Novel Concepts Integrated in Neuromuscular Assessments for Surgical Restoration of Arm and Hand Function in Tetraplegia

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KEYWORDS

• Tetraplegia • Spinal cord injury • Tendon transfer
• Novel concepts • Immediate activation • Combined procedure
• Nerve transfer

In the United States alone, approximately 225,000 to 300,000 persons live with a spinal cord injury (SCI), and about 12,000 new SCI injuries occur every year, mostly in young, healthy, and active individuals in their most productive years. More than 50% of all SCIs occur at the cervical level and lead to tetraplegia.[1]

Upper extremity function is, apart from the brain, the most important functional resource of tetraplegic patients and is judged to be the most desirable ability to regain after cervical SCI before bowel, bladder, sexual function, or walking ability.[2–6] Surgical rehabilitation of arm and hand abilities can indeed meet many of patient's requirements. Although regrettably greatly underused, tendon transfer surgery is a powerful

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tool to improve upper extremity function, and an asset to enhance self-esteem and increase spontaneity.[7–10] Transfers can provide a certain amount of autonomy for persons with tetraplegia and allow them to regain meaningful roles and productive work. Restoration of hand function can eliminate the need for adaptive equipment for eating, personal care, catheterizing, and other activities of daily living.[11–13] Results from more than 500 cases in 14 studies were recently summarized, and revealed a mean increase of Medical Research Council score for elbow extension from 0 to 3.3 after reconstruction and a mean postoperative pinch strength of 2 kg, which markedly improved upper extremity usability.[10]

This article summarizes novel concepts of surgical restoration of arm and hand function based on neuromuscular assessment.

ANATOMY AND CLINICAL EXAMINATION

Muscle Testing

Surgical planning depends on preoperative evaluation of the upper extremity, and includes muscle strength tests according to the British Research Council system and International Classification of Surgery of the Hand in Tetraplegia (ICSHT) (**Tables 1** and **2**).[14]

The donor muscle must be healthy and of adequate strength (M4), preferably not injured or reinnervated, yet with limited available donor muscles; a weaker muscle (M3) may be considered for transfer. Optimally it should be synergistic, similar in architecture, and have an adequate soft-tissue bed along the route of transfer.[15,16]

Joint Range of Motion

Passive joint motion is a prerequisite for active and passive functional reconstruction. A tenodesis effect during wrist extension (hand closure), flexion (hand opening), and joint stability (primarily the thumb carpometacarpal [CMC] joint) is preferable but not required for reconstruction.

Sensibility Testing

Sensory examination focuses on cutaneous afferences of the hands with a 2-point discrimination, which should be 10 mm or better in the thumb for cutaneous control (Cu); otherwise ocular control (O) is required.

Table 1
Muscle function according to British Research Council system

Muscle Strength Grade	Muscle Function
M0	No active range of motion, no palpable muscle contraction
M1	No active range of motion, palpable muscle contraction only
M2	Reduced active range of motion—not against gravity, no muscle resistance
M3	Full active range of motion, no muscle resistance
M4	Full active range of motion, reduced muscle resistance
M5	Full active range of motion, normal muscle resistance