



Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: www.JHSGO.org

Original Research

Multiple Concurrent Decompressions for the Treatment of Upper Extremity Pain



Andrew L. O'Brien, MD, MPH, * Jessica Zimmer, BS, * Julie M. West, MS, PA-C, * Amy M. Moore, MD *

* Department of Plastic and Reconstructive Surgery, The Ohio State University Medical Center, Columbus, OH

ARTICLE INFO

Article history:

Received for publication February 1, 2022

Accepted in revised form August 31, 2022

Available online November 18, 2022

Key words:

Nerve

Pain

Plastic surgery

Surgery

Purpose: Neuropathic pain can be life altering and difficult to treat. Nerves can be compressed along their path in the upper extremities, resulting in chronic neuropathic pain. This study was performed to evaluate the effectiveness and safety of multiple concomitant distal nerve decompressions for the treatment of upper extremity nerve pain.

Methods: A retrospective review of patients from a single surgeon's academic practice was performed to identify those undergoing nerve decompressions for an indication of "pain" as the referring diagnosis between April 2020 and June 2021. The primary outcomes included patient-reported severity of pain using the Visual Analog Scale and quality-of-life measures, including level of frustration, depression, and impact on quality of life attributable to pain on a similar 0–10 Likert scale. Complications, if any, were also determined.

Results: Eleven patients were identified to have undergone multiple concurrent nerve decompressions for the indication of upper extremity pain. All sites chosen for decompression were found to be provocative, ie, elicited increased pain on examination with compression. The median number of decompressions performed was 5 (interquartile range, 4–6), ranging from 3 to 7. The mean follow-up time was 5 months (SD, 3.43 months). The average pain over the last month and the average pain over the past week had significant improvement at the final follow-up, and there was a statistically significant decrease in the patient-reported mean impact of pain on quality of life following decompressions (preoperative, 5.8; postoperative, 3.6; $P = .017$; 95% confidence interval, 0.2–4.3). No complications were identified.

Conclusions: Performing multiple concomitant nerve decompressions of the upper extremities is safe and effective in the treatment of chronic neuropathic pain following upper extremity trauma.

Type of study/level of evidence: Therapeutic IV.

Copyright © 2022, THE AUTHORS. Published by Elsevier Inc. on behalf of The American Society for Surgery of the Hand. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Neuropathic pain of the upper extremities is a debilitating condition that can result in physical impairment and impose deleterious effects on patients' quality of life.^{1–3} Following nerve injury of any degree, nerves demonstrate subsequent swelling and an increase in the diameter of the distal nerve. This can lead to nerve compression syndromes as the size of the nerve is increased in relation to the space through which it travels.^{4–6} Nerve

entrapments can cause perineural ischemia, inflammation, demyelination, and eventual degeneration, which often manifests as a constellation of symptoms, including pain, allodynia, paresthesias, and eventual muscle weakness.^{3,7–9}

Although they are the most common sites of compression, releasing the carpal tunnel and/or cubital tunnel alone may not be adequate for the treatment of refractory pain if a proximal injury has occurred, such as trauma, surgical intervention, or viral neuritis.¹⁰ In these instances, multiple nerve compression sites along the length of the nerve, from the shoulder to the hand, should be evaluated. If tenderness and pain are elicited at known compression sites and are reproducible, releasing multiple sites concurrently may improve symptoms. The purpose of this study was to describe the surgical characteristics of this unique patient

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

Corresponding author: Amy M. Moore, MD, Department of Plastic and Reconstructive Surgery, The Ohio State University Wexner Medical Center, Orlentangy River Road, Suite 2100, Columbus, OH 43212.

E-mail address: amy.m.moore@osumc.edu (A.M. Moore).

