SCIENTIFIC ARTICLE

Shoulder and Elbow Recovery at 2 and 11 Years Following Brachial Plexus Reconstruction

Jung-Pan Wang, MD, PhD,*‡§ Schneider K. Rancy, BA,* Steve K. Lee, MD,*†
Joseph H. Feinberg, MD,*† Scott W. Wolfe, MD*†

Purpose To report short-term and long-term outcomes on a single patient cohort observed longitudinally after nerve reconstruction for adult brachial plexus injury.

Methods Eleven male patients who underwent plexus reconstruction by the same surgeon at 2 institutions presented for clinical examination 7.5 or more years after surgery (average, 11.4 years; range, 7.5−22 years). Average age at the time of operation was 35 years (range, 17−73 years). Mean delay until surgery was 5 months (range, 2−11 months). Two patients had C5 paralysis, 2 had C5−C6 paralysis, 2 had C5−C7 paralysis, and 5 had complete 5-level injuries. Outcome parameters included active range of motion (ROM) in degrees, a modified British Medical Research Council (mBMRC) scale for muscle strength, and electromyographic motor unit configuration and recruitment pattern. Differences in ROM and mBMRC between 2-year and long-term follow-up were assessed with paired-sample *t* tests using an alpha value of .05.

Results Average shoulder abduction and mBMRC at final follow-up were both significantly improved compared with the 2-year follow-up results ($P < .05$). Average elbow flexion and mBMRC increased significantly between 2 years and final follow-up ($P < .05$). Electromyographic results for 6 patients at final follow-up showed improved motor unit configuration in 10 of 15 muscles and improved recruitment in 3 of 15 muscles compared with 2-year electromyographic results.

Conclusions Patients continued to gain ROM and strength in the shoulder and elbow well after 2 to 3 years after surgery, contrary to previous reports. Although the precise mechanism is unknown, we speculate that a number of factors may be involved, including terminal collateral sprouting, maturation of motor units, improvements in motor unit recruitment, additional muscle fiber hypertrophy, or an as-yet undescribed mechanism. We recommend that patients be encouraged to continue strengthening exercises well after the initial recovery period and that more comparative long-term data be collected to expand on these observations. *(J Hand Surg Am. 2016;41(2):173−179.*

Type of study/level of evidence Therapeutic IV.

Key words Brachial plexus, nerve graft, nerve transfer, EMG, long-term.

LONG-TERM FOLLOW-UP AFTER BRACHIAL plexus nerve reconstruction is critical because of the multifaceted nature of these injuries and the extraordinary degree of impairment that brachial plexus injuries (BPIs) cause. Whereas several case reports and studies have reported long-term outcomes after nerve reconstruction, long-term follow-up has been variably described in the literature.[1−4] We were able to

*From the *Center for Brachial Plexus and Traumatic Nerve Injury, Hospital for Special Surgery; and the †Weill Medical College of Cornell University, New York, NY; the ‡Department of Orthopaedics and Traumatology, Taipei Veterans General Hospital; and the §School of Medicine, National Yang-Ming University, Taipei, Taiwan.*

Received for publication September 10, 2015; accepted in revised form November 4, 2015.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: Scott W. Wolfe, MD, Hand and Upper Extremity Surgery Service, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021; e-mail: wolfes@hss.edu.

0363-5023/16/4102-0001$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2015.11.010

identify only one case report discussing follow-up over 10 years after brachial plexus reconstruction.[1]

Previous authors have stated that 2 to 3 years are required to assess nerve transfer outcomes fully, and have suggested that patients' motor recovery plateaus within 2 to 3 years after surgery.[5] Gu et al[2] reported motor and sensory recovery in the triceps, biceps, wrist, and fingers after contralateral C7 transfer in 20 patients observed up to 2 years. Chuang and Hernon[3] reported finger and elbow flexion strength after contralateral C7 transfer in patients with at least 4 years of follow-up. Suzuki et al[4] reported the results of spinal accessory-to-suprascapular nerve transfer, and patients were observed for 2.5 years on average, with the longest follow-up at 4 years. We were unable to identify a longitudinal comparison study of short-term and long-term outcomes in the same adult patient cohort after plexus reconstruction to determine whether improvement continues beyond this 2- to 3-year window.

