Combined proximal nerve graft and distal nerve transfer for a posterior cord brachial plexus injury

Case report

JOHANNES F. PLATE, M.D.,1,2 L. KIRSTEN ELY, B.A.,1 BENJAMIN R. PULLEY, M.D.,1 BETH P. SMITH, PH.D.,1 AND ZHONGYU LI, M.D., PH.D.1

1Department of Orthopaedic Surgery, Wake Forest School of Medicine; and 2The Neuroscience Program, Wake Forest University Graduate School of Arts & Sciences, Winston-Salem, North Carolina

The treatment of patients with prolonged denervation from a posterior cord brachial plexus injury is challenging and no management guidelines exist to follow. The authors describe the case of a 26-year-old man who presented to our clinic for treatment 11 months after suffering a high-energy injury to the posterior cord of the brachial plexus. A combined 9-cm proximal cable nerve graft procedure and a pronator branch to the posterior interosseous nerve transfer were performed. Satisfactory deltoid, triceps, wrist, and finger extensor recovery was noted 3 years after surgery. Patients with prolonged denervation from posterior cord injuries can be successfully treated with a combination of a proximal nerve graft and a distal nerve transfer.

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KEY WORDS • brachial plexus • posterior cord • nerve • transfer • graft • pronator branch • peripheral nerve

Delayed surgical management of traumatic BPI presents a challenge for nerve reconstruction because of the time and distance required for reinnervation of the distal target muscles.7,9 Prolonged denervation reduces the functional outcomes after grafting procedures in BPI4,5,13,20 due to progressive muscle atrophy and degeneration of the distal nerve stump, with loss of structural and trophic support of the injured axon. There is no consensus on the treatment of patients in whom conservative management fails after chronic BPI and in whom surgical intervention is required. While tendon transfers have shown success in the management of muscle deficiencies from proximal BPIs,4,9,10,18 these procedures can be extensive and demand functional sacrifice of the donor muscles in individuals with limited donor muscle.10,18

Distal nerve transfers preserve the natural position of the target and donor muscles and allow for rapid reinnervation of the denervated muscle groups to prevent atrophy.11 The combination of combined proximal nerve grafting and distal nerve transfers increases the likelihood of functional muscle recovery.2,3 The nerve graft provides regenerating axons across the defect and reinnervation of proximal target muscles, while the nerve transfer provides rapid reinnervation of the denervated distal target muscles to minimize atrophy.

In the current report, we present the case of a patient with a posterior cord BPI who underwent surgical management 11 months after the injury. Isolated posterior cord injury is uncommon, and the literature does not provide a clear guideline for surgical management. Treatment options may include nerve repair with a free nerve graft, nerve transfers, or tendon transfers. In the current case, deltoid and triceps function was restored by placing a proximal long cable nerve graft, and wrist and finger extension was restored by performing a distal nerve transfer. The combination of proximal nerve grafting and distal nerve transfer may be used to successfully treat a challenging subset of patients with prolonged, isolated posterior cord BPI.

Abbreviations used in this paper: BPI = brachial plexus injury; PIN = posterior interosseous nerve.
Case Report

History and Physical Examination. This 26-year-old man presented to the hand clinic with right upper-extremity weakness, pain, and paresthesias 11 months after a right BPI, following a motor vehicle accident, that had been managed conservatively at another institution. There was no functional improvement since the injury. Inspection revealed marked atrophy of the deltoid, triceps, and dorsal forearm muscles. There was complete loss of motor function and strength (Grade 0/5) of the deltoid and triceps. Wrist, thumb, and finger extensions were absent (Grade 0/5). There was no sensation to light touch on the dorsum of the right hand. Biceps, pectoralis major, latissimus dorsi, wrist flexion, wrist pronation, intrinsic hand muscles, and rotator cuff muscles exhibited normal strength (Grade 5/5) and function. The patient had no active elbow extension and no active wrist extension. Active shoulder abduction was limited to 90°, with compensatory movement of the torso and scapula. Vascularity was intact. Electrodiagnostic studies confirmed a complete posterior cord BPI.