<https://doi.org/10.1016/j.jhsg.2022.08.014>

2589-5141/Copyright © 2022, THE AUTHORS. Published by Elsevier Inc. on behalf of The American Society for Surgery of the Hand. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

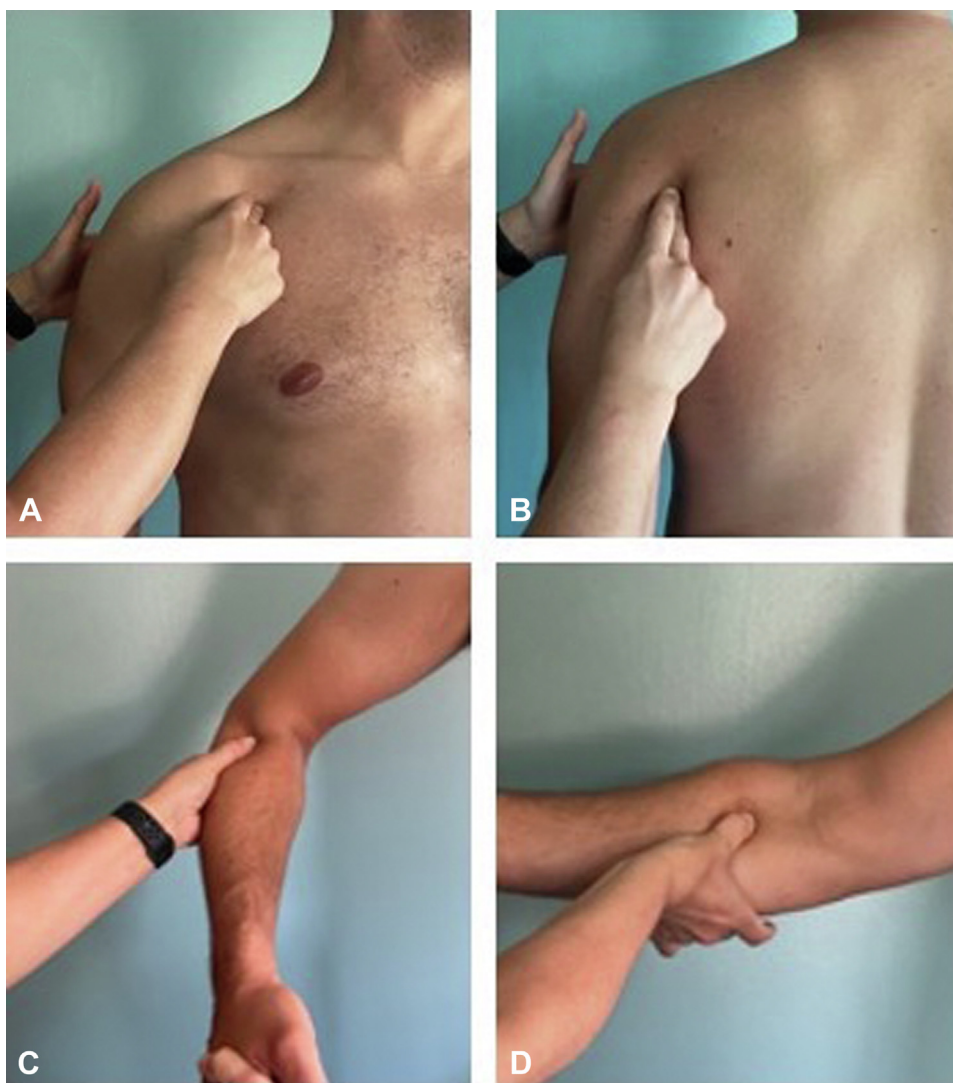


Figure 1. Physical examination of upper extremity nerve entrapment of the **A** infraclavicular brachial plexus at the pectoralis minor, **B** axillary nerve in the quadrangular space, **C** radial nerve in the radial tunnel, and **D** median nerve in the forearm.

cohort, demonstrate the safety of multiple concurrent nerve decompressions, and determine the effectiveness of multiple decompressions in the treatment of pain in the upper extremities using patient-reported outcomes.

Materials and Methods

After receiving institutional review board approval (IRB2020E0537), a retrospective review of patients from a single surgeon's academic practice was performed to identify patients who underwent nerve decompressions for an indication of pain between April 2020 and June 2021. The inclusion criteria were an age of 18 years or older, reported preoperative upper extremity neuropathic pain, and a history of nerve decompression at 3 or more distinct sites. Patients who underwent isolated nerve decompressions or concurrent nerve transfers were excluded.

