Orthotics and Prosthetics, Vol. 32, No. 2, pp. 21-24, June 1978

THE FUNCTIONAL RATCHET ORTHOTIC SYSTEM

David J. Hoy, C.O.[1]
Arthur W. Guilford, C.O.[2]

Because of the anatomical structure of the cervical spine, a C-5 on C-6 vertebral fracture with resulting C-6 neurological deficit is commonly observed. The residual muscle functions for this level, as described by McKenzie (1), are the shoulder flexors and abductors, scapular muscles, and elbow flexors.

Owing to improved medical care, the survival rate of individuals acquiring a high-level cervical lesion has increased over the past few years. For example, at the Rancho Los Amigos Hospital Spinal Injuries Center, a total of 985 quadriplegic patients were admitted from 1964 to 1974. Of these, 32 percent, or 314 patients, had C-5 on C-6 lesions.

Orthotic management of the involved upper-limb patient has historically presented the rehabilitation team with an enigma, especially in the case of traumatic quadriplegia. Level of independence and activity are closely related to level of lesion. Restoration of function involves many factors, including the application, acceptance, and utilization of orthotic systems.

When the lesion is complete, the sensory deficit will be complete. Incomplete lesions will display mixed evidence of both motor and sensory loss or function. Individual patient evaluations must be thorough if full advantage is to be taken of the residual functions.

The involvement of the radial wrist extensors is of great importance, for this muscle group can be utilized through the application of a wrist-driven flexor-hinge orthotic system to provide force for prehension.

The individual suffering a fracture of C-4 on C-5 lacks the residual functional musculature to power a wrist-driven orthosis. At this level of neurological deficit, the radial wrist extensors are absent, and the patient is forced to seek additional mechanical assistance.

Previous attempts to utilize external power systems have resulted in non-acceptance for a number of reasons. Both the electric and compressed gas systems previously described require a substantial amount of familiarity and expertise by the orthotist to achieve a functional application for the patients' needs (2) (3). In addition, the gadgetry of the systems required too much effort by the patient, and many were quickly discarded after the patient left the rehabilitation center.

Beard and Long (4) have conducted a 12½-year follow-up on the use of externally powered orthoses. Their findings indicate an overall usage rate of 33 percent, and that "both the poor quality of performance and the small number of activities which can be accomplished, due to limited range of motion and lack of forceful movement, lead to disuse. Without good proximal arm function, the externally powered hand splint is apparently of little value to these patients. The additional time required for application of the entire system is not justified. Poor quality of performance of activities was the reason most frequently cited by patients for disuse of externally-powered orthoses." The primary reasons for discarding the orthosis are:

1. Time required for application.
2. Poor quality of performance of activities.
3. Slow speed of performance of activities.
4. Hindrance during other activities.

To remedy these shortcomings, the ratchet principle first demonstrated at Warm Springs, Georgia (5) was utilized. In the original design, the ratchet system simply allowed the patient to maintain prehension of an object over any given period of time required to complete a task. However, it left much to be desired with respect to adaptability and adjustment.

Through a sequence of clinical applications, the ratchet (Fig. 1) has undergone several modifications. The first major change of the original design involved conversion of the ratchet principle to the existing wrist driven wrist-hand orthosis. This design utilizes opposition of the thumb and the first two fingers. A friction wrist joint was then applied to maintain stability, yet allow some adjustment of flexion and extension in a clinical setting.

The spring-activated ratchet lock in itself (Fig. 2) prohibits release of an object until the user so desires. At this point, pressure applied to the release lever of the ratchet bar frees the object held in grasp. Finger opening is accomplished through the application of a return spring system. It was noted that in a number of cases, objects had a tendency to slip under firm prehension. To remedy this problem, a prehension compression spring

