

# Patient-reported Outcome Measures for Peripheral Nerve Injuries: A Systematic Review

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**Background:** The goal of managing patients with peripheral nerve injuries is to improve how a patient feels and functions. This goal is best assessed with patient-reported outcome measures (PROMs), which elicit patient concerns, treatment goals, and clinical progression. This study reviews existing PROMs for adult patients with peripheral nerve injuries to assess how comprehensively they measure outcomes important to patients.

**Methods:** A systematic review of Ovid MEDLINE, Scopus, Web of Science, and Embase (from inception to August 13, 2022) was conducted to identify PROMs developed for adult patients with peripheral nerve injuries. Studies were included if (1) the study population involved traumatic or acquired peripheral nerve injuries; (2) they were randomized controlled trials, cohort studies, or single-arm observational studies; (3) participants were 18 years or older; and (4) PROMs were used to assess quality of life or patient satisfaction.

**Results:** A total of 378 studies were included in this systematic review. We identified 141 unique PROMs used in the adult peripheral nerve injury literature: 20 are disease-specific (14%), 10 are function-specific (7%), 19 are mental health and well-being-specific (13%), 11 are quality of life-specific (8%), 32 are body region-specific (23%), 29 are symptom-specific (21%), 3 are satisfaction-specific (2%), 15 are generic (11%), and 2 are other (1%).

**Conclusions:** There exists considerable heterogeneity of PROMs used in research on patients with peripheral nerve injuries. None of the PROMs comprehensively assess this patient population. The need for the development of a comprehensive PROM for this patient population is highlighted. (*Plast Reconstr Surg Glob Open* 2024; 12:e6408; doi: 10.1097/GOX.0000000000006408; Published online 19 December 2024.)

## INTRODUCTION

Peripheral nerve injuries are common conditions, affecting up to 5% of patients admitted to a level 1 trauma center.<sup>1</sup> The sequelae following loss of sensory and motor

function in the upper and/or lower extremities cannot be understated. Patients may experience debilitating chronic pain and long-term disruptions in activities of daily living, leisure, professional development, and education. Similarly, acquired nerve pathologies such as nerve compression, postamputation phantom limb pain, nerve tumors, brachial plexus neuritis, and neuroma pain also lead to impaired function and reduced quality of life (QoL).

Patient-reported outcome measures (PROMs) are increasingly used in many areas of medicine and surgery to inform patient care and research. PROMs offer valuable insights into patients' health status by measuring a range of outcomes including symptoms; functional status; and physical, mental, and social well-being. Regular use of PROMs in clinical care has been shown to enhance

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communication between patients and healthcare providers, guide decisions for value-based health system improvements, and improve overall patient care experiences and outcome.<sup>2,3</sup> As such, PROMs are indispensable in the provision and advancement of patient-centered care.

Peripheral nerve injuries are challenging to manage. Although nerve transfers are performed to restore motor and sensory function, targeted muscle reinnervation and regenerative peripheral nerve interfaces<sup>4</sup> are performed to relieve pain in upper and lower extremity nerve injuries. As the field of peripheral nerve surgery continues to advance, and these newer interventions become the standard of care for managing nerve injuries, it is important for healthcare providers to integrate PROMs into their daily practice to improve patient experiences and outcomes. The aim of this systematic review of the literature was to identify PROMs currently in use in the adult peripheral nerve injury literature, and to explore the variation, advantages, and disadvantages of these measures, thereby providing researchers, healthcare providers, administrators, and stakeholders with meaningful, precise, and reliable feedback on peripheral nerve injury PROMs.

## METHODS

### Search Strategy and Study Selection

This systematic review is reported in concordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Fig. 1). A literature search was performed on Ovid MEDLINE (from inception to August 13, 2022), Scopus (from inception to August 13, 2022), Web of Science (from inception to August 13, 2022), and EMBASE (from inception to August 13, 2022). (See appendix, Supplemental Digital Content 1, which displays the literature search strategies, <http://links.lww.com/PRSGO/D717>.) The search was limited to English language articles.

