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The Team Approach to Orthotic Management in Quadriplegia

by Wayne R. Rosen, C.O.
Janie J. McColey, O.T.R.
John H. Bowker, M.D.

This article presents the approach to orthotic intervention in quadriplegia taken at the University of Miami/Jackson Memorial Rehabilitation Center. To begin, it must be emphasized that quadriplegia implies not only loss of walking, but also loss of normal use of the hands. Since our hands are the tools with which we sustain life, a major goal of rehabilitation must be to restore the ability to independently carry out common activities of daily living such as feeding, grooming, and manipulation of devices which may allow resumption of educational and vocational goals.[9] As health care professionals in the rehabilitation field, we must be aware of advances in technique and equipment which can enhance the ever-increasing life span of this young population whose educational, economic, and social progress has been so severely curtailed.[5,6] The role of the orthotist and occupational therapist as members of the rehabilitation team is to address this very underemphasized problem of upper limb management.

When the spinal cord team is first asked to evaluate and treat a newly injured quadriplegic patient, they must take into consideration all aspects of care, not just those in their individual areas of specialization. During the acute medical phase, the emphasis is on preserving life and preventing further neurological damage. At this stage, there is little concern for joint positioning or splinting. After life-threatening problems have been addressed, however, prompt management of the upper limbs is of primary importance if we are to avoid joint stiffness and/or deformity which would interfere with the progression of rehabilitation.[13,14] This approach to the upper limbs involves a number of basic methods: frequent joint range of motion, limb positioning with and without positioning devices (temporary and permanent), dynamic orthoses (temporary and permanent), and externally powered orthoses. In our facility, spinal cord injured patients are initially placed on Roto-Rest beds. These beds, with their continuously alternating side-to-side motion, have proven to have a positive effect on the respiratory, renal and circulatory systems, as well as providing skin protection for the S.C.I. patient.[3] There is, however, potential for loss of glenohumeral and scapular mobility with its use for extended periods. We have currently adapted the bed so as to allow positioning of the shoulders in abduction and external rotation, alternating with the usual adduction and internal rotation. This change of shoulder position has been included in our regular routine of joint range of motion and should reduce the pain and stiffness that often interferes with arm placement and coordination.[13,14] Elbow flexion-forearm supination deformity is another potential problem, especially in C5 quadriplegics.[1] This may be managed by positioning the elbow in extension and pronation

between range of motion sessions. The use of thermoplastic elbow-extension splints (Figure 1), bivalved casts (Figure 2), or serial casting (Figure 3), will assist the therapist in maintaining proper position. Functional hand position should be maintained with the use of a resting hand splint (Figure 4) or a functional long opponens splint with C-bar and lumbrical bar (Figure 5), to avoid the development of a flat "simian" hand.

Once the patient is medically stable, he is able to begin a more active phase of rehabilitation, including the use of functional orthoses, if appropriate. His response to this whole process depends largely on the success of the first few days, which in turn depends on how the treatment team constructs the patient's first experiences of sitting, trunk balancing, and functional arm placement. Only when control of these factors is satisfactory will it be appropriate to introduce orthoses for function. This becomes a critical point in time for the patient and therapist, because two possible approaches to future functional activities exist. The first approach is based on the use of adaptive devices which will allow some patients to perform specific functions such as self-feeding and oral-facial hygiene. However, it is our feeling that even at this early stage, multipurpose temporary functional orthoses must be introduced if definitive orthoses are to play a useful part in the patient's life. Therapists should be prepared to fabricate and properly fit a training orthosis, which will

