Tendon Transfers for Tetraplegia

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KEYWORDS

• Tetraplegia • Quadriplegia • Cervical spinal cord injury • Tendon transfer • Rehabilitation

KEY POINTS

- It is estimated that 65% to 75% of patients with cervical spinal cord injuries could benefit from upper extremity tendon transfer surgery.
- The goals of surgery are to restore elbow extension, as well as hand pinch, grasp, and release.
- Patients who have defined goals, actively participate in therapy, and understand expected outcomes appear to have the highest satisfaction following tendon transfer procedures.

It is estimated that in the United States there are 12,500 new cases of spinal cord injury each year and 276,000 people currently living with a spinal cord injury. Men constitute 80% of spinal cord injury victims. Approximately 45% of spinal cord injuries result in incomplete tetraplegia and 14% in complete tetraplegia. The lifetime cost of a patient with C5–8 tetraplegia injured at age 25 is estimated at $3,452,781. It is estimated that a person who sustains a C5–8 cervical spinal cord injury at age 20 will live 40 years with his or her injury.[1]

Patients with tetraplegia face many physical, functional, and psychological limitations. Physically, they have difficulty controlling the arm in space and limited or absent grip and pinch strength. Functionally, there is a decrease in mobility, activity of daily living (ADL) performance, and independence with work tasks. The appearance of the hand and patient confidence in social interactions are additional psychological challenges. When patients are asked what function they would most like restored, more patients desired hand function (75%) than bowel and bladder use (13%), walking (8%), and sexual performance (3%).[2]

The goals of surgical reconstruction of the upper limb in tetraplegia are to increase independence and upper extremity function through elbow control for reaching overhead, weight shifting, and transfer; restoration of hand function to allow lateral pinch for self-catheterization, dressing, and ADLs; and grasp and release for feeding and ADLs. Although it is estimated that approximately 65% to 75% of cervical spinal cord patients would benefit from upper extremity surgery to improve on these functional limitations, fewer than 400 of these surgeries are performed per year.[3,4] In other words, only 14% of patients who are surgical candidates actually have tendon transfer procedures.[5] A variety of reasons have been proposed to explain why so few patients have surgery, including a lack of communication among rehabilitation specialists, physiatrists, and surgeons; poor access to care; and poor knowledge that such procedures are possible. A lack of coordinated cross-specialty collaboration appears to be the greatest barrier to appropriate use of upper extremity reconstruction in patients with cervical spinal cord injury.[5]

CERVICAL SPINE INJURY AND CLASSIFICATION

Spinal cord injuries are classified using the American Spinal Injury Association (ASIA) impairment scale (**Table 1**),[6] which grades the degree of spinal

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Table 1
American Spinal Injury Association (ASIA) impairment scale

ASIA Grade	Patient Function
A	Complete, no sensory or motor preserved distal to injury, no sacral preservation
B	Incomplete sensory, sensory preserved below injury level, including sacral, no motor preservation
C	Motor incomplete, more than half of the key muscle functions below level of injury have grade <3 strength
D	Motor incomplete, at least half of motor below level grade >3 strength
E	Normal

cord injury from A to E and as complete or incomplete based on the lowest functioning cord segment. Manual motor testing graded 0 to 5 is based on the British Medical Research Scale (Table 2).[7] A motor score of 0 to 100 is given based on the sum of the motor grades in 5 key upper and lower extremity functions bilaterally. The total upper extremity score is 0 to 50 and based on elbow flexion, wrist extension, elbow extension, finger flexion, and finger abduction.

Although the ASIA classification is widely used to categorize patients with tetraplegia, the levels are too broad to make decisions about reconstructive procedures of the upper extremities. The International Classification for Surgery of the Hand in Tetraplegia (ICSHT) was developed to evaluate the upper extremity and formulate a treatment plan for patients with tetraplegia (Table 3).

Table 2
British Medical Research Scale manual motor testing

Grade	Function
5	Full motion against gravity and full resistance
4	Full motion against gravity and moderate resistance
3	Full motion against gravity only
2	Full motion with gravity eliminated
1	Trace motion/palpable or visible contraction
0	No contraction/paralysis

Table 3
International Classification for Surgery of the Hand in Tetraplegia

Class	Description
0	No functioning muscles
1	Brachioradialis
2	Extensor carpi radial longus
3	Extensor carpi radial brevis
4	Pronator teres
5	Flexor carpi radialis
6	Extensor digitorum communis
7	Thumb extensors
8	Partial finger flexors
9	All but intrinsics
X	Exceptions

The ICSHT determines the number of muscles present below the elbow with at least grade 4 strength. The muscles are listed in the order in which recovery is expected in complete tetraplegia.

PATIENT EVALUATION

A thorough history begins with age, preexisting conditions, and medications. Patients should be asked about past and present opioid use. The history of the spinal cord injury includes date of injury, method of injury, spinal cord injury level, other associated injuries, and surgical history. The patient's functional goals should be discussed to determine what activities the patient would like to regain. In evaluating the upper extremities, the examiner should identify which arm is now the dominant extremity. All muscles of the upper extremity are graded with manual motor testing. Joints are placed through active and passive range of motion. Contractures or spasticity are noted. Patients are examined for concomitant brachial plexus injuries.

The brachioradialis (BR) is palpated with the elbow flexed at 90° and the forearm in neutral rotation while active elbow flexion is resisted with a forced applied to the distal forearm. The muscle is too weak to transfer if the muscle belly can easily be displaced anteriorly and posteriorly. It also is important to determine if both the extensor carpi radialis longus (ECRL) and brevis (ECRB) are functioning. Both are usually intact if the wrist extension strength is 5/5 and there is a groove or depression distal to the lateral epicondyle with strength testing (Bean sign).[8] Allieu and colleagues[9] stated that if the pronator teres (PT) is