The clinical examination finding that led to surgical intervention included tenderness during palpation of upper extremity nerves at known entrapment points that reproduced symptoms. The nerves of the upper extremities were evaluated at their compression sites and examined in all patients. These included the infraclavicular

plexus by the pectoralis minor muscle at the level of the coracoid, axillary nerve in the quadrangular space, ulnar nerve in the cubital tunnel and Guyon canal, median nerve in the forearm (lacertus fascia, pronator teres, and flexor digitorum superficialis arch) and carpal tunnel, and radial nerve in the radial tunnel. The specific examination included deep palpation of the nerve at the compression site of the noninvolved extremity, followed by deep palpation of the involved extremity (Fig. 1). The presence or absence of tenderness at each site was recorded.

Data were collected on patient demographics, including age at the time of surgery, sex, race, marital status, body mass index, and American Society of Anesthesiologists Physical Status Score. Surgical characteristics, including the likely etiology of insult to the extremity leading to nerve symptomatology, frequency, and the total number of anatomic sites decompressed, were reviewed.

To characterize pain, the patients were presented with a non-validated, multiple-response question using a variety of pain descriptors (Appendix, available on the Journal's website at www.jhsgo.org). Data on diagnostic evaluations were also collected, including the use of diagnostic nerve blocks, chemodenervation

Table 1
Characteristics of Patients Undergoing Multilevel Nerve Decompressions

Patient Characteristics	Total N = 11
Age (y), mean (SD)	42.46 (14.53)
Sex, n (%)	
Female	4 (36.4)
Male	7 (63.6)
Race/ethnicity, n (%)	
White	8 (72.7)
African American	2 (18.2)
Asian or Pacific Islander	1 (9.1)
Marital status, n (%)	
Single	76 (7.2)
Married	143 (13.5)
Divorced or separated	325 (30.7)
ASA class, n (%)	
Class 2	9 (81.8)
Class 3	2 (18.2)
BMI, mean (SD)	26.9 (4.14)
Follow-up time (mo), mean (SD)	5 (3.43)

ASA, American Society of Anesthesiologists; BMI, body mass index.

with botulinum toxin injections, and preoperative electromyography studies.

The primary outcomes included patient-reported severity of pain and quality-of-life measures. The patients were asked to recall the severity of their pain on average over the last month and at its worst in the last week. The severity of pain was assessed using the Visual Analog Scale on a 11-point Likert scale, with 0 representing no pain and 10 representing the most severe pain. Similar 11-point Likert scales were used via nonvalidated questions (Appendix, available on the *Journal's* website at www.jhsgo.org) to assess the patient-reported level of depression, level of frustration, and impact on quality of life attributable to their pain; higher scores represented worse symptoms. These patient-reported data were obtained before and after surgery at each patient's most recent follow-up. The secondary outcomes included pharmacologic therapies used to treat upper extremity pain in the patients both before and after surgery.

Descriptive statistics were performed using proportions and means for categorical and continuous variables, respectively. Paired *t* tests were performed to assess the repeated measures of parametric continuous patient-reported outcomes, and Paired Wilcoxon tests were used if continuous variable distributions were found to be nonparametric using the Shapiro-Wilk test. McNemar tests were used to assess the repeated measures of categorical outcomes. The Mann-Whitney U test was used to compare nonparametric continuous variables.

Results

Upon retrospective review, 11 patients were identified to have undergone concurrent multiple nerve decompressions for the indication of upper extremity pain. In this cohort, the mean age of the patients was 44.8 years (SD, 16.2 years), ranging from 23 to 69 years. Most patients had American Society of Anesthesiologists class 2 ($n = 9$), with the remaining patients having American Society of Anesthesiologists class 3 ($n = 2$). The mean follow-up time was 5 months (range, 1.6–17.7 months). Additional demographic data are displayed in Table 1.