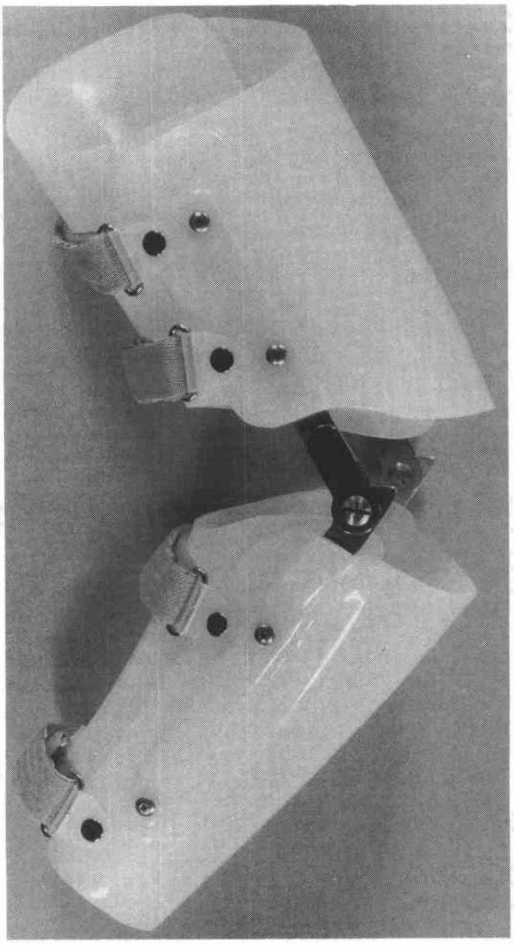


Figure 1. Elbow Control Orthosis.

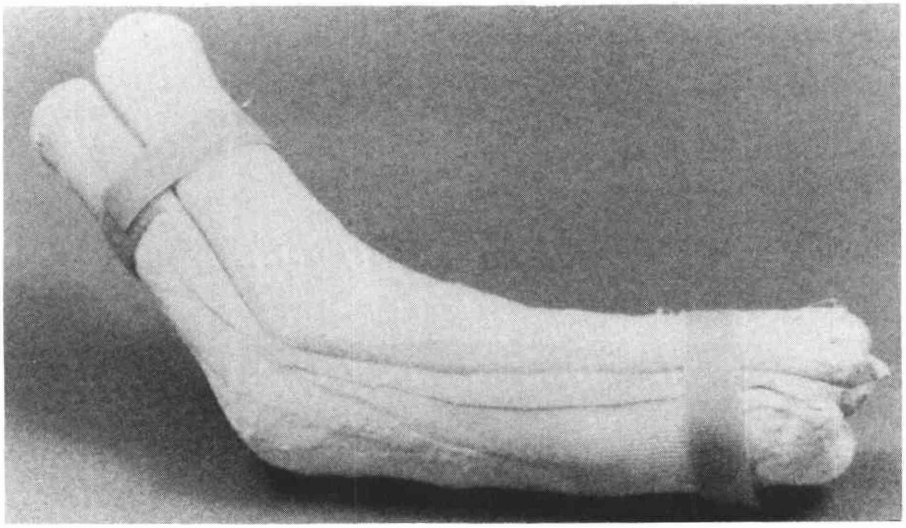


Figure 2. Bivalved plaster cast.

Figure 3. Serial casting (Plaster of Paris).

allow the patient reasonable options in developing his functional goals.[2,9,10,12]

The following chart provides guidelines for management techniques according to the level of remaining neurologic function. Many of the orthotic options listed in the "Recommended Management" column are from the N.Y.U. Upper Extremity Orthotics Manual.[7]

The guidelines listed above have been generally accepted throughout the world as the rational basis for orthotic intervention. The following variables, however, must receive equal consideration before an orthosis can be successfully fit to a patient.

Locality

The patient should reside not only reasonably close to a facility capable of adjusting his orthosis, but should have accessible transportation available if a problem arises.

Cost

Sufficient funds must be allocated to cover not only the initial cost of the orthosis prescribed but also maintenance and replacement as necessary.[15]

