

Wheelchair Based Upper Limb Orthotics

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Modular designed assistive devices for patients with paralysis of the upper limbs have shown continual improvement. Although the prototype production of a seven degree of freedom, powered arm orthosis¹ resulted in failure, spring load, mechanical modules with a variety of attachment options are very effective in the management of patients with bilateral paralysis of arms and hands caused by lower motor unit dysfunction or mixed lesions of the spinal cord.

The Burke Rehabilitation Center (BRC) upper limb orthotic system consists of four modules.

Shoulder-Arm Modules

The shoulder-arm module consists of a spring loaded linkage with its proximal ball bearing housing attached to a standard, adjustable balanced forearm orthosis (BFO) bracket (Fig. 1). The distal ball bearing housing contains a sleeve receptacle for forearm modules. Spring tension can be adjusted for arm weight to achieve the desired lift. This module is commercially available.*

Forearm Modules

These generally consist of standard BFO's with the following refinements:

- An adjustable mechanism which allows for the determination of the optimal pivot point of the forearm swivel (Fig. 2).
- A multi-position elbow dial as an improved method to stabilize the arm (Fig. 3).

Wrist Modules

Wrist stabilizer splints attached to the forearm trough can be provided. These can be made for temporary use from low temperature thermoplastics and from acrylic nylon (Nyoplex) for permanent use.

Terminal Modules

These range from simple to complex. Attachments to the wrist support include a universal pocket, which serves as a receptacle for meal time and grooming devices, a cup terminal for joy stick wheel control and a number of other self-help devices.

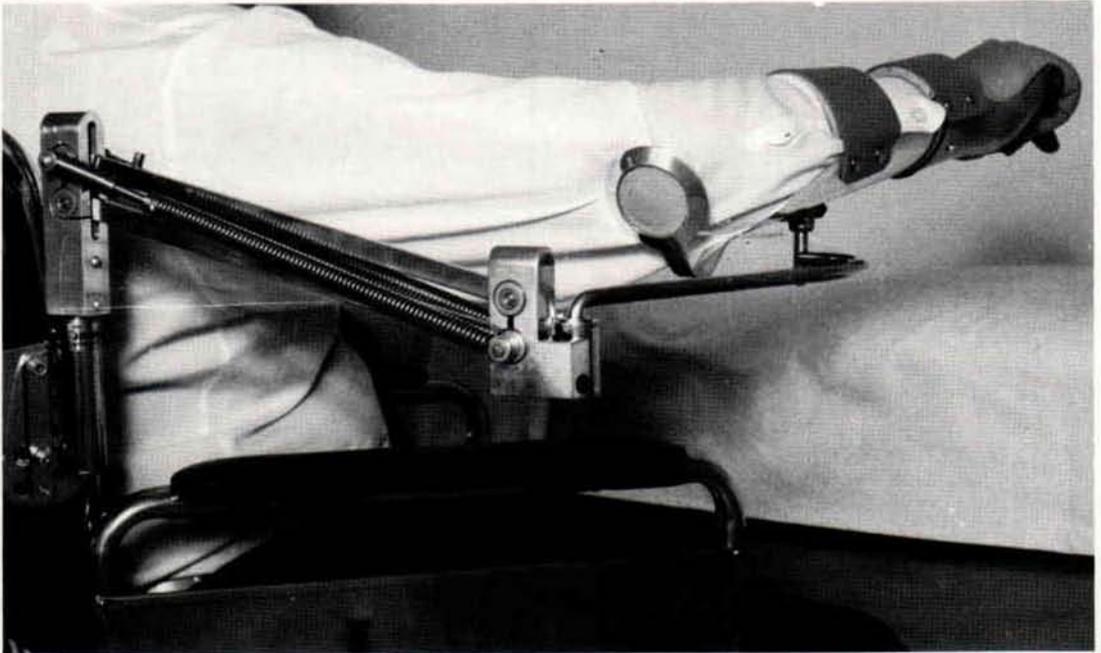


Fig. 1—Four bar spring loaded linkage attached to wheelchair.

The use of two or three jaw chuck prehension devices have been virtually abandoned in favor of key grip orthoses which come either wrist driven or externally powered with Bowden cable actuation⁴ (Fig. 4).

