



Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: [www.JHSGO.org](http://www.JHSGO.org)

Original Research

## Changes in Patient-Reported Pain Interference After Surgical Treatment of Painful Lower Extremity Neuromas

Adam Liebendorfer, MA, \* Esther Ochoa, BA, \* Christopher J. Dy, MD, MPH \*

\* Washington University in Saint Louis School of Medicine, St Louis, MO



## ARTICLE INFO

**Article history:**

Received for publication January 18, 2022

Accepted in revised form March 29, 2022

Available online April 28, 2022

**Key words:**Nerve pain  
Nerve surgery  
Neuralgia  
Neuroma  
Neuropathy

**Purpose:** Painful neuromas commonly cause neuropathic pain, in up to 1 in 20 cases of traumatic or iatrogenic nerve injury. Despite the multiple surgical treatment types that reduce pain, no type has been universally accepted.

**Methods:** We performed a retrospective cohort study by administering follow-up surveys to all surgical patients treated in our department for lower-extremity neuroma from September 1, 2015, to October 22, 2021, that could be contacted, excluding those with Morton neuroma. In addition to the Patient-Reported Outcomes Measurement Information System (PROMIS) Pain Interference (PI) questionnaire, survey questions covered the time to pain reduction, use of physical or occupational therapy, and characteristics of the pain. When available, previously collected preoperative and postoperative PROMIS PI data were used for patients who could not be contacted for the telephone survey. Paired-sample nonparametric testing was used to compare preoperative and postoperative PROMIS PI scores.

**Results:** Initial query in the medical record by Current Procedural Terminology codes yielded 1,812 patients for chart review, of whom 33 were eligible to call. In total, 9 (27%) patients completed both preoperative and postoperative PROMIS PIs: 6 (18.2%) completed full telephone surveys and 3 (9.1%) had preoperative and postoperative PROMIS PI data in the chart review but could not be contacted for the full telephone survey. Four of the 6 telephone-survey respondents reported pain reduction within 12 months of their surgery. Wilcoxon signed-rank testing demonstrated a moderate but nonstatistically significant reduction in PROMIS PI scores, with a median difference of  $-4.85$  ( $P = .1$ ; 95% CI  $-12$  to  $1.2$ ).

**Conclusions:** There were notable improvements in our cohort, but larger studies are needed to determine whether surgical treatment of lower-extremity neuroma results in a clinically important and significant difference in PROMIS PI scores, as well as to discern the advantages each treatment.

**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/>).

Neuromas are painful complications that occur after a peripheral nerve injury or amputation. Of all traumatic or iatrogenic peripheral nerve injuries, 3% to 5% result in a painful neuroma.<sup>1</sup> Multiple effective treatment options are used, including pharmacotherapy, prosthetic adjustments, steroid injections, neurolysis,

cryoablation, radiofrequency ablation, and surgical treatment, but none are universally accepted.<sup>2,3</sup>

While these treatments have been shown to reduce pain in patients with neuromas, no 1 technique has been shown to be clearly most effective. Reoperation rates have reached 65% in some studies, and up to 30% of neuromas present with symptoms refractory to surgical intervention.<sup>4–6</sup> Recent work suggests that combining neuroma excision with transposition of the distal nerve is superior to neuroma excision and capping or excision alone, including in those with refractory pain. Among these, targeted nerve implantation has shown the most promise for durable control of neuroma pain.

**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:** Christopher Dy, MD, MPH, Department of Orthopaedic Surgery, Washington University in Saint Louis School of Medicine, 660 S. Euclid Ave, CB 8233, St Louis, MO 63110.

E-mail address: [dyc@wustl.edu](mailto:dyc@wustl.edu) (C.J. Dy).

<https://doi.org/10.1016/j.jhsg.2022.03.005>

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/>).