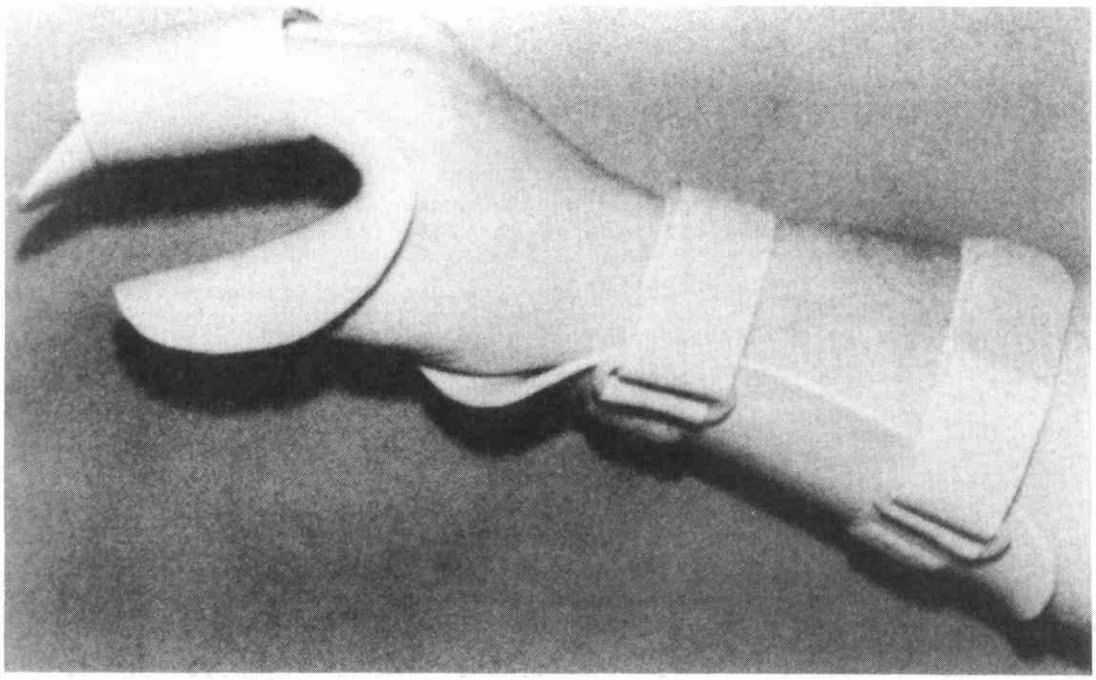


Figure 4. Thermoplastic resting splint.

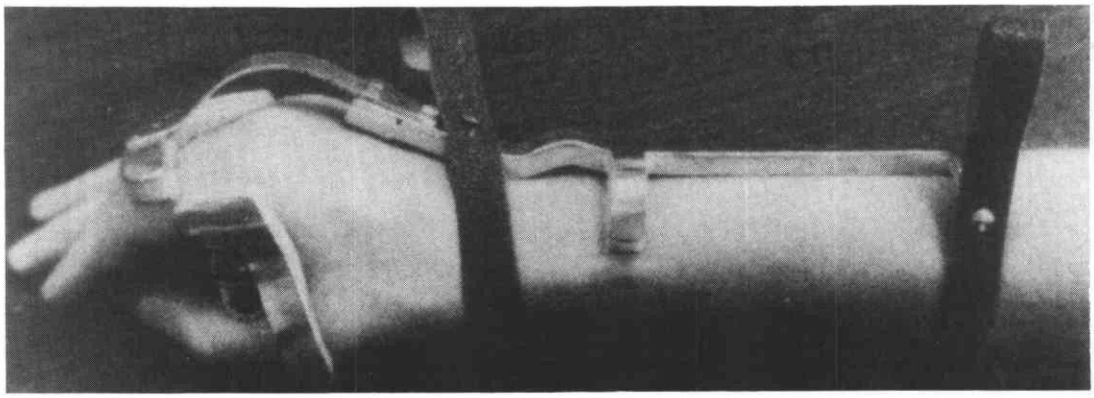


Figure 5. Long opponens with MCP extension stop.

Gadget Tolerance

The patient must have the patience to don and doff the orthosis or he will discard it because it "takes too long to apply." He may then actually prefer to sacrifice his independent performance of intricate manual tasks by either choosing a less effective piece of adaptive equipment or relying on another person for assistance. We, as practitioners, must monitor the attitude of a candidate to be sure that the function of the orthosis will be greater than the perceived inconvenience of wearing it.[2,15]

Dominance

The hand preferred prior to injury for writing and activities of daily living will usually be maintained as the dominant hand. This hand should be fit initially and the patient's progress monitored with specific activities before fitting the nondominant hand. Specific activity usage will determine whether or not the second orthosis is indicated.[9]

