sites. It is therefore recommended that other means of controlling a multiple-degree-of-freedom system be explored, e.g., myoelectric control which requires a better understanding of the EMG potentials available in the facial and cervical areas. This should be based on a mapping of these areas as well as exploration of EEG control or a hybrid system involving various control systems.

3. *Body powered/hybrid systems for quadriplegics.* It is believed that there is not only a need for more sophistication in providing function for quadriplegics but simplifications as well. As such, the work being done by Guilford which uses the effects of gravity beneficially

and thereby enhances the use of residual body power to provide hand and arm function is recognized. Other related systems provide manual control or locking of a prehension orthosis. Such body powered systems may also be incorporated, in part, in externally energized multiple-degrees-of freedom systems.

4. *Hand manipulators.* This is conceived to be an externally energized system for high level quadriplegics. These systems need not be based on an anatomic analog of the arm, but rather would bypass his shoulder, elbow, and wrist joints to simply guide the patient's hand along an XYZ axis. This is not to be confused with manipulators presently under investigation at the University of California, Los Angeles, by Lyman, which are systems that do not incorporate any part of the patient's body.

5. *Improved man-machine interface materials.* Generally, it is found that upper-limb orthoses tend to migrate distally on the patient's hand or forearm. Thus, it is recommended that better stabilization by improved attachments and materials with necessary friction characteristics be investigated.

6. *New materials.* It is felt that there is a need to investigate and develop materials that are both transparent as well as low temperature forming in order to observe injured areas in acute splinting.

7. *Improved functional orthoses for the C-6 quadriplegic.* Although wrist-driven prehension orthoses are available for this type of patient it was believed that such orthoses kinematically inhibit not only wrist movement but induce compensatory movement at the other major more proximal joints. It is recommended that the fitting of a hand orthosis distal to the wrist that may be energized either by external power or by body power be investigated. Such an orthosis would allow the patient to move his major joints, including the wrist, without inhibition by the orthosis.

8. *Improved arm sling designs.* An evalution of the designs of arm slings is believed to be in order to identify the relative value of each. It is recommended also that the vertical arm support sling be made available to a larger patient population in order to enhance the cosmesis and permit better positioning of the arm.

9. *Elbow flexion assist for ambulatory patients.* A need exists for an elbow flexion assist, which may use either external power or stored energy from the body, to aid patients with total paralysis of the upper limb, particularly those with brachial plexus lesions.

There are two remaining areas of top priority that were not mentioned in the preceding listing due to their specialized needs.

The first, and perhaps most urgent, concerns arthrists. It is recognized that very little has been done for arthritic patients. Other than the work being done by Dr. Robert Bennett and by the group at the University of Michigan referred to earlier, no real active and comprehensive action has been taken to investigate the entire problem of the rheumatoid arthritic patient. Specific reference is made to the recommendations noted at the CPRD-sponsored Workshop Panel held in May, 1973 in Hot Springs, Arkansas. In spite of these recommendations from the Workshop Panel, we are not aware of any

significant research being done in this area since that time. In view of the large number of arthritics, this is deemed a major priority item. It is generally agreed that Early Fitting Procedures must be accomplished in order to provide good professional service. Contractures and deformities can be prevented if the patient was fitted promptly and accurately. There is a definite need for more qualified personnel both in orthotics and occupational therapy to handle this problem. In addition, we feel that our educational institutions should place a much greater emphasis on current methods available.

In the area of service delivery, it was recognized that problems exist due to the unavailability of competent orthotic service. The most advanced orthotics management is presently practiced at a few select major rehabilitation centers. However, the needs of may patients requiring orthotic services are not met optimally in may areas of the country. It is therefore recommended that central fabrication facilities be encouraged to provide upper-limb orthotic services. Further, it is believed that improved prefabrication systems might aid the orthotist who treats only a limited number of patients in the course of the year. For example, a basic wrist-hand orthosis may be stocked by the orthotist and trimmed to specific needs, e.g., basic opponents orthosis, wrist support, etc.

In conclusion, it should be recognized that the development of newer devices and techniques as recommended above in itself will not result in optimum patient care. Rather, such developments should be viewed as important tools in the overall management by the rehabilitation team in which the orthotist must play an integral role. With the advent of the more sophisticated technology that is available today including environmental control systems for the quadriplegic patient, it becomes important to provide advanced training for orthotists or rehabilitation engineers to be able to provide these services.