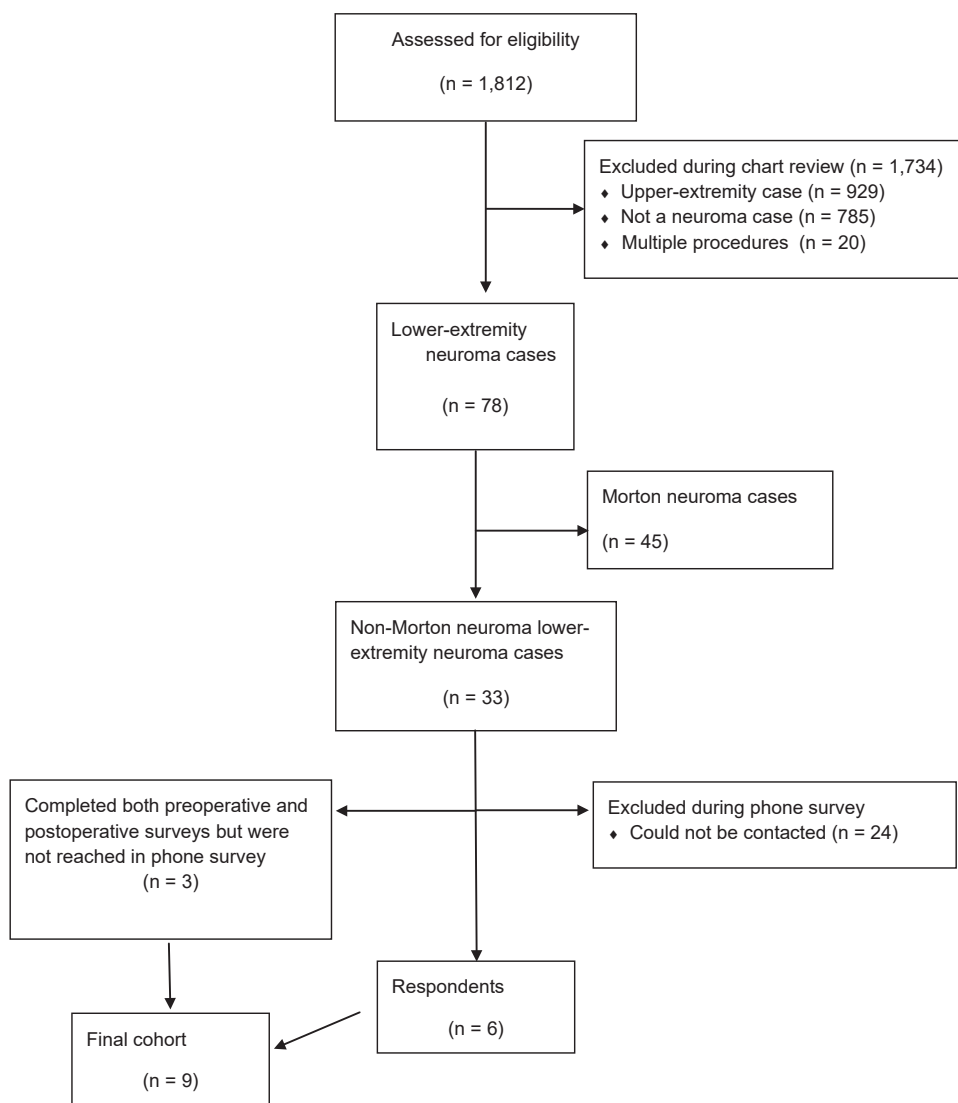


Figure 1. Lower-extremity, painful neuroma exclusion criteria.

Table 1 Demographics, Diagnoses, and Procedures

Characteristics	n (%)
<b>Demographics</b>	
Females	6 (55)
Males	5 (45)
Average age at date of surgery, y	39 (SD, 14.63)
<b>Diagnosis</b>	
Neuroma of the peroneal nerve	8 (73)
Neuroma of the saphenous nerve	2 (18)
Neuroma of an amputation stump	1 (9.1)
<b>Treatment</b>	
Nerve transfer	8 (18)
Nerve transfer with nerve graft	2 (6.3)
Neuroma excision	1 (9.1)

Here, we present a retrospective cohort study and case series of patients who have undergone surgery for lower-extremity neuromas. Using telephone surveys to collect up-to-date data, we set out to evaluate neuroma outcomes over the past 6 years in our department. We hypothesized that patients experience the highest

degree of relief, measured by the Patient-Reported Outcomes Measurement Information System (PROMIS) Pain Interference (PI) measurement, in painful neuroma symptoms when targeted nerve implantation was used.