Vocation/Avocation

The patient's ability to perform fundamental activities of daily living is basic to maximum restoration, but it is equally important to determine additional intended uses of the orthosis, both vocationally and avocationally (i.e., manual work, desk work, telephone answering services). These data will help determine the type of materials suitable for fabrication or even the type of orthosis that would best suit the individual's needs.[12]

Psychological/Familial Roles

Assessment of the patient's psychological status is vital in establishing a treatment plan. Psychological make-up of the individual can play a very large role as to whether or not the patient will accept an orthosis. In this regard, cosmesis may play as important a role as function when dealing with a person's already altered body image. Psychological intervention is necessary to assist the patient through the stages of denial, anger, and depression to final adaptation. Indeed, the team members may need help in dealing with their own value systems regarding quality of life in relation to long term disability.

The personalities of the patient and family members, as well as those of the orthotist and occupational therapist, play important roles in rehabilitation after a spinal cord injury. An air of confidence emanates from professionals who are comfortable and confident with the task at hand. This confidence can be passed on to the patient, who will in turn become comfortable and confident with the orthosis being fitted. Too often, however, therapists and orthotists are not comfortable with the intricacies of fabricating upper limb orthoses, leaving the patient at a disadvantage as he begins his rehabilitation process, in that he may not be made aware of all the options available, but rather only those preferred by the professionals. Therefore, it is necessary to assemble a team of practitioners who are well versed in all aspects of their respective specialties so as to not hinder the patient in an already stressful situation. Family support is also extremely important as a

reinforcement of professional recommendations. Clear, concise instructions should be given to the patient and family members in order to increase the effective use of the orthosis.[9,10]

Economics

Since most orthotists in private practice cannot afford the luxury of skill maintenance for the small part of orthotic practice represented by upper limb orthotics, the majority of these devices are being made in an institutional setting, where an orthotist and occupational therapist on staff service the needs of quadriplegics. More time and energy can then be devoted, with less concern for monetary return, to fabrication and fitting of a complex device such as a wrist-driven prehension orthosis. Being on-site means quicker response time to the patient with no travel time for the practitioner, which also means that more time can be spent actually working with the patient as the need for adjustment arises. The expertise afforded by a qualified and skilled team of practitioners to the patient can only help an already trying and difficult situation.[9]

Through a team approach to orthotic evaluation of the spinal cord injured patient, the best orthosis for that individual should be provided. That does not necessarily mean the most complex or expensive orthosis. It means that, given a specific clinical picture, an orthosis is chosen based on all the factors previously discussed. The purpose of setting standards and guidelines is to increase the success rate of our patients, in allowing them every opportunity to return to a meaningful lifestyle. When this occurs, we as practitioners have done our job and can consider the input of our specialty a success. Conversely, our failures have a negative effect on both the patient and the practitioner. For the patient, it becomes a setback in that his hospital stay may be extended or, more importantly, the potential for independence may be lost because of rejection of the orthosis. For the practitioner, it may be not only a time of second-guessing, but a learning experience at the patient's expense.

Our approach to fitting of functional orthoses is as follows. All candidates for wrist driven prehension orthoses are initially fitted by the occupational therapist with a temporary training orthosis, namely the Rehabilitation Institute of Chicago (R.I.C.) tenodesis splint (Figure 6). The patient then trains for a period of time determined by the therapist. Once he has mastered this device, he can be fit by the orthotist with a definitive orthosis. The choice at our facility is the Engen wrist-driven prehension orthosis (Figures 7, 8, and 9). We feel this device best suits our needs because of ease of fit, adjustability, and cosmesis.[8] The occupational therapist trains the patient to use his orthosis for activities of daily living, including