Studies were included if (1) the study population were patients with traumatic nerve injuries (from upper or lower extremity trauma or amputation) or acquired nerve pathologies (nerve tumor or compression neuropathy); (2) they were randomized controlled trials, prospective or retrospective cohort studies, or single-arm observational studies; (3) patients were age 18 years or older; and (4) the study utilized a patient-reported outcome measure to measure QoL and/or patient satisfaction. Studies were excluded if (1) they were not primary research articles (ie, abstracts, conference proceedings); (2) the data could not be extracted; and (3) they were case reports or case series with fewer than 10 patients. The main objective of this study was to identify PROMs currently in use in the adult peripheral nerve injury literature, and to explore the variation, advantages, and disadvantages of these measures.

### Data Abstraction and Collection

Studies were screened by 2 independent reviewers (C.R.W. and M.K.). Reviewers conducted a pilot screen of the titles and abstracts of the first 50 studies to ensure that the inclusion and exclusion criteria were applied

### Takeaways

**Question:** What patient-reported outcome measures (PROMs) are being used in adult patients with peripheral nerve injuries?

**Findings:** We identified 141 unique PROMs: 20 are disease-specific (14%), 10 are function-specific (7%), 19 are mental health and well-being-specific (13%), 11 are quality of life-specific (8%), 32 are body region-specific (23%), 29 are symptom-specific (21%), 3 are satisfaction-specific (2%), 15 are generic (11%), and 2 are other (1%).

**Meaning:** There exists considerable heterogeneity of PROMs used in research on patients with peripheral nerve injuries, highlighting the need for a comprehensive PROM for this patient population.

consistently. Following this, title and abstract screening was completed and the aforementioned authors proceeded with full-text review of the identified studies. The senior author (J.D.) was consulted in cases of disagreement, as needed. Interrater agreement was calculated using an unweighted kappa statistic. Abstracted data included study title, authors, year of publication, study design, level of evidence, peripheral nerve injury category, patient population, and PROMs utilized.

### Synthesis of Results

PROMs identified in the literature were organized into the following categories: disease-specific, function-specific, mental health and well-being-specific, QoL-specific, body region-specific, symptom-specific, satisfaction-specific, generic, and other.

## RESULTS

The results of the systematic review of the literature are outlined in Figure 1. After removal of duplicates, a total of 13,282 articles were identified. Of these, 722 underwent full-text screening. Interreliability kappa scores were 0.716 for title and abstract screening and 0.868 for full-text screening. A total of 378 articles were included in this study, describing upper extremity amputation/trauma (n = 73; 19%), upper extremity nerve injury (n = 60; 16%), upper extremity compression neuropathy (n = 72; 19%), upper and lower extremity amputation/trauma (n = 13; 3%), upper and lower extremity nerve injury (n = 11; 3%), lower extremity amputation/trauma (n = 67; 18%), lower extremity nerve injury (n = 10; 2%), lower extremity compression neuropathy (n = 60; 16%), nerve tumors in the upper or lower extremities (n = 7; 2%), mixed injuries (n = 3; 1%), and others (n = 2; 1%). (See appendix, Supplemental Digital Content 2, which displays characteristics of included studies, <http://links.lww.com/PRSGO/D718>.)

Of note, mixed injuries included studies that described patients with lower extremity nerve injury or compression neuropathy, upper extremity amputation/trauma or nerve injury, and upper extremity compression neuropathy or nerve injury (Fig. 2).

