

Management of Spinal Cord Injury-Induced Upper Extremity Spasticity



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KEYWORDS

- Spasticity • Spinal cord injuries • Tetraplegia • Upper extremity • Reconstructive surgery
- Tendon operations • Rehabilitation

KEY POINTS

- Spasticity affects more than 80% of patients with spinal cord injury (SCI) and is significant challenge for the treating surgeon.
- Spasticity resulting from SCI typically presents with shoulder adduction/pronation, elbow, wrist, and finger flexion (closed fist), and forearm pronation.
- Tendon lengthening, release, transfer, and selective neurotomies may prevent further contracture and improve posture and function over the long term.

INTRODUCTION

The global incidence of spinal cord injury (SCI) has been estimated at 10 to 80 new cases per million annually, which translates into approximately 250,000 to 500,000 newly paralyzed people worldwide every year¹. In about 50% of patients, SCI occurs at the cervical level, leading to a profoundly disabling tetraplegia (paralysis of all 4 extremities), mainly because of the lost arm and hand function.² As SCI remains incurable, upper extremity function is, aside from the brain, the most important functional resource of tetraplegic patients. In fact, patients judged upper extremity function to be the most desirable function to regain, before bowel, urinary, and sexual function, or walking ability. In a survey, 49% of tetraplegic individuals ranked rehabilitation of arm and hand function as the first priority, with no other goal surpassing 13%.³ Another study reported that 77% of 565 tetraplegic patients expected important or very

important improvement in quality of life if their hand function improved.⁴

Upper extremity surgery involving tendon and nerve transfers, tenodeses, and joint stabilizations can reliably reconstruct key functions.^{5–9} Restoration of elbow extension improves reaching capabilities and stabilizes the elbow, allowing for further reconstruction to achieve grasp, and the ability to swim and drive.¹⁰ Reconstructed grip eliminates the need for adaptive equipment, allows one to self-groom, feed, catheterize, manipulate objects, write, and perform productive work, and markedly improves autonomy and spontaneity, thus enhancing self-esteem for tetraplegic patients.¹¹

Spasticity affects about 80% of patients with SCI, especially those with cervical lesions and incomplete injuries. These include anterior cord syndrome, central cord syndrome, and Brown-Sequard syndrome,¹² which have increased in prevalence, mainly because of improved acute

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management and long-term rehabilitation.^{13–15} Spasticity in SCI represents a severe impairment and was, until recently, regarded as a contraindication for functional surgery.¹⁶ Consequently, it represents a seldom-described and challenging problem.^{12,17}

This article details surgical treatment options for spasticity of the upper extremity in patients with cervical SCI and tetraplegia. The authors summarize fundamentals of upper extremity spasticity and describe their experience with surgical methods to restore balance and control of the upper extremity.

CHARACTERISTICS OF SPASTICITY IN SPINAL CORD INJURY

Pathophysiological Features

Although the exact pathogenesis is still unknown, spasticity after SCI involves several features:

- Muscle hypertonicity
- Hyper-reflexia
- Clonus
- Clasp-knife responses
- Long-lasting cutaneous reflexes
- Muscle spasms (evoked by brief non-noxious skin stimuli)¹⁸

Evolution

Spasticity in SCI develops gradually over several months in a characteristic sequence:

- Spinal cord becomes areflexic (spinal shock)
- Tendon reflexes below the level of the lesion are lost
- Muscle paralysis apparent
- Flaccid muscle tone occurs¹⁹

Especially in individuals with incomplete SCI, spasticity may reduce the functional utility of residual voluntary motor control and thus severely compromise efforts at rehabilitation.

Muscle-Tendon-Joint Alterations

The pathophysiology of spasticity varies depending on the location of the lesion, but mostly develops in the antigravity muscles. Although neural mechanisms are thought to prevail, and alterations in muscle contractile properties may be less pronounced than that observed after stroke, an SCI also leads to major structural changes influencing tonicity of muscles. These changes include atrophy and fibrosis of muscle tissue because of several causes:

- Decreased myofibrillar elasticity
- Disregulation of sarcomere number

- A change of collagen type distribution and expression
- Accumulation of connective tissue
- An alteration of contractile properties, with a tendency toward tonic muscle characteristics^{18,20,21}

Useful Versus Harmful Spasticity

The many manifestations of spasticity in incomplete SCI make the assessment of the SCI patient in daily practice often confusing and challenging. As a foundation, the upper extremity surgeon needs to have a simple starting point when assessing SCI patients with spasticity. Allieu proposed a practical classification of spasticity: useful or harmful spasticity.²²

Useful spasticity can be helpful in several daily life situations (eg, finger flexor spasticity when holding an object or triceps spasticity when transferring to or from a wheelchair). It may also help to preserve muscle volume and joint-bone strength. Spasticity can be triggered by multiple stimuli or agents, such as pain (injury, wound, nerve compression), body temperature change (fever), mood change (stress, anxiety), infection (urinary tract, wound).

Harmful spasticity typically causes

- Increased muscle tone
- Involuntary movements
- Spasms (quick or sustained involuntary muscle contractions)
- Clonus (series of fast involuntary contractions)
- Pain or discomfort involving the muscles, joints, and tendons
- Joint contractures/deformities
- Hygiene problems, such as that seen with a hyperflexed elbow, adducted thumb, or clenched fist
- Transfer problems
- Abnormal posture
- Social inconveniences

Many individuals with spasticity after SCI have learned to use key trigger strategies to beneficially apply spasticity in daily life. Therefore, useful spasticity needs to be discerned before any surgical intervention is undertaken. In general, patients describe spasticity as a harmful and disturbing factor in their lives.

In a person who does not perform regular range-of-motion exercises, muscles and joints become less flexible, and almost any minor stimulation can cause severe spasticity. In this population, an acute exacerbation of spasticity also serves as a warning system when sensation is otherwise absent. For example, increased spasticity may

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