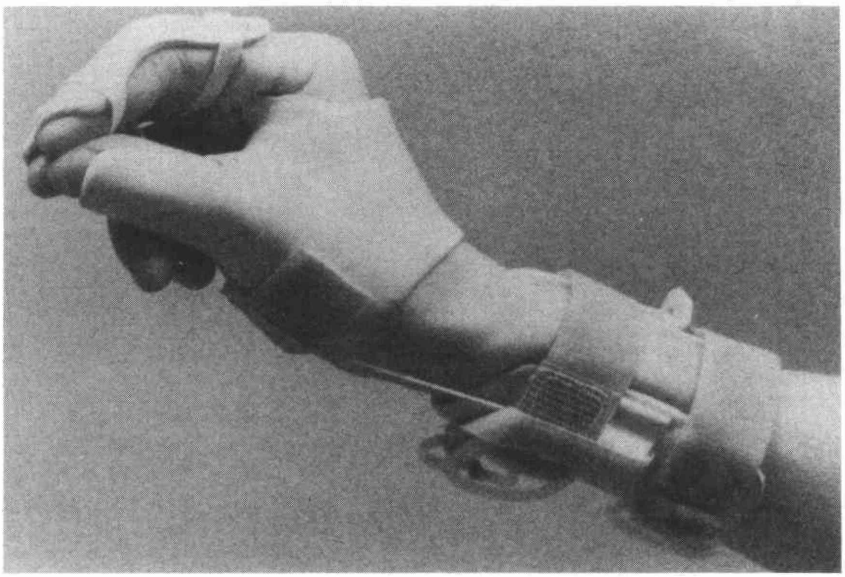


Figure 6. R.I.C., Tenodesis (temporary) splint with wrist extended and fingers apposed.

Functional Neurological Level	Residual Function (Cumulative)	Expected Deformity Without Treatment	Recommended Management
C4	Head Control Shoulder elevation	Shoulder subluxation Passive positional contractures shoulder elbow wrist hand	Complete passive range of motion 1–3 times daily (13,14) Binder, corset and/or lateral trunk supports Slings, overhead supports, lapboard, arm troughs Elbow extension or flexion orthoses Opponens orthoses with wrist control (Resting hand and/or long opponens with MCP extension stop) Balanced forearm orthoses (BFO) (may add externally powered actuator) Externally powered prehension orthoses (11) Externally powered elbow flexion assist and lock Externally powered shoulder flexion assist and lock Environmental control systems (13)
C5	Weak arm placement Elbow flexon Minimal postural compensation for trunk stability (13,15)	Shoulder abduction contracture Elbow flexion/ supination contracture (1) Passive, positional contractures wrist hand	Complete passive range of motion 1–3 times daily Power wheelchair, chin, breath or joystick control Manual wheelchair, short distance Binder, corset or lateral trunk supports Slings, overhead supports, lapboard, arm troughs Elbow extension orthoses BFO's (May delete later) Opponens orthoses with wrist control and utensil pocket assembly Externally powered prehension orthoses (May include passive or externally powered shoulder flexion assist and lock)
C6	Postural compensation for trunk stability Radial wrist extension Pronation (13,15)	Elbow flexion contracture Radial wrist deviation contracture Passive positional contractures hand	Complete passive range of motion 1–3 times daily Manual wheelchair Power wheelchair long distance only Binder, corset Elbow extension orthoses Opponens orthoses with wrist control and utensil pocket assembly Wrist driven prehension orthoses

Functional Neurological Level	Residual Function (Cumulative)	Expected Deformity Without Treatment	Recommended Management
C7	Elbow extension Wrist flexion Finger extension (13)	MCP extension/IP flexon contracture	Complete passive range of motion 1–3 times daily Manual wheelchair Possible binder, corset Basic opponens with MCP extension stop Finger driven prehension orthoses
C8	Finger flexion	Intrinsic minus deformity	Basic opponens orthoses Finger driven prehension orthoses *Note: Orthoses are rarely accepted by C8 quadriplegic patients*
T1	Intrinsic hand muscles At progressively lower levels proximal muscle function is stronger	None	None

the important function of self-catheterization of the bladder.[4] By virtue of thorough training, we feel the acceptance rate of orthoses is increased.

