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SPECIAL COMMUNICATION

Rehabilitation of Supinator Nerve to Posterior Interosseous Nerve Transfer in Individuals With Tetraplegia

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Abstract

Despite being a routine part of the early surgical management of brachial plexus injury, nerve transfers have only recently been used as a reconstructive option for those with tetraplegia. Subsequently, there is limited published literature on the rehabilitation theories and techniques for optimizing outcomes in this population. This article seeks to address this void by presenting our centers' working model for rehabilitation after nerve transfers for individuals with tetraplegia. The model is illustrated with the example of the rehabilitation process after a supinator nerve to posterior interosseous nerve transfer. This nerve transfer reconstructs wrist, finger, and thumb extension. The topics covered in the model include the following: patient selection and presurgical planning/intervention, managing the postoperative healing phase of an individual who is wheelchair dependent, maximizing motor reeducation, increasing muscle strength, and ensuring use in functional tasks. This article provides a platform for further development and collaboration to improve the outcomes of patients who undergo nerve transfers after tetraplegia.

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Tendon transfers have been widely used for upper limb reconstruction after cervical spinal cord injury (cSCI) since the 1970s.[1] Nerve transfers have been a routine part of the surgical management of brachial plexus injury (BPI) since the 1990s,[2] and there are a number of recent case reports outlining this technique to improve upper limb function post-cSCI.[3-8] Similar to tendon transfers, nerve transfers rely on the identification of a working but expendable muscle in the vicinity of the proposed nerve transfer. If a suitable muscle is identified, the motor nerve to this muscle (donor nerve) can be cut and transferred to the nerve(s) of a paralyzed muscle(s) (recipient nerve[s]). Axons from the donor nerve then regenerate down through the recipient nerve(s) to reanimate the previously paralyzed muscle(s).

As is common with new reconstructive procedures, published literature has focused on documenting surgical approach and outcomes rather than rehabilitation models and techniques. In 2012, when our center commenced using nerve transfers in cSCI there was little published information about rehabilitation techniques. Information was limited to brief descriptions of postoperative care after nerve transfer in cSCI[4,8-12] and Novak's article[13] on rehabilitation techniques after BPIs.

To enable safe and effective rehabilitation of individuals undergoing a nerve transfer for upper limb reconstruction post-cSCI, a working model was developed. This model was based on available literature and the clinical experience of those within our center, where there has been an established upper limb reconstruction surgery program for individuals' with cSCI since the 1980s. The model has been adapted as new information has become available and as our direct experience with nerve transfer procedures in this client group has grown.

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This article presents our current working model for the supinator nerve to posterior interosseous nerve (PIN) transfer, which is the most common nerve transfer completed by our center.

Background on the supinator nerve to PIN transfer

The aim of a supinator nerve to PIN transfer is to reinnervate the extensor carpi ulnaris, extensor pollicis longus (EPL)/brevis, and abductor pollicis longus and the extensor digitorum communis (EDC), extensor digiti minimi, and extensor indicis (recipient muscles). This transfer is considered when an individual with an cSCI has been assessed as having a Medical Research Council (MRC) grade of 0 (ie, unable to extend the fingers or thumb) and where biceps brachii and supinator have an MRC grade of 5 (usually a C5 lesion or lower).[14] The transfer involves neurotomy of the motor branch(es) to supinator at a point as distal as possible and neurotomy of the PIN just distal to the exit of the supinator nerve from the deep branch of the radial nerve.[15] After neurotomy, the 2 are coapted.[15] The supinator can be comfortably used as a donor because the biceps brachii has been shown to reliably perform supination in the absence of the supinator.[3,7,11]

Working model for transfer of the supinator nerve to PIN post-cSCI

We have observed 5 stages of rehabilitation. These include the following: patient selection and presurgery planning/intervention, acute postsurgical management, motor reeducation, muscle strengthening, and functional use. These are each described in detail and an overview is provided in figure 1.