PRESCRIPTION PRINCIPLES

As in other branches of medicine, a good prescription requires a thorough diagnostic evaluation. This includes a kinesiological and

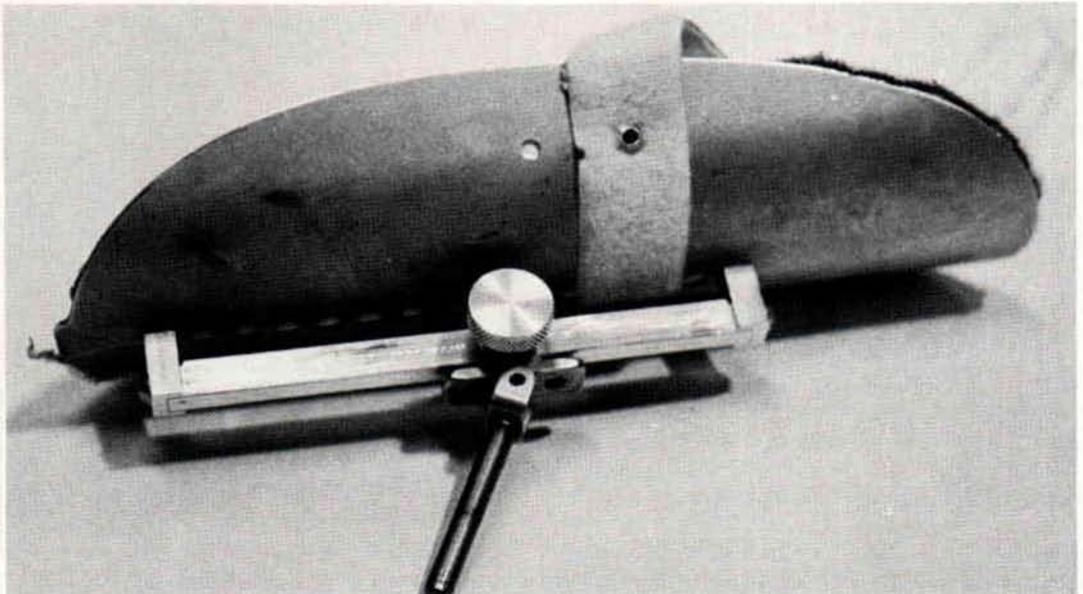


Fig. 2—Silver bar for the determination of optional pivot point.

functional assessment and sensory testing. At the BRC this is done by an occupational therapist (O.T.) in conjunction with a physical therapist (P.T.) and a nurse. The O.T. can "pull off the shelf" any or all of the modules described for an initial trial. The patient will then be brought up for a full team presentation for the physician to finalize the prescription.

Indications

The application of the BRC upper limb orthotic system (ULOS) should be considered not only for patients with bilateral upper extremity paralysis as a result of lower motor neuron disease such as Guillain Barre syndrome (GBS) and poliomyelitis, but also for mixed lesions such as spinal cord injury, multiple sclerosis and amyotrophic lateral sclerosis. Also, in rare instances, patients suffering from rheumatoid arthritis or primary muscle disease can benefit from this system. Mild to moderate spasticity is not a contraindication though severe spasticity cannot be accommodated. Patients must have wheelchair sitting tolerance with the wheelchair

back rest adjusted to at least 45 degrees. Ataxia and incoordination can be a problem which can sometimes overcome by the application of a friction device (damper) at the elbow sleeve.

Specific Criteria

Proximal muscle groups in the shoulder and arms should grade at least poor for pectoralis major and poor minus for the deltoids. Elbow flexors and extensors can grade zero, simply because gravity can be used or the patient can use muscle substitution provided the various components are set with accuracy.

There is, of course, a great deal of variation in the selection of elbow and wrist modules and a "trial and error" approach is still needed. The same pertains to the hand where a good minus strength in wrist extension is required for the flexor hinge movement to actuate the BRC key-grip orthosis.