Operation and Intraoperative Findings. The brachial plexus was exposed through a transverse incision 1 cm above the right clavicle and by division of the platysma and omohyoid muscle. The upper, middle, and lower trunk of the brachial plexus appeared to be healthy and intact. Electrical stimulation of the trunks revealed non-responsiveness of all muscles in the dorsal compartment of the arm and forearm.

The incision was extended inferiorly to expose the lateral, medial, and posterior cord. A large neuroma on the posterior cord (3 cm in width × 8 cm in length) was discovered extending from the clavicle to the axilla (Fig. 1A and B). Subsequent direct electrophysiological stimulation of the posterior cord failed to induce any muscular response except the latissimus dorsi. Intraoperative somatosensory evoked potential recordings confirmed no response to posterior cord stimulation distal to the lesion; however, we noted a good somatosensory evoked potential response to stimulation of the posterior division of the upper trunk proximal to the lesion. The neuroma was excised until healthy fascicles were observed in both the proximal and distal stumps.

Surgical Reconstruction. A 38-cm segment of sural nerve was harvested from the patient’s right leg. A 9-cm cable graft of three sural nerve strands was used to bridge the posterior division of the upper trunk to the posterior cord (Fig. 1C). The graft was anchored with 8-0 nylon sutures and secured with fibrin glue (Evicel, Johnson & Johnson).

After an incision in the elbow distal to the antebrachial crease, the radial and median nerves were exposed and the PIN transected proximally. One of the median nerve branches to the pronator teres was identified with nerve stimulation, transected near its muscular insertion, turned laterally, and coapted with the distal stump of the transected PIN without tension using 8-0 nylon sutures and fibrin glue. The surgical wounds were irrigated, closed, and covered with sterile dressings. The patient wore a sling for 4 weeks and started range of motion exercises and transcutaneous electrical stimulation 4 weeks after surgery.

Functional Outcome. At the 5-month follow-up, active shoulder abduction had improved to 120°, forward shoulder elevation to 130°, and extension to 20°. Deltoid strength improved to a grade of 3/5. There was no active elbow, wrist, finger, or thumb extension. Between the 5-month and 1-year follow-ups, the patient regained wrist...
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extension. At the clinic visit 1 year after surgery, we noted that wrist extension strength had recovered to Grade 2/5 and that deltoid and triceps strength had improved to Grades 4/5 and 2/5, respectively. Active shoulder forward elevation improved to 170° and abduction to 160°. At the 2-year follow-up, the patient had 40° of active wrist extension, wrist extensor strength of Grade 4/5, and finger extensor strength of Grade 4+/5.

Three years after the surgery, the patient’s upper-extremity function was markedly improved. He exhibited recovery of full active elbow extension and shoulder abduction to 180°. Full active finger extension returned, with active wrist extension to 40° (Fig. 2). Deltoid, triceps, and wrist extension strength was Grade 4+/5 (Fig. 3) and finger extension strength was Grade 4/5. Muscle bulk of the deltoid and triceps was increased significantly compared with preoperative muscle atrophy and was found to be symmetrical. There was only a moderate increase of the forearm muscle bulk. The patient was able to perform activities of daily living independently, participate in normal social activities, resume playing guitar, and engage in physical activities including push-ups.

Discussion

Management of BPI remains a challenge and there are no clinical guidelines specific to chronic posterior cord lesions. The use of extended-length nerve grafts in the scenario of longstanding lesions and chronic denervation has been disappointing because of the time needed for reinnervation of the distal target muscles. Nerve transfers, such as those involving the spinal accessory nerve and intercostal nerve, have been used for irreparable root avulsion BPI with limited success,11,21 and a vascularized nerve graft may be considered.22 Distal nerve branch or fascicular transfers have gained popularity since Oberlin et al.14 reported success in using an ulnar nerve fascicular transfer to reanimate the biceps after C5–6 BPI.