Unfortunately, our success rate with the Externally Powered Prehension Orthosis (EPPO) has not been as favorable as that of the wrist driven type (Figure 10). Two-thirds of all EPPOs that have been fit at our institution have not been used long-term. The feedback from our patients is that they were trained throughout the long rehabilitation process to adapt with the aid of special equipment and then, just prior to discharge, given a brace to replace the adaptive equipment. The patient who spent four to six months in the rehabilitation facility would have perhaps a week to learn to function with his new orthosis. It is hardly surprising that, in most cases, the orthosis was discarded in favor of the adapted equipment with which they were familiar. The problem has been, that for high cervical injuries, a training version of an externally powered prehension orthosis does not exist. This problem could be solved by development of a training EPPO in which the components could be reused on different patients. The only parts of the orthosis that would need to be custom-made would be the hand shells. The cost to the patient for these would be minimal and in the long run we could save the patient the cost of a very expensive "closet trophy" if he proved to be a poor candidate. We have initiated this project as a joint effort of the Occupational Therapy Department and the Department of Orthotics.

Summary

The fabrication and fitting of functional upper limb orthoses in quadriplegia requires close team work, especially between the orthotist and occupational therapist if the ultimate goal of acceptance of the orthosis as a useful aid to activities of daily living is to be achieved. We feel strongly that quadriplegics with wrist extensors should be fitted early with a functional training orthosis rather than supplied with activity-specific adaptive equipment. A confident, caring attitude on the part of the occupational therapist and orthotist can also do much toward achieving this goal. For quadriplegics with shoulder and elbow motion but no wrist extension, a training version of an externally powered prehension orthosis is badly needed for evaluation prior to ordering a definitive device. Success in the fitting of complex

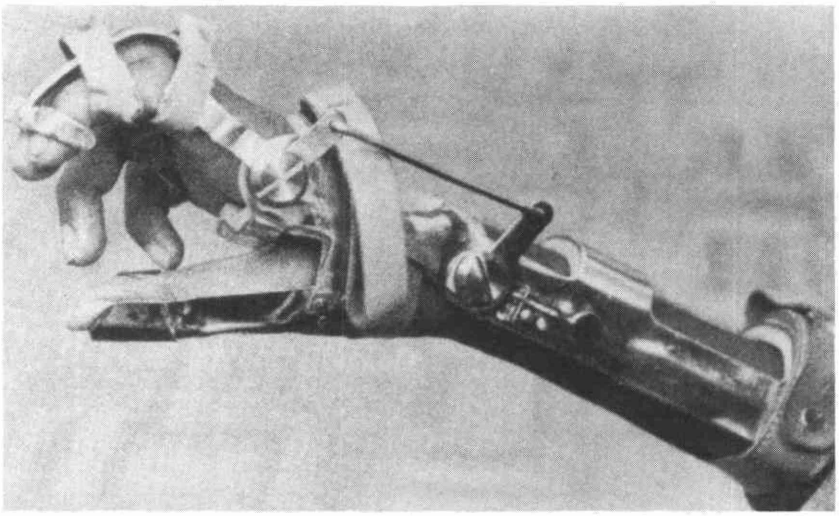


Figure 7. Wrist-driven prehension orthosis with wrist in neutral position and fingers open—Ranchos Los Amigos type.