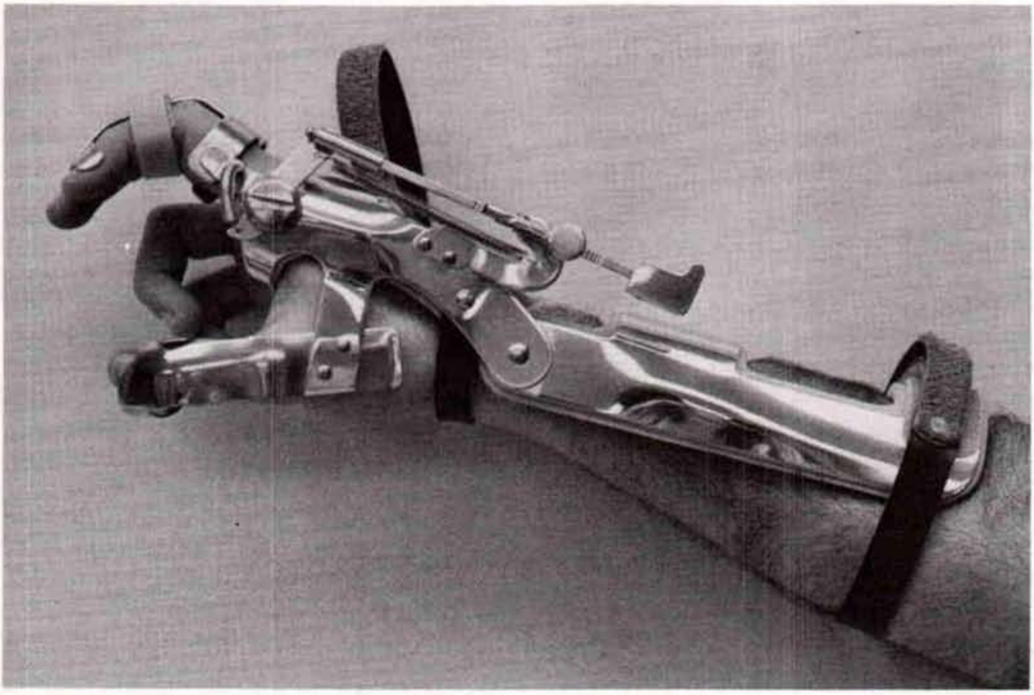

Fig. 1. Ratchet orthosis in MP extension indicating full positional opening of finger pieces.

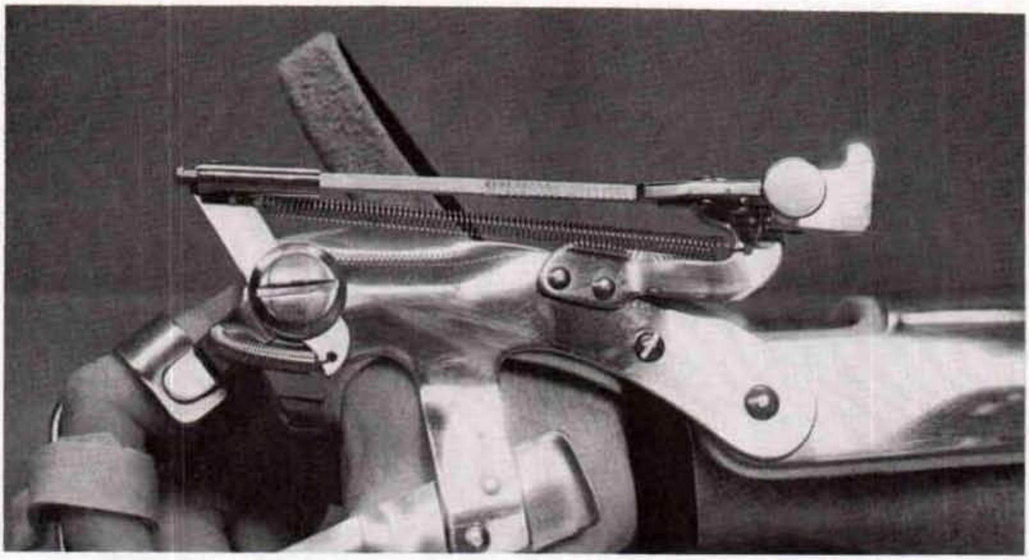

Fig. 2. Ratchet element including compression prehension component, ratchet bar, spring activated lever, and return spring system.

was devised to maintain constant pressure.

That which has been presented to this point provides a general overview to acquaint the orthotist with the ratchet principle. It must also be emphasized that this functional level of quadriplegia requires additional forms of assistive devices to attain proficient levels of activity. The ratchet is one primary component of an entire system which would ordinarily include radial mobile arm supports, a powered wheelchair, lap trays, mouth sticks, special seat cushions, etc. It is beyond the scope of this discussion to detail these items, but the practitioner must be aware if their importance in the care of the quadriplegic. A more detailed discussion of fitting indications for the ratchet is required if the practitioner is to benefit the patient. It must be kept foremost in mind that a high rejection rate of devices is prevalent in this category of patient.

Acceptance depends primarily on a well-defined purpose or rehabilitation goal. Mechanical efficiency and accuracy of fit are demanded of the orthosis. Replacement of lost function can only be achieved by the knowledgeable orthotist with the skill and dexterity to meet the challenge.

The functional ratchet orthotic system is comprised of the following component parts:

1. forearm section with proximal stabilizing strap,
2. palmar section with wrist strap,
3. finger and thumb pieces,
4. the ratchet element,
5. wrist and MP joints.

The purpose of both the forearm and palmar sections is to maintain the hand in a functional position. Careful observation must be made to ensure that the ulnar styloid and MP joints are free of obstruction so as to avoid pressure and restriction of movement.