The most common etiology of proximal extremity injury leading to nerve symptomatology (ie, pain, paresthesia, and dysesthesias) was trauma ($n = 5$), followed by iatrogenic causes ($n = 2$), oncologic causes ($n = 2$), brachial neuritis ($n = 1$), and others ($n = 1$)—a case in which the patient underwent a period of accelerated growth

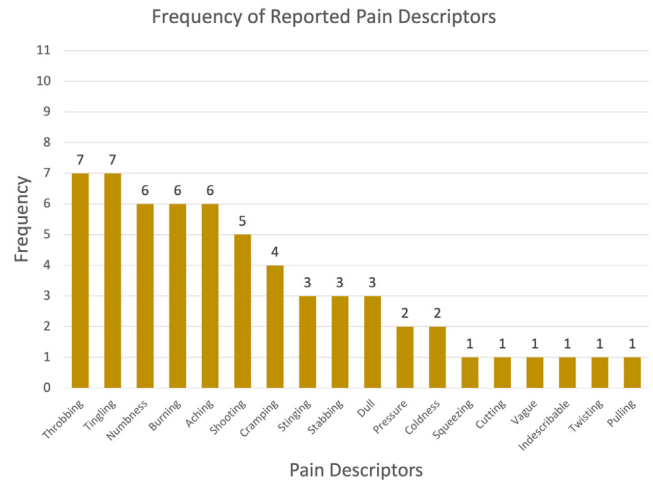


Figure 2. Histogram of patient-reported pain descriptors of upper extremity pain at presentation.

(6–8 inches in height over 1 year), with subsequent idiopathic upper extremity pain. Among patients presenting with traumatic etiologies, the mechanisms of injury included proximal gunshot wounds, and traction injuries due to heavy lifting and abrupt pulling of the arm while holding a dog on a leash. The average time from the traumatic injury to surgery was 24.6 months (range, 7–81 months). Before surgery, the patients presented with pain that was most frequently described as “throbbing” and “tingling” ($n = 7$, 63.6%), followed by “numbness,” “burning,” and “aching” ($n = 6$, 54.5%). The frequencies of each reported pain descriptor can be found in Figure 2. Ten patients underwent preoperative electrodiagnostic studies, 8 of whom were found to have abnormal findings, ranging from mild carpal tunnel syndrome to panbrachial plexopathy, whereas 2 did not show any evidence of neuropathy. Three patients had undergone diagnostic ultrasound-guided interscalene and/or pectoralis minor nerve blocks using 1% lidocaine, which was performed by a physiatrist, to which only 1 reported reduction in pain. Lastly, 2 patients underwent preoperative chemodenervation of the pectoralis minor with botulinum toxin injections, both of whom reported subsequent improvement in their pain. The patients were indicated for surgical decompression if tenderness with compression was found during examination at the site of known compression points.

The median number of decompressions performed was 5 (interquartile range [IQR], 4–6), ranging from 3 to 7 (Fig. 3). The most commonly decompressed sites were the cubital tunnel and radial tunnel, each decompressed in 10 of the 11 patients (90.9%) (Fig. 4). In 2 of the 10 patients who underwent cubital tunnel release, subfascial transposition of the ulnar nerve at the elbow was also warranted: 1 in the setting of revision decompression and 1 that displayed overt tension in situ with observable tethering and flattening of the nerve with full elbow flexion. The next most common was decompression of the median nerve in the forearm, with attention to releasing the lacertus fascia and the tendinous arch of the flexor digitorum superficialis ($n = 8$, 72.7%), carpal tunnel ($n = 8$, 72.7%), and Guyon canal ($n = 8$, 72.7%). Pectoralis minor tenotomy was performed in 6 patients (54.4%), and decompression of the axillary nerve in the quadrangular space was performed in 4 patients (36.4%). In a single patient, the medial antebrachial cutaneous nerve was found to be encased in a scar; thus, it was treated with neurolysis. No minor or major—those requiring reoperation—complications occurred in any patients.