Functional Benefits

Patients with flail arms and hands are usually even more helpless in a wheelchair than

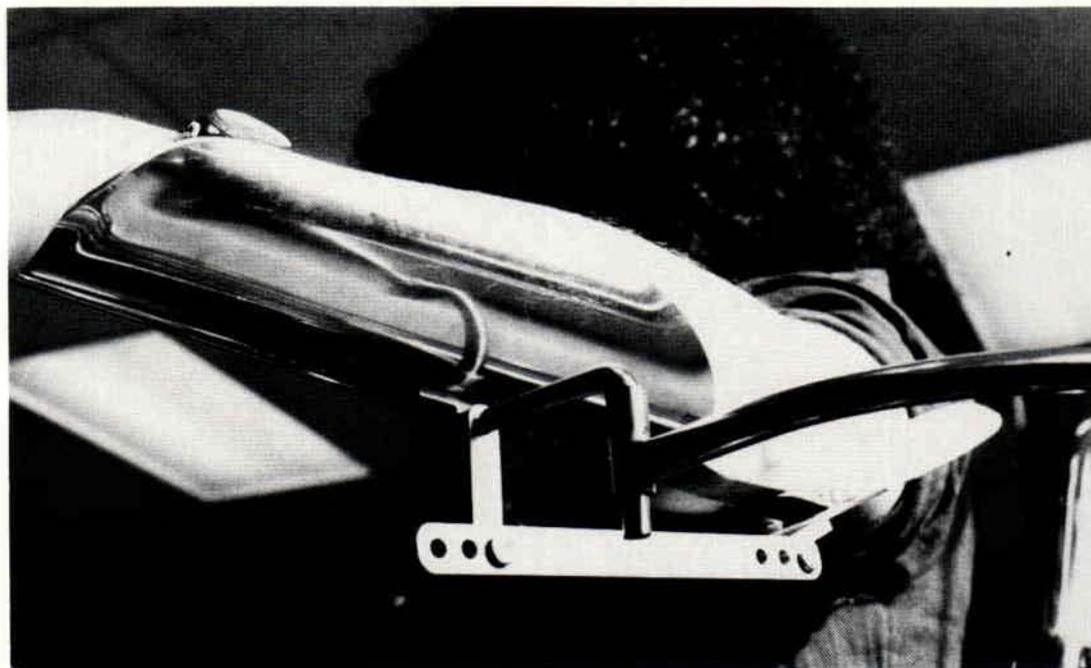


Fig. 3 - Multi-position elbow dial.