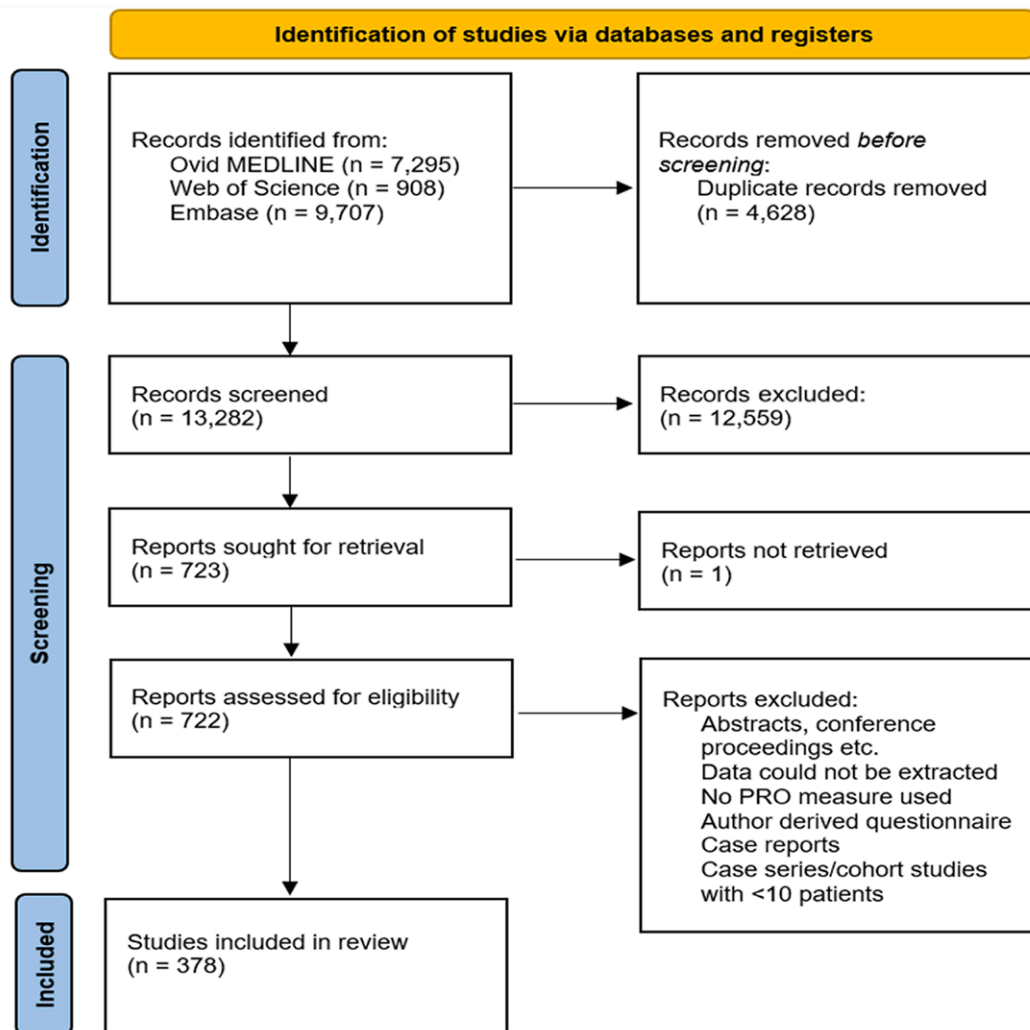


Fig. 1. PRISMA diagram.

A total of 141 unique PROMs were used in adult patients with peripheral nerve injuries. (See appendix, Supplemental Digital Content 3, which displays PROMs used in adult patients with peripheral nerve injuries, <http://links.lww.com/PRSGO/D719>.)

The visual analog scale was the most commonly used PROM, reported in 145 (38%) of the included studies. The identified PROMs were categorized as disease-specific (n = 20; 14%), function-specific (n = 10; 7%), mental health and well-being-specific (n = 19; 13%), QoL-specific (n = 11; 8%), body region-specific (n = 32; 23%), symptom-specific (n = 29; 21%), satisfaction-specific (n = 3; 2%), generic (n = 15; 11%), and other (n = 2; 1%). Of the 141 unique PROMs, 17 (12%) specifically assess outcomes of the upper extremity, 28 (20%) in the lower extremity, 5 (4%) can be used in both upper and lower extremity injuries, and 91 (65%) are not extremity-specific. (See appendix, Supplemental Digital Content 4, which displays PROMs categorized by body region, <http://links.lww.com/PRSGO/D720>.) Figure 3 illustrates the number of publications in the peripheral nerve injury literature reporting a PROM, by year.

## DISCUSSION

### PROMs Used in Peripheral Nerve Injuries

We identified 141 unique PROMs used in the following contexts: upper and lower extremity amputation/trauma, nerve injury, compression neuropathy, mixed injury, and nerve tumors. These outline the vast number of generic and condition-specific PROMs used in the peripheral nerve injury population, each with variable strengths and limitations in their use.