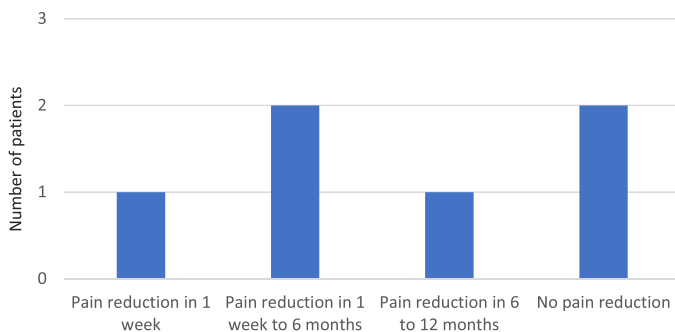
**Materials and Methods**

*Patients*

For this retrospective study, all patients were contacted by telephone using a telephone survey, telephone script, and a Health Insurance Portability and Accountability Act–compliant telephone number using Doximity Dialer that had been approved by the Institutional Review Board of the Washington University in Saint Louis School of Medicine. We generated a study cohort using Current Procedural Terminology codes related to nerve excision and/or transfers, identified by departmental query of electronic health records from September 1, 2015, to October 22, 2021. The Current Procedural Terminology codes included in this study were 28080, 64905, 64707, 64895, 64896, 64718, 64907, 64708, and 64722. We did not restrict our initial query by

**Table 2**  
Patient Details

Patient	Gender	Diagnosis	Treatment
Patient 1	F	Right superficial peroneal nerve neuroma after remote ankle fracture and persistent lateral ankle pain.	Right superficial peroneal neuroma allografting (5 cm AxoGen Avance Acellular nerve allograft with a 2- to 3-mm diameter) for extension prior to transposition.
Patient 2	F	Left superficial peroneal nerve neuroma after open reduction internal fixation of a bimalleolar ankle fracture.	Excision left superficial peroneal nerve neuroma.
Patient 3	M	Right superficial peroneal painful neuroma with co-occurring compression of the right common peroneal nerve at the fibular neck and superficial nerve at the lateral lower leg.	Neurolysis of the right superficial peroneal nerve medial branch, neurectomy and intramuscular burying of right superficial peroneal nerve lateral or intermediate branch neuroma-in-continuity, and decompression of the common and superficial peroneal nerves.
Patient 4	F	Neuroma-in-continuity of medial and intermediate branches of the superficial peroneal nerve at the anterior ankle with co-occurring compressions of the left common peroneal nerve at the fibular neck and left deep peroneal nerve deep to extensor hallucis brevis, as well as entrapment of the superficial peroneal nerve at the fascial exit.	Left superficial peroneal nerve medial and intermediate branch external neurolysis at the anterior ankle with decompression of the common peroneal, superficial peroneal, and deep peroneal nerves.
Patient 5	F	Left superficial peroneal nerve painful neuroma after lateral ankle ligament reconstruction 1 year prior with co-occurring compressive neuropathy of the left common peroneal nerve.	Superficial peroneal nerve neurectomy and intramuscular transposition with nerve allograft extension (2- to 3-mm x 70 mm; Axogen Avance) and decompression of the superficial and common peroneal nerves.
Patient 6	F	Left superficial peroneal nerve medial branch painful neuroma with co-occurring compression of the nerve at the lateral lower leg.	Internal neurolysis of the left superficial peroneal nerve with intramuscular transposition of the medial branch and decompression.
Patient 7	M	Left sciatic nerve injury, including neuroma, secondary to a gunshot wound of the distal femur.	Sciatic nerve neurolysis with neuroma excision and autografting from the contralateral sural nerve to the common peroneal and tibial nerves.
Patient 8	M	Neuroma-in-continuity of the right deep peroneal nerve with co-occurring compression of the common peroneal nerve.	Transfer of the deep peroneal nerve to the motor branch to the lateral gastrocnemius muscle with decompression of the common peroneal nerve at the fibular head.
Patient 9	M	Right painful saphenous neuroma with compression at Hunter's canal.	Right saphenous nerve decompression and muscle burying of the infrapatellar branch.

**Figure 2.** Time to pain reduction among telephone-survey respondents.

International Classification of Diseases codes. The exclusion criteria included cases of neuromas of the upper limb, patients younger than 18 years of age, cases with previous neuroma surgery on the same limb, and cases with neuroma treatment performed at another institution, as well as cases of Morton neuroma. Survey data were only included in paired-sample statistical testing if a preoperative-postoperative data pair was available. Missing preoperative survey data precluded use of an individual's data in statistical testing, and only their telephone-survey responses were used. If a preoperative survey was available, results from our telephone-administered PROMIS PI survey were used as the postoperative score. If a prior postoperative PROMIS PI score was available, the more recent telephone-survey score was used in its place.