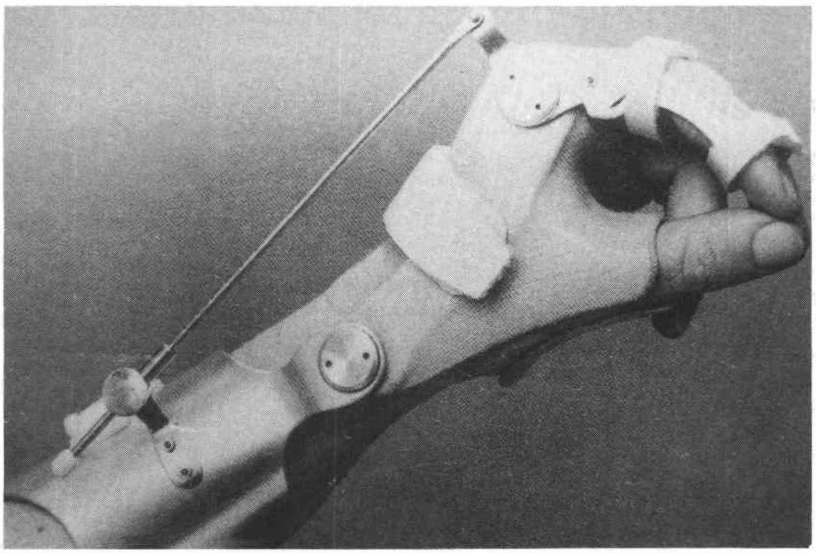
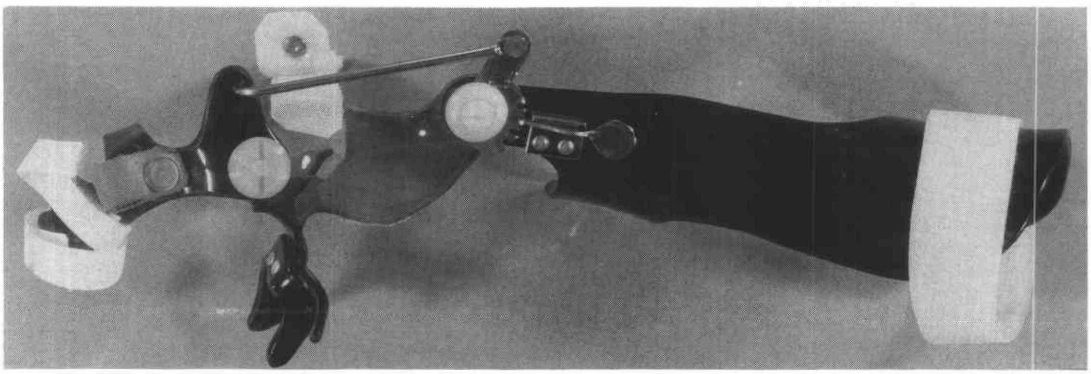


Figure 8. Wrist-driven prehension orthosis with wrist extended and fingers apposed—Engen type.

Figure 9 (below). Wrist-driven prehension orthosis (Modified N.Y.U.-I.R.M. system).



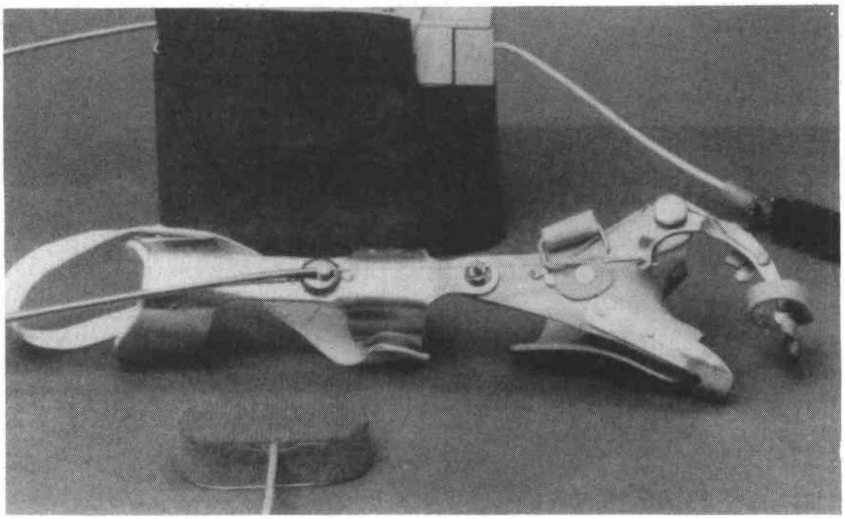


Figure 10. Externally powered prehension orthosis.

orthoses such as these requires almost unlimited "gadget-tolerance" on the part of the practitioner, if not the patient. The ultimate professional responsibility is to be equipped with both the manual skills and the objectivity to introduce all available options to our patients for their acceptance or rejection.

Authors

Wayne R. Rosen, C.O., C.P.E.D., is Chief Orthotist, Department of Prosthetics and Orthotics at the University of Miami/Jackson Memorial Rehabilitation Center, 1611 N.W. 12th Avenue, Miami, Florida 33136.

Janie J. McColey, O.T.R., is the Supervisor of Occupational Therapy, Spinal Cord Unit at the University of Miami/Jackson Memorial Rehabilitation Center in Miami.

John H. Bowker, M.D., is Professor and Associate Chairman of the Department of Orthopaedics and Rehabilitation at the University of Miami School of Medicine and Medical Director of the University of Miami/Jackson Memorial Rehabilitation Center in Miami, Florida.

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