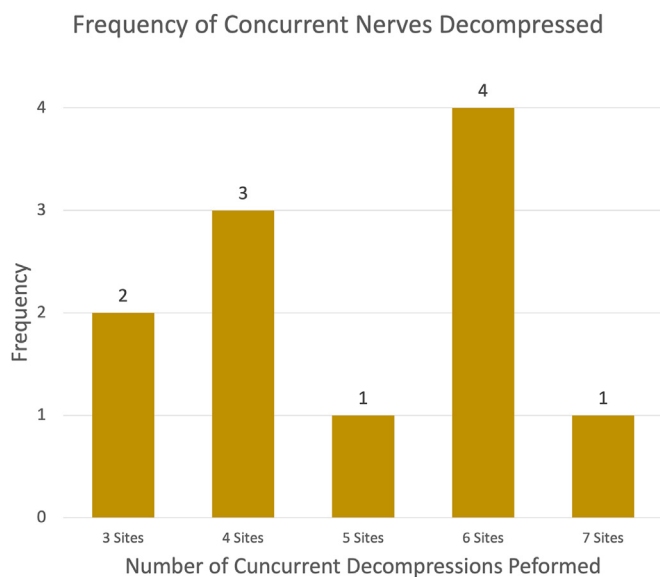


Figure 3. Histogram of the number of concurrent decompressions performed per patient.

With respect to patient-reported outcomes, the mean score for the “average pain in the last month” was 6.1 (SD, 2) before surgery, which decreased to 3.9 (SD, 1.8) after surgery ($P = .008$; 95% confidence interval, 0.54–4), with a mean difference of 2.3. The median score for the “worst pain in the last week” was 8 (IQR, 6–8.5) before surgery and 3 (IQR, 3–5.5) after decompressions ($Z = -2.8$; $P = .005$). The median level of depression attributable to pain was reported to be 3 (IQR, 0–6) before surgery and 0 (IQR, 0–4) after surgery; however, this was not a statistically significant change ($Z = -1.5$; $P = .123$). The level of frustration decreased, with a mean difference of -1.7 , from 4.4 (SD, 3) before surgery to 2.7 (SD, 2.3) after surgery ($P = .075$). The patients reported a statistically significant decrease in the impact of pain on their quality of life, with a mean score of 5.8 (SD, 1) before surgery and 3.6 (SD, 2.6) following decompressions ($P = .017$; 95% confidence interval, 0.2–4.3). The data are presented in [Table 2](#).

Before surgery, 3 patients (27.3%) reported taking opioids for their upper extremity pain, whereas no patients continued to report using opioid medications after decompression ($P = .25$). Furthermore, there was a statistically significant reduction ($P = .016$) in the proportion of patients taking nonsteroidal anti-inflammatory drugs before surgery ($n = 8$, 72.7%) compared with that of patients taking nonsteroidal anti-inflammatory drugs after surgery ($n = 1$, 9.1%). Four patients (36.4%) reported regularly taking acetaminophen for their pain before surgery compared with 1 (9.1%) who took it after surgery ($P = .25$). Five patients (45.5%) were taking neuromodulators, either pregabalin or gabapentin, before surgery, and 4 (36.4%) continued to take these after surgery ($P = .22$). Lastly, there was a statistically significant decrease in the number of medication classes taken after surgery (median, 0.5; range, 0–1) compared with that of medication classes taken before surgery (median, 1; range, 0–4; $P = .007$).

Discussion

Patients presenting with neuropathic upper extremity pain of varying etiologies pose a diagnostic challenge. Proximal extremity injuries can lead to either a direct insult to the nerves or transient crush and/or stretch injuries, resulting in changes within the nerve that can lead to pain. For instance, nerve injuries (including stretch