#### Data collection

The PROMIS PI instrument was used as the primary outcome measure. Prior survey data for PROMIS PI were collected through review of patient charts from surveys that were administered

during outpatient visits. After removing cases according to the above exclusion criteria, the telephone survey was conducted on the final cohort. During the telephone survey, the PROMIS PI measure was administered, as well as a 7-item questionnaire that included questions regarding current pain, aggravating factors, effectiveness of surgery, effectiveness of physical and occupational therapy, and residual symptoms. Satisfaction with physical or occupational therapy was assessed with a question asking whether the patient attributed changes in pain level to either or both types of therapy.

#### Statistical analysis

For patients for whom preoperative PROMIS PI data were present and postoperative data were either present from the chart review or obtained during the telephone survey, paired-sample statistical testing was conducted to determine whether the reduction in pain attributed to surgery was statistically and clinically significant. Wilcoxon signed-rank testing was used if the samples violated assumptions of parametric testing or fewer than 10 patients were eligible for the final analysis. Postoperative PI measures were defined as those collected at least 6 months following surgical treatment. Telephone-survey data were used as most recent PROMIS PI result for patients who completed it.

Because the minimal clinically important difference (MCID) has not been established for lower-extremity neuroma treatment, sample size calculations were based on the MCID for patients seen for orthopedic foot and ankle conditions at 6 or more months of follow-up (8.0; SD, 6.7). Related means sample size calculations assumed the aforementioned MCID score with a power of 0.8, 2-sided  $\alpha$  of 0.5, and effect size of 1.194, indicating a sample size of 8 patients total would be sufficient for detecting a clinically important decrease in PROMIS PI scores.

**Table 3**  
Change in PROMIS PI Scores by Treatment Type and Diagnosis

Treatment Types and Diagnoses	N (%)	Mean Preoperative (SD)	Mean Postoperative (SD)	Mean Change (SD)
<b>Treatment</b>				
Nerve transfer	8 (89)	62.55 (3.42)	56.08 (9.04)	−6.48 (8.78)
Nerve transfer with nerve grafting	1 (11)	66.90*	68.10*	1.20*
<b>Diagnoses</b>				
Peroneal nerve	7 (78)	63.81 (3.57)	59.33 (7.04)	−4.49 (5.82)
Saphenous nerve	2 (22)	60.30 (1.70)	50.70 (16.97)	−9.60 (18.67)

\* n=1

## Results

The patient query yielded 1,812 procedures, 33 of which involved patients surgically treated for lower-extremity neuroma at our department, excluding those with Morton neuroma. Details of the exclusion criteria can be found in [Figure 1](#). In total, 9 (27.2%) patients completed both preoperative and postoperative PROMIS PIs, 6 (18.2%) of whom completed full telephone surveys. Two (6.1%) telephone-survey respondents had completed preoperative and postoperative PROMIS PI surveys before the telephone survey, so the PROMIS PI data from the telephone survey were used. An additional 3 patients (9.1%) were found to have historical preoperative and postoperative PROMIS PI data but could not be contacted for the full telephone survey. In our cohort, 1 (11.1%) patient had received an amputation and the remaining 8 (88.8%) were treated for peroneal neuromas following intact limb injuries. The 9 patients who made up the final cohort for analysis had completed follow-up postoperative PROMIS PIs, with a mean time to the most recent follow-up of 16.8 months, ranging from 7 months to 2.9 years. Demographic, diagnostic, and treatment details can be found in [Table 1](#). Diagnostic and treatment information for each case in this study can be found in [Table 2](#).