Patient selection and presurgery planning/intervention

Nerve transfers, similar to tendon transfers, require appropriate patient selection. The following factors are used by our center to guide patient selection: (1) cSCI where an individual has not shown any motor recovery for at least 3 months to minimize the risk of compromising natural recovery; (2) supinator and biceps brachii MRC grade of 5 to minimize the risk of deficit in the donor action; (3) supinator assessed as innervated and MRC grade of 5 since the time of injury to maximize the strength attained in the recipient (where there may or may not be evidence of a minor degree of upper motor neuron or lower motor neuron injury on electromyography in the supinator[7,16]); (4) no activity in the recipient muscles as confirmed by physical examination and electromyography to minimize the risk of compromising natural muscle return[17]; (5) surgery able to be completed between 6 and 15 months post-cSCI (for this particular nerve transfer), unless electromyography and surface electrical stimulation suggest an upper motor neuron pattern of injury, which would preserve motor end plates where a later surgery may be considered; (6) full passive range of motion within the joints that the recipient muscles act on, or joints which may respond to conservative intervention to improve range prior to surgery or before the recipient muscles are reinnervated; and (7) consensus, within the team, that the patient has some acceptance of the effect of their injury on their ongoing function, realistic expectations of the proposed surgery, willingness/ability to participate in ongoing therapy and is prepared wait ≥6 months for an outcome. The team consists of the patient, their family, the treating rehabilitation team, plastic and reconstructive surgeons, and the cSCI program occupational therapists.

List of abbreviations:

BPI	**brachial plexus injury**
cSCI	**cervical spinal cord injury**
EDC	**extensor digitorum communis**
EPL	**extensor pollicis longus**
IPJ	**interphalangeal joint**
MCPJ	**metacarpophalangeal joint**
MRC	**Medical Research Council**
PIN	**posterior interosseous nerve**

Assessing an individual's acceptance of their injury, expectations of the surgery, and their willingness/ability to engage in therapy is a challenge. Strategies that may assist include the following: (1) clear and repeated education on the surgery and postoperative rehabilitation using mediums that are suitable for the individual (ie, verbal descriptions, diagrams, videos); (2) completing specific and targeted goal setting (ie, "to be able to extend my fingers to shake hands" rather than "greet my friends as I did prior to injury"); (3) planning for managing everyday activities (eg, eating, showering, transfers, mobility) both during and immediately after the immobilization period; (4) familiarization of the individual with active, isolated supination, which will be used to activate the recipient movements; and (5) peer support and discussion with others of a similar injury level who have previously undergone nerve transfer surgery.

Baseline outcome measures are also completed presurgery. These measures are similar in concept to those used by other groups previously[17-19] and include the following: (1) British MRC grades for muscle strength of supinator, biceps brachii, and recipient muscles[14]; (2) passive range of the metacarpophalangeal joint (MCPJ) and interphalangeal joint (IPJ) measured with a goniometer[20]; (3) web space opening as defined by the distance between the distal radial edge of the nail plate of the index finger and the distal ulnar edge of the nail plate of the thumb with the wrist in neutral; (4) cutaneous sensation in the distribution of the PIN measured using the Weinstein Enhanced Sensory Test[21]; (5) assessment of pain, based on International Spinal Cord Injury Pain Classification[22]; (6) Spinal Cord Independence Measure—III[23]; and (7) Canadian Occupational Performance Measure.[24]

Acute postsurgical management

The first stage postsurgery aims to maintain the integrity of the nerve transfer coaptation while minimizing scar tissue, edema, and pain; preventing pressure areas; avoiding loss of passive range in surrounding joints; and minimizing the effect on the individuals' functioning.

The first dressing change occurs in the first 3 days postsurgery. Bulky dressings are removed leaving wound closure strips in place for 10 to 14 days. Leaving the wound closure strips in place minimizes disruption to the wound and maintains support for the healing wound. The individual wears a full arm tubular compression bandage to assist with managing edema. Elevation and retrograde massage are not able to be used because of positioning requirements. A thermoplastic splint and sling are applied to maintain the wrist in neutral, the MCPJs at 70° flexion, the IPJs at 0°, the elbow at 90° flexion, and the forearm in neutral rotation (fig 2). In bed, a folded towel is placed under the upper arm to prevent the