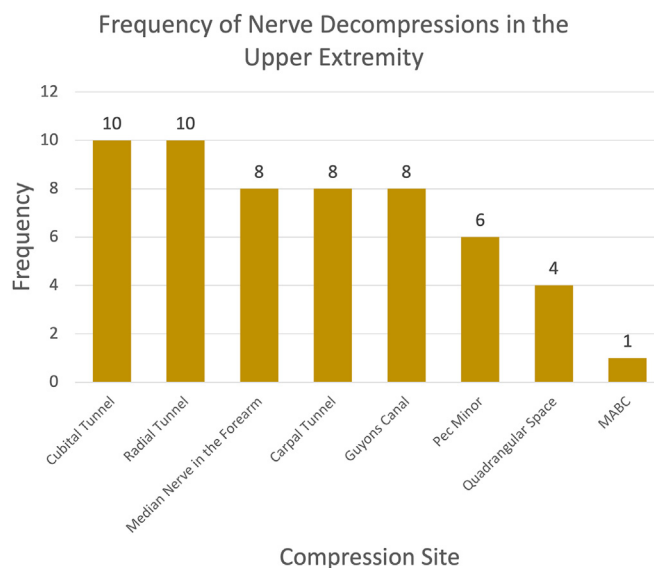


Figure 4. Histogram of total decompressed sites of nerve entrapment. MABC, medial antebrachial cutaneous nerve.

or compression insults) cause increases in the diameter of the distal nerve that can lead to symptomatic nerve compression at known points of entrapment along the upper extremities.^{4,6,11} The patients in this cohort presented with a complaint of generalized, often nonspecific, but life-altering pain—many without motor or sensory deficits. Tenderness and pain that could be elicited at compression sites and reproducible with the patient’s symptoms were indicators for surgery. This study demonstrates that with appropriate patient selection, improvements in patient-reported pain and quality of life may be safely realized by performing multiple concurrent nerve decompressions.

In our cohort, the majority of the patients presented with a history of a proximal extremity injury, often at the level of the brachial plexus. The most common etiology of nerve injury was trauma, specifically, the result of a gunshot wound or a traction-like injury involving the shoulder or neck, ie, a dog on a leash suddenly pulled the shoulder. Patients who presented with an iatrogenic etiology had a history of proximal upper extremity instrumentation, ie, shoulder arthroscopy with biceps tenodesis or first-rib resection. These events led to the development of pain, which was often worked up thoroughly, without a clear diagnosis. In the absence of defined nerve distribution or motor weakness, chronic generalized neuropathic pain may imply multilevel compressive neuropathy and warrants thorough evaluation—including isolated manual palpation—of these entrapment sites.

The selection of appropriate patients for decompression requires keen clinical examination but starts with the appreciation of the possibility of proximal injuries based on history. A thorough sensory and motor examination is performed, and manual compression of known entrapment sites is performed and compared bilaterally. Tenderness and pain elicited at the sites and reproducible with the patient’s symptoms are indicators for surgery and serve to aid in both diagnosis and surgical planning. As our data demonstrated, patients present with variable subjective symptomatology, and diagnostic studies often have limited utility; diagnostic blocks and chemodenervation may only identify proximal points of compression, if at all, and electrodiagnostic findings are often inconsistent and inconclusive. Further, patients often see many specialists, including shoulder surgeons, spine surgeons, pain specialists, and neurologists, prior to referral to a nerve surgeon.

Table 2
Comparison of Preoperative and Postoperative Pain Severity and Quality-of-Life Measures (n = 11)

Characteristics	Preoperative VAS	Postoperative VAS	P Value
Average pain in the last mo, mean (SD)*	6.1 (2.1)	3.8 (1.8)	.008
Worst pain in the last wk, median (IQR) [†]	8 (6–8.5)	3 (5.5)	.005
Level of depression attributable to pain, median (IQR) [†]	3 (0–6)	0 (0–4)	.123
Level of frustration attributable to pain, mean (SD)*	4.4 (3)	2.7 (2.3)	.075
Impact of pain on quality of life, mean (SD)*	5.8 (1)	3.5 (2.6)	.017

VAS, Visual Analog Scale.

* Paired t test.

[†] Paired Wilcoxon test.

Once indicated for surgery, the nerve releases are determined based on a physical examination and performed in a standard fashion. A bulky dressing is applied, without immobilization. After surgery, patients begin a nerve glide exercise program within 7 days following decompressions. Nerve glides serve to harness the concept introduced by Wilgis and Murphy¹² that nerves experience longitudinal excursion throughout the range of motion of adjacent joints. Nerve glide exercises serve to stretch and minimize adhesions through direct mobilization, reduce perineural edema, improve venous return, and decrease pressure within the nerve.^{13–15} In the early postoperative period, patients often report changes in their symptoms, such as increased tingling, sensation, and, in some cases, improvement in motor and sensory function. In our cohort, the patients reported improvements in the severity of their pain and quality of life early and were maintained until the final follow-up. Although surgery itself presents an inherent risk, there were no complications, including no worsening of pain symptomatology, in any patient. Our results demonstrate that performing multiple decompressions for the treatment of neuropathic pain is safe and effective.