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Satisfactory results after distal nerve transfers are due to the proximity of the transferred donor nerve to the target muscles, which shortens the regeneration distance and time. However, the use of distal nerve transfers has not been described after a prolonged period of denervation.

In the present case, a distal nerve transfer in combination with a proximal nerve graft was used to address the concern of a prolonged, 11-month period of muscle denervation. The distal nerve transfer led to recovery of wrist extension between 5 months and 1 year after surgery. A distal nerve transfer may decrease the denervation interval of the distal target muscles following BPIs by providing a source of regenerating axons close to the target muscles. In a review comparing distal nerve transfers to proximal grafts for traumatic upper trunk BPI repair, 83% of patients receiving nerve transfers achieved flexion strength of Grade 4/5 or greater, whereas only 56% of patients with nerve grafts achieved Grade 4/5 or greater.

Treatment of the proximal lesion in this case was performed with a 9-cm proximal cable nerve graft to bridge the gap between the posterior division of the upper trunk and the posterior cord. In a previous study of nerve grafts for radial nerve lesions, 85% of patients receiving grafts within 6 months of injury achieved muscle strength of Grade 3/5 or better, while patients receiving grafts more than 12 months after injury experienced no useful functional recovery. At the 3-year follow-up, the patient exhibited excellent deltoid and triceps function. Successful results also have been reported in cases of axillary nerve repairs using cable nerve grafts that are a mean length of 9 cm.

The use of a distal nerve transfer in combination with a proximal graft has been described in a case 6 months after injury. In this patient, recovery of wrist extension was delayed, and deltoid function recovered earlier than wrist extension. One would expect a quicker recovery of the PIN-innervated muscle function from a distal nerve transfer. Surprisingly, the signs of deltoid and triceps recovery appeared before the wrist and finger extensor recovery in this case. One possible explanation of this phenomenon is that the functional recovery after a nerve transfer may require a more extensive cortical readaptation process than is required after a neurorrhaphy with nerve graft. Longer periods of denervation may not lead to the desired functional recovery.

Alternatively, a tendon transfer to regain wrist and finger extension could have been performed in the present case. However, nerve transfers may be preferable to tendon transfers for several reasons: (1) nerve transfers may employ redundant nerves, while tendon transfers demand the sacrifice of the donor muscle, (2) tendon transfers require dissection of the muscle bed, (3) intraoperative determination of proper length and tension during tendon transfer is difficult, and (4) tendon transfers have been associated with tightness and discomfort when used to restore function following radial nerve palsy.

For radial nerve palsy, 3 separate tendons are required to restore wrist, thumb, and finger extension, with significant donor sacrifice, disturbance of natural muscle biomechanics, fibrosis, and compromise of vascularity. In contrast, redundant motor branches from the median nerve may be transferred to the distal radial nerve or PIN for high radial nerve palsy with decreased donor-site morbidity.

In a cadaveric dissection, 74% of examined median nerves demonstrated a common branching pattern, with the branches to the pronator teres being the most proximal branches with the greatest redundancy and at least one branch being of adequate length for neurolysis and transfer to the PIN. Specifically in our young patient, a distal nerve transfer was the preferable treatment option, with a tendon transfer being a secondary procedure if functional wrist and finger recovery was not obtained.

Thoracodorsal nerve function was preserved in our patient with latissimus dorsi strength of Grade 5/5 at the initial clinic visit. Most commonly, the thoracodorsal nerve is described as originating from the posterior cord; however, this pattern was present in approximately 79% of cadaveric dissections of 57 specimens. The thoracodorsal nerve was found to originate from the middle trunk of the brachial plexus in approximately 4%. Preservation of latissimus dorsi function in this patient indicated that the zone of injury was distal to the origin of the thoracodorsal nerve from the posterior cord.

In conclusion, this report may provide guidance for the challenging treatment of patients with prolonged muscle denervation following posterior cord BPI. Delayed surgical management with a combined proximal nerve graft and transfer of the distal pronator branch to the PIN nerve can lead to successful functional recovery in these patients.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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