Mechanical axes of the wrist and MP joints must match the anatomical axes as precisely as possible to avoid unwanted relative motion between the orthosis and hand. Functional opposition can be achieved only if the thumb and first two fingers are aligned properly. Both the finger and thumb pieces must be adjusted to provide direct finger and thumb tip opposition.

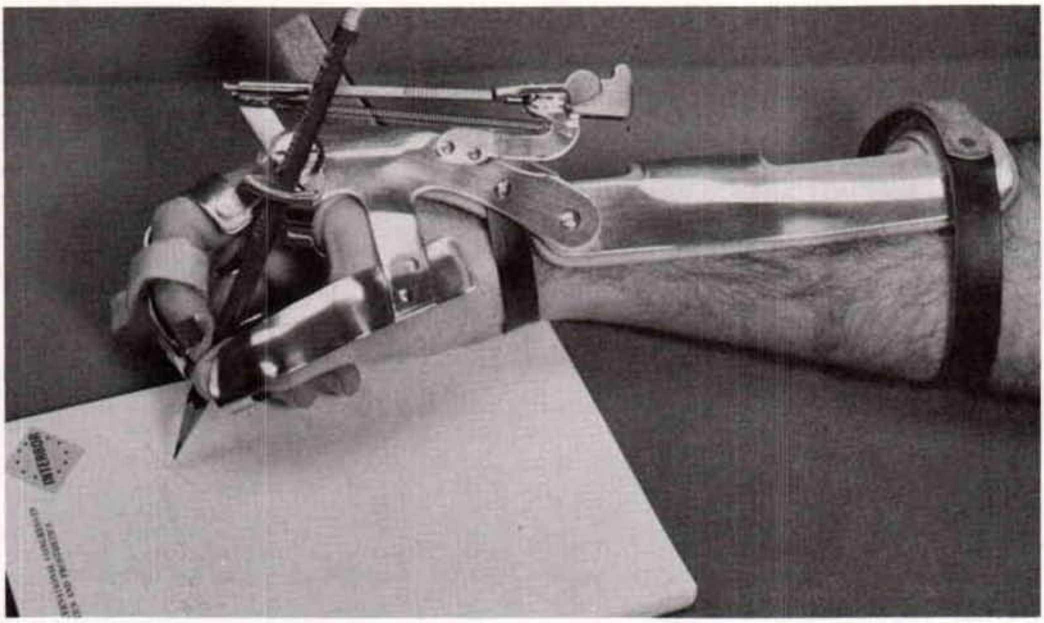

Fig. 3. Adaptive spring allows functional positioning of writing implement.

Fine adjustment on the ratchet bar is accomplished by allowing the spring-activated lever to position itself with the notched increments. To activate the ratchet and close the orthosis, the patient simply presses the finger pieces together against either the chin or the other hand. Opening is achieved by depressing the spring-activated lever and allowing the return spring to facilitate full MP extension.

Tension of the return spring system is easily adjusted by shortening or lengthening the spring. It should be noted that an adaptive spring is provided to permit use of a pen or pencil (Fig. 3). With a certain amount of training and persistence, writing can be accomplished effectively.

Training is an essential segment of the overall rehabilitation for these patients. The authors emphasize that the skills of a qualified therapist be employed to accomplish the training goals.

Although intimate fit of the orthosis is essential, fabrication need not be required of the individual practitioner. Central fabrication of these systems in component parts or completed definitive form have been utilized with a great deal of success, and are now a part of the practitioner's armamentarium.

One point should be reiterated. Because of the precision that is the essence of the hand, the orthotist is presented with his greatest challenge in any attempt toward its restoration.

Literature Cited

1. McKenzie, M.W., *"The ratchet handsplint", Am. J. Occup. Ther.*, 27, 477-9, 1973.

2. Karchak, A. Jr., J.R. Allen, V.L. Nickel, and R. Snelson, *"The electric handsplint", Orthotics and Prosthetics*, 19:2, June 1965.

3. Barber, L.M., and V.L. Nickel, *"Carbon dioxide-powered arm and hand devices", Am. J. Occup. Ther.*, 23: , 215-225, 1969.

4. Beard, J.E., and C. Long, *"Follow-up study on usage of externally-powered orthoses", Orthotics and Prosthetics*, 24:2, June 1970.

5. Licht, S.: *Orthotics etcetera*, Elizabeth Licht, New Haven, 1966.

Footnotes

1 Orthotist, Orthotic and Prosthetic Department, Newington Children's Hospital, Newington, Connecticut

2 Director, Applied Orthotic Systems, Central Fabrication Service, Fountain Valley, California