Generic PROMs may be applied to different population groups and are thus useful in comparing diseases or comparing to population normative values. In the context of peripheral nerve injuries, generic PROMs such as the 36-Item Short Form Survey (SF-36) and EQ-5D measure QoL; however, they fall short in evaluating a patient's function and feelings as it relates to the loss of both sensory and motor function, the presence or characterization of neuropathic pain, or the ensuing length of time to return of function after surgical reconstruction. In fact, the US Food and Drug Administration and the European

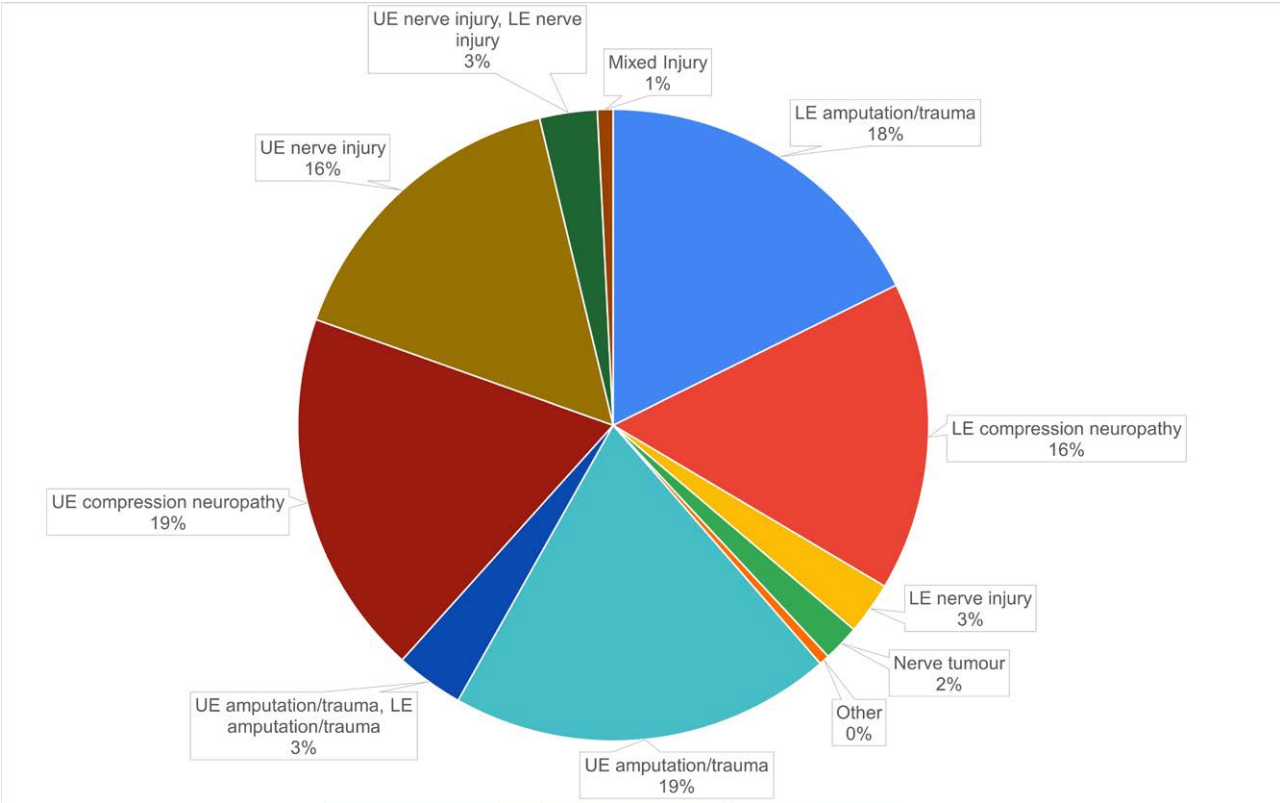


Fig. 2. Nerve injury types in included studies.

