Nerve Transfers for the Restoration of Wrist, Finger, and Thumb Extension After High Radial Nerve Injury

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KEYWORDS

• Nerve transfer • Radial nerve injury • Wrist extension • Finger extension • Thumb extension

KEY POINTS

- High radial nerve injuries have traditionally been reconstructed using techniques of nerve repair, nerve grafting, and/or tendon transfer.
- Nerve transfer has emerged as an alternative reconstructive strategy that is supported by the literature and offers several advantages.
- For classic high radial nerve injury, nerve transfer is a reliable option to restore wrist, finger, and thumb extension.
- Nerve transfer is also applicable to radial nerve dysfunction of other etiologies, including brachial plexopathy, cervical spinal cord injury, and stroke.

Video content accompanies this article at http://www.hand.theclinics.com

INTRODUCTION

High radial nerve palsy can occur after a variety of traumatic, compressive, and iatrogenic insults to the upper extremity. It presents most commonly in association with humeral shaft fractures, complicating approximately 11.8% of these injuries.[1] The radial nerve can be injured by bony fragments during the original trauma or reduction, iatrogenic injury during open reduction and internal fixation, and by entrapment within bony callus and scar surrounding the healing fracture.

The classic high radial nerve palsy reflects injury at the level of the humeral shaft and presents with the inability to actively extend the wrist, fingers, and thumb. Unchecked by the extensors, the intact wrist and finger flexors produce a resting position characterized by a flexed wrist ("wrist drop") and partially closed palm. This leaves the patient unable to fully open the hand for the purpose of initiating grasp, rendering tasks requiring manual dexterity quite difficult.[2] Furthermore, because of the inability to stabilize the wrist during activation of the wrist and finger flexors, power grip is also diminished significantly. Without consistent splinting, passive motion can be lost and fixed flexion at the wrist and finger joints may be observed.

There is a considerable body of literature surrounding the optimal management of high radial nerve palsy, especially in the setting of humeral shaft fracture.[2] Although most authors agree that open injuries should be explored acutely, differing opinions exist regarding the timing and type of reconstruction offered when a radial nerve discontinuity is identified. The management of

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closed injuries is even more controversial, with some authors advocating early exploration and others preferring a period of observation to allow a chance for spontaneous recovery. Recent publications, including a rigorous decision analysis[3] and metaanalysis,[1] seem to demonstrate that there is no evidence of inferior outcomes when a waiting period of several months is allowed, and waiting has become a popular strategy.

Although areas of controversy persist, most published algorithms[1,4,5] for the management of high radial nerve palsy have several key features in common:

- Early exploration of open or very high-energy injuries and acute or subacute reconstruction by primary repair or nerve grafting, based on the zone of injury;
- Observation of closed injuries for a period of 3 to 6 months, followed by nerve exploration and reconstruction in patients who demonstrate no evidence of clinical or electromyographic recovery; and
- Tendon transfers for wrist, finger, and thumb extension for patients with a failed nerve reconstruction or delayed presentation.

Despite their increasing acceptance as a viable alternative to tendon transfer for the restoration of wrist, finger, and thumb extension, nerve transfers are notably absent from this outline. As such, this article aims to summarize the development of nerve transfers applicable to this clinical scenario, review the supporting literature, and provide illustrative case examples. Classic high radial nerve palsy will be examined first, followed by a discussion of nerve transfers for radial nerve dysfunction of other etiologies.

ANATOMY

The course of the radial nerve in the upper arm, and how this relates to its propensity for traumatic injury, have been extensively studied and carefully documented.[2] More pertinent to this article is a review of the branching pattern of the radial nerve in the forearm and the key anatomic relationships that guide safe and reliable dissection during nerve transfer surgery. Familiarity with the median nerve and its branches is equally important, because it is the principal donor in these nerve transfers. Branch sizes and axon counts are not discussed but are well-described in multiple anatomic studies.[6–8]

Radial Nerve

After piercing the lateral intermuscular septum in the upper arm, the radial nerve courses between the brachialis and brachioradialis muscles. Within this interval, the radial nerve branches first to the brachioradialis muscle. At or just above the interepicondylar line, the extensor carpi radialis longus (ECRL) branch arises and runs for a short distance between the brachioradialis and ECRL. The radial nerve then enters the forearm by passing anterior to the lateral epicondyle before splitting into a superficial radial sensory nerve (RSN) (which travels beneath the brachioradialis) and a deep motor branch. The deep motor component gives a branch to the extensor carpi radialis brevis (ECRB) approximately 2 to 3 cm distal to the interepicondylar line. Just proximal to the leading edge of the supinator (arcade of Frohse), 1 or 2 branches to the supinator arise from the deep surface of the motor branch. After coursing beneath the tendinous leading edge of the supinator and traversing the supinator muscle, the deep motor branch becomes the posterior interosseous nerve (PIN). During exposure, the PIN is found to be the most radial branch, the RSN is the most ulnar, and the smaller ECRB branch lies in between.

Median Nerve

The first branch from the median nerve as it travels medial to the brachial artery in the antecubital fossa is to the pronator teres (PT). This branch originates from the superficial surface of the nerve near the interepicondylar line and may be duplicate or of a single origin with rapid bifurcation before entering the PT. The median nerve then travels underneath the tendinous arch of the flexor digitorum superficialis (FDS), which must be divided to expose the underlying branches. Further distal, branches to the flexor carpi radialis (FCR) and palmaris longus (if present) originate from the deep ulnar aspect of the nerve individually, or as a single trunk with rapid bifurcation. Two or 3 FDS branches then arise from the ulnar side of the nerve, and the larger anterior interosseous nerve (AIN) arises from the radial side. The main trunk of the median nerve goes on to give rise to the palmar cutaneous branch in the distal forearm before entering the carpal tunnel.

SURGICAL TREATMENT OF HIGH RADIAL NERVE INJURY

Primary Repair and Nerve Grafting

In cases of high radial nerve injury without a nerve gap, an expedient and tension-free primary repair is a time-tested reconstructive strategy[2] that is applicable most commonly in cases of sharp laceration from penetrating trauma or iatrogenic injury during open treatment of a humerus fracture. It is only in these cases of sharp nerve transection