### Telephone-survey results

Of the 33 patients called for the telephone survey, 6 (18.2%) completed it, and no patients declined to participate. Further details on the reported time to pain reduction can be found in [Figure 2](#). Among respondents, 1 (16.7%) stated they experienced resolution of neuroma-related pain within 1 week after surgery. One patient (16.7%) experienced reduced pain between 1 week and 6 months after surgery, and an additional 1 (16.7%) experienced reduced pain between 6 months and 12 months after surgery. Of the 4 patients who reported improvement via questions in the telephone survey, 2 had completed both preoperative and postoperative PROMIS PI surveys for comparison. One of these 2 patients reported an increase in the PROMIS PI of 1.2, and the other reported a decrease in the PROMIS PI of 10.9. Two patients (33.3%) reported that their pain did not resolve at all after surgery and postoperative therapy. No patients reported postoperative complications in this cohort. Within the cohort, all 6 telephone-survey respondents attended physical therapy for at least 6 months after surgery. Three (50%) of the respondents reported physical therapy helped further reduce neuroma pain, 2 of whom attended therapy for 9 months and 1 of whom attended for 12 months. Among the other 3 patients who reported that physical therapy did not help relieve their pain, 2 reported they attended therapy for 6 months and 1 reported they attended for 9 months. Persistent numbness was the most common symptom from surgery for the neuroma (n = 4; 66.7%), and 2 patients (33.3%) reported regular paresthesias. All patients who experienced numbness and paresthesias reported that the symptoms were not bothersome and expressed that these persistent symptoms were a worthwhile tradeoff compared with

their prior neuroma. An additional 1 patient-reported phantom pain from an amputation stump.

### Statistical testing

Without taking surgical treatment into account, the average PROMIS PI decrease across our cohort was 5.6 (SD, 8.6). Further details of changes by diagnosis and surgical approach can be found in [Table 3](#).

Although Kolmogorov-Smirnov testing indicated normally distributed preoperative ( $P = .2$ ) and postoperative ( $P = .17$ ) PROMIS PI scores, as well as changes in scores ( $P = .16$ ), sample size restrictions precluded the use of parametric paired-samples testing. Nonparametric Wilcoxon signed-rank testing found a median difference of  $-4.85$  (95% CI  $-12$  to  $1.2$ ), with an effect size of  $-0.38$ , which was not statistically significant ( $P = .097$ ).

## Discussion

We found that in this small cohort of patients, surgical treatment of lower-extremity neuromas (outside of cases of Morton neuroma) was associated with decreased PROMIS PI scores for some patients but overall did not result in a statistically significant decrease across the group. We framed our sample size calculation based on MCIDs reported broadly for foot and ankle conditions, so our study may have been underpowered.

Our results provide a new context for what the MCID for PROMIS PI might be for neuromas of the lower extremity. Despite the statistically nonsignificant difference in PI scores, 67% of respondents reported a lasting, noticeable pain reduction within 1 year after surgery. Of the patients who reported pain reduction, 75% cited the use of physical or occupational therapy as a factor in their improved symptoms.

Our study was limited by a number of factors. The relatively small sample size, with substantial loss to follow-up, prevented the analysis from detecting the calculated effect size. Telephone-survey administration is also prone to ascertainment and recall bias, which was compounded by a relatively low (18.2%) survey completion rate.

This article provides future directions in neuroma outcomes research. Our study does not elucidate what might drive both the trend of lower satisfaction with postoperative physical therapy and reduced duration of its use. The inability to detect the calculated effect size and the trend of poorer satisfaction with shorter physical therapy use underscore the need for a well-powered, prospective study to tackle such questions. Such a study could also help establish an MCID directly associated with lower-extremity neuromas. In addition, further work is needed to compare treatment approaches with each other.

We present the findings of a small, retrospective cohort study that found a potentially clinically meaningful but not statistically significant reduction in neuroma pain after surgical treatment.

## References

1. Stokvis A, Coert JH. Operative treatment of painful neuromas. *Ned Tijdschr Geneeskd*. 2011;155(18):A2592.
2. Rajput K, Reddy S, Shankar H. Painful neuromas. *Clin J Pain*. 2012;28(7):639–645.
3. Lu C, Sun X, Wang C, Wang Y, Peng J. Mechanisms and treatment of painful neuromas. *Rev Neurosci*. 2018;29(5):557–566.
4. Poppler LH, Parikh RP, Bichanich MJ, et al. Surgical interventions for the treatment of painful neuroma: a comparative meta-analysis. *Pain*. 2018;159(2):214–223.
5. Guse DM, Moran SL. Outcomes of the surgical treatment of peripheral neuromas of the hand and forearm: a 25-year comparative outcome study. *Ann Plast Surg*. 2013;71(6):654–658.
6. Nelson AW. The painful neuroma: the regenerating axon versus the epineurial sheath. *J Surg Res*. 1977;23(3):215–221.