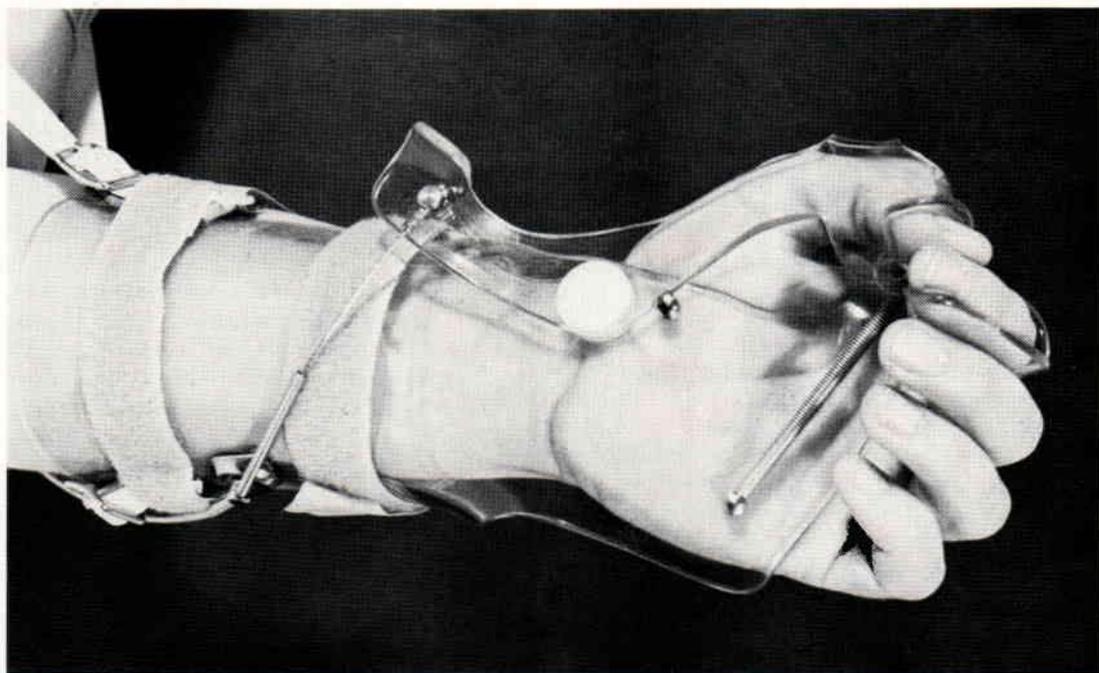


Fig. 4—Externally powered, Bowden cable activated key-grip orthosis.

in bed where at least a bed-based environmental control system can be useful. Following application of ULOS, the following activities can usually be carried out after varying lengths of training and adjustments:

- Mobility. Joy stick controlled motorized wheelchair using a cup terminal.
- Mealtime activities. Using a universal cuff terminal patients can begin to eat by themselves given tray preparation. A lap board is to be provided.
- Grooming. Again with the help of the universal cuff a variety of self-help items such as shavers, toothbrushes and combs can be used.
- Writing/Communications. A variety of self-help devices can be adapted for use with a variety of terminal devices.

DISCUSSION

The Burke Rehabilitation Center developed an entirely externally powered seven degree of freedom exoskeletal arms/leg/hand assist which failed in clinical trials as did previous attempts by others.^{5,6} Complexity of design, component breakdown and

human factors in matters of control have made such ambitious projects unusable. The described ULOS has found widespread acceptance by patients and staff alike at this institution. However, there is a need for compulsive attention to details concerning the evaluation, application and "fine tuning" of all of the components. This alone is a labor intensive process.

While using ULOS, further refinements and additions are evolving. While these will be the subject of discussion at a later time, we believe that ULOS now is mature enough to be utilized by other rehabilitation institutions who serve patients in the disease categories mentioned. At the time of this writing, we have fabricated four dozen of these devices which are mostly used in-house but at times are also given to the patient at the time of discharge. We observed an additional benefit for patients who suffer from constrictive capsulitis or just general joint stiffness in the shoulder joints as a result of prolonged immobility in bed and under cervical traction. The ULOS system allows self-ranging to supplement physical therapeutic activities. The painful discomfort of stiff joints is markedly reduced over time.

SUMMARY AND CONCLUSIONS

A relatively simple, mechanical upper limb orthotic system (ULOS) is described which consists of four different modules supporting and assisting proximal and distal residual muscle power in patients with essentially flail arms and hands. The system is labor intensive in its initial application but should be cost effective particularly when commercially produced for widespread applications in patients who suffer from spinal cord injury, Guillain Barre syndrome, post polio paralysis, multiple sclerosis, amyotrophic lateral sclerosis or primary muscle diseases.

References

1. Stern, P.H., Lauko, T., Modular Designed, Wheelchair Based Orthotic System for Upper Extremities *Paraplegia*, 12, 299-304, 1975
2. Drew, W.E., Stern, P.H., Modular Adjustment Mechanism for the Balanced Forearm Orthosis, *Archives of Physical Medicine and Rehabilitation*, Vol. 60, p. 81, 1979
3. Griswold, N., Grzymala, J., A Multi-Position Elbow Dial, *Proceedings of International Conference on Rehabilitation Engineering*, Toronto, p. 264-267, 1980
4. Stern, P.H., Griswold, N., Key-Grip Orthosis for Quadriplegic Patients, *Proceedings, World Congress, International Society for Prosthetics and Orthotics*, p. 75-76, 1977
5. Lehneis, H.R., Wilson, R.G., Jr., An Electric Arm Orthosis, *Bulletin of Prosthetics Research*, Department of Medicine and Surgery, Veterans Administration, Washington, D.C.
6. Nickel, V.L., Karchak, A., Jr., Allen, J.R., Electrically powered orthotic system, *The Journal of Bone and Joint Surgery*, Vol. 51 A. No. 2

*Available from Pro-Com, P.O. Box 325 Millington, NJ 07946

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