The purpose of this article was to report short-term and long-term outcomes of a single patient cohort observed longitudinally after reconstruction of traumatic brachial plexus palsy. We hypothesized that patients with BPIs who underwent supraspinatus, infraspinatus, deltoid, biceps, and brachialis reinnervation would continue to gain strength and range of motion (ROM) for shoulder abduction and elbow flexion well beyond 2 years.

MATERIALS AND METHODS

All patients with BPIs seen at our institution are enrolled in a secure Health Insurance Portability and Accountability Act of 1996–compliant, institutional review board–approved registry. Clinical outcome data on BPIs and peripheral nerve injuries consisting of modified British Medical Research Council (mBMRC) grade and ROM are collected prospectively at each visit by the operating surgeon.

Between 1993 and 2007, over 70 patients with BPI underwent brachial plexus reconstruction by the same surgeon (S.W.W.) at 2 different institutions. Of 23 patients who had had surgery at least 7.5 years before (21 males and 2 females), confirmed electromyogram (EMG) documentation of reinnervation was available for 20 patients. Three patients' charts were incomplete as a result of the senior author's change from one institution to another. Although the authors attempted to contact all patients for routine follow-up examination, several patients were unable to return to the office owing to travel distance; others could not be reached because of expired contact information.

Eleven male patients comprised the study cohort (Table 1). Average age at the time of operation was 35 years (range, 17–73 years). All patients were right-handed, and the dominant upper limb was affected in 8 patients. Two patients had C5 paralysis, 2 had C5–C6 paralysis, 2 had C5–C7 paralysis, and 5 had complete 5-level injuries. Six patients had upper plexus palsy; 3 were the result of motorcycle accidents, consistent with previously reported distributions of BPI causes.[6] Preoperative computed tomography myelography and intraoperative examination revealed that the most common injury was preganglionic avulsion (n = 6), followed by postganglionic rupture (n = 4) and infraclavicular lesions (n = 2). Mean delay until surgery was 5 months (range, 2–11). Long-term follow-up occurred on average 11 years (range, 7.5–22 years) after surgery.

Shoulder reconstruction

Techniques for reconstructing BPI have been well described in the literature.[5,7–16] Injured roots were routinely explored to assess for potential donor nerves. Intraoperative somatosensory evoked potential demonstrated acceptable donor roots for nerve grafts when shown to be in continuity with the central nervous system. Each donor and recipient nerve had greater than 75% preserved fascicular architecture on frozen-section histopathological analysis.[7,13] All nerves were coapted with 8-0 and 9-0 nylon under the operating microscope and were reinforced with fibrin glue.[15]

All patients underwent surgical repair within 6 months of injury with the exception of one patient who underwent radial to axillary transfer 1 year after injury. Nine patients presented with a suprascapular nerve (SSN) injury and EMG evidence of supraspinatus and infraspinatus denervation. Reinnervation of the SSN by spinal accessory nerve transfer was performed in 7 patients (patients 2, 3, 4, 5, 7, 8, and 9) and by graft from C5 to the SSN in 2 patients (patients 6 and 10). Axillary nerve reinnervation was performed by transferring the triceps long head branch in 4 patients (patients 7, 8, 10, and 11), intercostal nerves (ICNs) in 1 patient (patient 3), and the medial pectoral nerve in 1 patient (patient 9). Four patients (patients 2, 4, 5, and 6) underwent nerve grafting from C5 to the axillary nerve and 1 patient (patient 1) received a graft from the posterior cord to the axillary nerve.

Elbow reconstruction

We performed musculocutaneous nerve reconstruction by transferring fascicles of the ulnar nerve in 4 patients (patients 2, 6, 7, and 8), the medical pectoral