Our study is not without limitations. The small sample size limited the statistical power of the analysis and likely introduced type II errors into the interpretation of the data. Furthermore, the case series design of our study precluded the use of a formal control cohort and more rigorous methodology, such as blinding, to limit potential confounding. The retrospective nature of this study also limited the available data and introduced a bias. The patient-reported data instruments used were mostly nonvalidated. Finally, the use of patient-reported outcomes over numerous recall periods may have introduced a recall bias; however, we believe that the longer 1-month recall period allowed for the representation of baseline pain, whereas the shorter 1-week recall period allowed for more acute recollection of pain at its worst.

Upper extremity pain can be a result of multiple compressions of the distal nerve. Our study serves to report a cohort with upper

extremity pain associated with multiple nerve entrapments as well as demonstrate the effectiveness and safety of concurrent multiple nerve decompressions for the treatment of such pain.

References

- Novak CB, Katz J. Neuropathic pain in patients with upper-extremity nerve injury. *Physiother Can.* 2010;62(3):190–201.
- Jensen MP, Chodroff MJ, Dworkin RH. The impact of neuropathic pain on health-related quality of life: review and implications. *Neurology.* 2007;68(15):1178–1182.
- Novak CB, Anastakis DJ, Beaton DE, Mackinnon SE, Katz J. Biomedical and psychosocial factors associated with disability after peripheral nerve injury. *J Bone Joint Surg Am.* 2011;93(10):929–936.
- Wilson TJ, Kleiber GM, Nunley RM, Mackinnon SE, Spinner RJ. Distal peroneal nerve decompression after sciatic nerve injury secondary to total hip arthroplasty. *J Neurosurg.* 2018;130(1):179–183.
- Stoebner AA, Sachanandani NS, Borschel GH. Upper and lower extremity nerve injuries in pediatric missile wounds: a selective approach to management. *Pediatr Surg Int.* 2011;27(6):635–641.
- Nassif T, Steiger E. Post-traumatic distal nerve entrapment syndrome. *J Reconstr Microsurg.* 1999;15(3):159–170.
- Flynn LS, Wright TW, King JJ. Quadrilateral space syndrome: a review. *J Shoulder Elbow Surg.* 2018;27(5):950–956.
- Mackinnon SE, Dellon AL, Hudson AR, Hunter DA. Chronic nerve compression—an experimental model in the rat. *Ann Plast Surg.* 1984;13(2):112–120.
- Mackinnon SE, Novak CB. Clinical commentary: pathogenesis of cumulative trauma disorder. *J Hand Surg Am.* 1994;19(5):873–883.
- Novak CB, Mackinnon SE. Multilevel nerve compression and muscle imbalance in work-related neuromuscular disorders. *Am J Ind Med.* 2002;41(5):343–352.
- Zaidman CM, Al-Lozi M, Pestronk A. Peripheral nerve size in normals and patients with polyneuropathy: an ultrasound study. *Muscle Nerve.* 2009;40(6):960–966.
- Wilgis EF, Murphy R. The significance of longitudinal excursion in peripheral nerves. *Hand Clin.* 1986;2(4):761–766.
- Tamaru Y, Yanagawa A, Matsugi A. Sensory nerve conduction velocity predicts improvement of hand function with nerve gliding exercise following carpal tunnel release surgery. *J Clin Med.* 2021;10(18):4121.
- Rozmaryn LM, Dovel S, Rothman ER, Gorman K, Olvey KM, Bartko JJ. Nerve and tendon gliding exercises and the conservative management of carpal tunnel syndrome. *J Hand Ther.* 1998;11(3):171–179.
- Coppieters MW, Alshami AM. Longitudinal excursion and strain in the median nerve during novel nerve gliding exercises for carpal tunnel syndrome. *J Orthop Res.* 2007;25(7):972–980.