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The Basis of Orthotic Management in Quadriplegia

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Statistics indicate that there are 150,000–200,000 spinal cord injured persons in the United States.[3] Each year, approximately 10,000 newly injured are added to this figure. About 80% are males under the age of 40 years, while slightly more than half (53%) are quadriplegics, with low cervical injuries being most common.[3,4] In recent years, improved medical management has led to an increase in post-injury life expectancy in spinal cord injury to a probable 30 to 40 years.[1,2] This ever-increasing national prevalence of spinal cord injury poses major problems in rehabilitation, several of which will be addressed in this issue of *Clinical Prosthetics and Orthotics*.

When the spinal cord team first confronts a person with a cervical spine injury, the first two priorities are preservation of life itself and prevention of further damage to the spinal cord and spinal nerve roots. Immobilization of the neck, followed by traction-reduction of vertebral malalignment, is carried out concomitantly with physiologic stabilization. Special studies, including magnetic resonance imaging, are then done to determine the need for immediate surgical relief of extrinsic pressure on the cord due to residual vertebral malalignment and/or fragments of bone or intervertebral disc. Intraoperative imaging with ultrasound further aids in the identification and removal of fragments causing extrinsic pressure. The preservation or restoration of function of just one nerve root by precise surgery of this sort can make the crucial difference between a modicum of independence and total dependence in self-care. Depending on the specific injury and the surgeon's preference, stabilization of the spine may be accomplished by means of a halo external fixation system alone or by internal fixation with wires and bone grafts, supplemented by an orthosis. In either case, stabilization will expedite the rapid mobilization of the patient. At this point, a decision can be made regarding the appropriateness of orthotic fitting.

A brief mention has been made of the functional significance of each residual cervical nerve root in the quadriplegic. This may be further elaborated upon as follows:

Fourth cervical root (C-4): innervates the diaphragm, allowing independent breathing.

Fifth cervical root (C-5): innervates the deltoid and biceps/brachialis, providing shoulder abduction/flexion and elbow flexion, respectively.

Sixth cervical root (C-6): innervates the radial wrist extensors, permitting wrist dorsiflexion and a passive opposition of thumb and fingers by "tenodesis effect" of the finger flexors.

Seventh cervical root (C-7): innervates the triceps, wrist flexors and finger extensors, allowing elbow extension, wrist volar flexion, and finger extension, respectively.

Eighth cervical root (C-8): innervates the finger flexors, allowing a gross grasp.

First thoracic root (T-1): innervates the intrinsic muscles of the hand, resulting in complete hand function, including grip and a precise thumb to finger pinch.

It is important to note three features of this progressive classification to develop a clearer understanding of its relative limitations. Firstly, many muscles are supplied by two roots. The root associated with a given muscle in the list above is that which primarily innervates that muscle. The preservation of the next lower root provides not only an additional distal function, but also greater strength in the muscle just above, due to the activation of additional motor units by this secondary nerve root. Again, this argues for preservation of every possible root. Secondly, preservation of root function is often asymmetrical. For example, a quadriplegic may have a functional level of C-5 on one side and C-6 on the other. In this case, an orthotic prescription for one side will be totally inappropriate for the other. Thirdly, with nerve fiber (axon) regrowth, improvement in strength of a given muscle may occur over time. Occasionally, even the next higher root may recover as well. Monitoring by repeated muscle testing can thus lead to a progressive change in orthotic prescription. The occupational therapist, by virtue of her close daily contact during the rehabilitation process, is often the first team member to note these changes. To aid in the prognosis of muscle return, it is now possible, by advanced biofeedback techniques, to find functioning motor units in muscles considered "paralyzed" by conventional muscle testing techniques. Following identification of working motor units, it may be possible to strengthen them with biofeedback-directed exercise. This often results in the addition of another useful upper limb function with or without the help of an orthosis.

Before an upper limb orthosis can be used, the quadriplegic must be positioned so that visual feedback allows contact between a partially insensate hand and the object to be manipulated. A properly designed and carefully fitted wheelchair can, therefore, be considered the basic orthosis for the quadriplegic. Lateral trunk supports or a corset may also be essential for functional sitting posture, freeing the upper limbs from supporting the trunk.

Throughout the process of rehabilitation, the orthotist should work closely with all members of the team, but especially the occupational therapist, physical therapist, psychologist, and physician if acceptance and use of orthotic devices is to be achieved. Successfully fitted orthoses are useful not only for self-care, but can also play a major role in achieving the ultimate goal of rehabilitation, the return to gainful employment. Many types of electronic devices, including computers, are manipulated more easily with an orthosis.

In conclusion, it is hoped that this issue will be helpful in not only delineating the unique role of the orthotist in the care of the quadriplegic, but equally importantly, in demonstrating the need for communication and cooperation among all team members, if we are to offer optimum care to our patients.

References

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