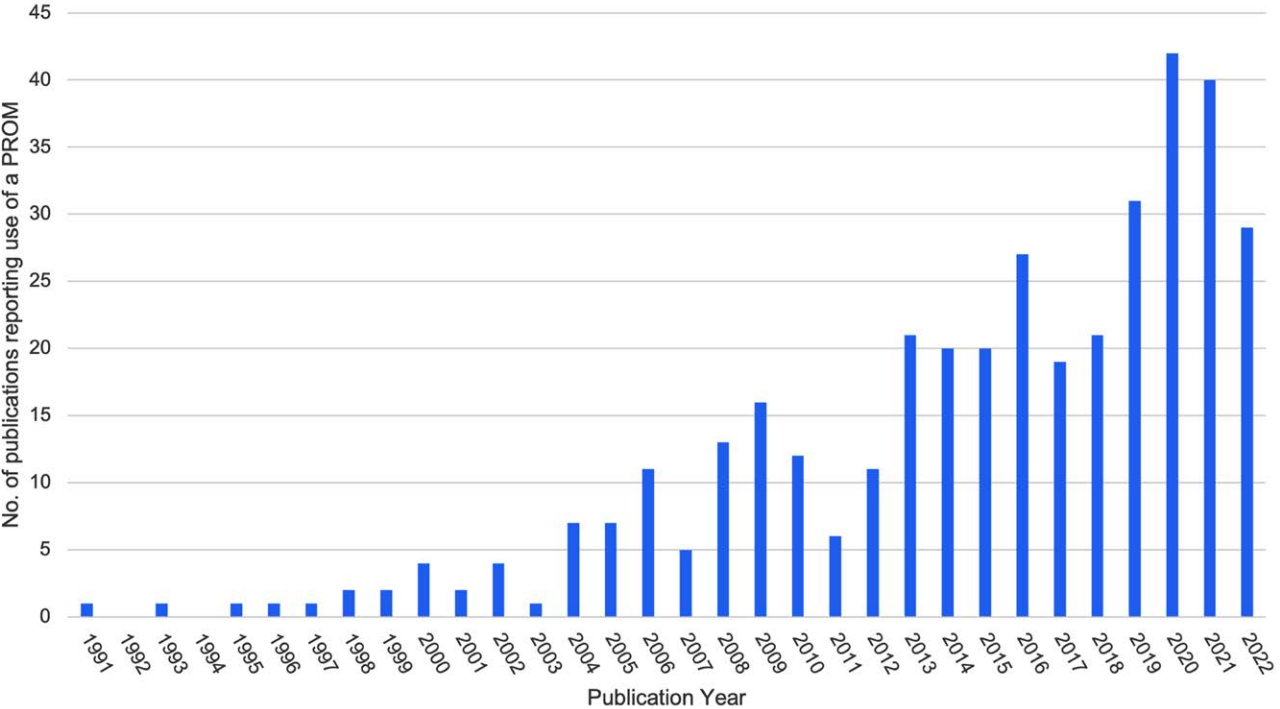


Fig. 3. PROM reporting in peripheral nerve injury literature over time.

Medicines Agency consider the most widely used PROM, the SF-36, inapt for use in studies comparing treatment efficacy.<sup>5</sup> Other PROMs are specific to anatomic region but can still be used across a variety of conditions and disease states. These include the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, Hand20, and the Michigan Hand Outcomes Questionnaire for upper extremity and the American Orthopedic Foot and Ankle Society Score, Short Musculoskeletal Function Assessment Questionnaire, and the Lower Extremity Functional Scale for lower extremity. PROMs in both categories concentrate on relevant activities of daily living but are insufficient in addressing neuropathic pain, sensory deficits, aesthetic outcomes, or socioemotional aspects, all of which are important to the provision of patient-centered care.<sup>6,7</sup>

Although generic PROMs are beneficial in the comparison of a wide range of patients across different health conditions, condition-specific PROMs are sensitive to pertinent changes in health status. Condition-specific PROMs, such as the Boston Carpal Tunnel Questionnaire, the patient-rated ulnar nerve evaluation, and the cold intolerance severity score, have been designed to assess outcomes specific to a particular patient population. Despite the availability of PROMs for conditions such as carpal tunnel syndrome, there is currently a lack of such measures specifically tailored for peripheral nerve injuries as a whole, primarily due to the diversity within this patient population. Therefore, the use of generic PROMs in conjunction with a condition-specific PROM is recommended. However, such redundancy can lead to unnecessary respondent burden, distress, and reduced compliance with recurring assessment over time.<sup>8</sup>

#### Why Is a PROM Needed for Peripheral Nerve Injuries?

Our review demonstrates that there is no existing PROM that is both specific to and comprehensive enough for the evaluation of patients with peripheral nerve injuries. The peripheral nerve injury population is unique for many reasons. First, patients with peripheral nerve injuries can suffer devastating impacts on their daily functions and routines,<sup>9–12</sup> some of which are lifelong, such as a profound economic impact due to change in work ability. Furthermore, depending on both the structure and site of injury, there is considerable variability in symptoms and patient presentation.<sup>13</sup> Second, recovery following peripheral nerve injury is multifactorial. Intrinsic factors include patient age; level and severity of injury; nerve tissue loss; type of nerve involved (motor, sensory, or mixed); which nerve is involved (eg, certain nerves are particularly susceptible to ischemia due to known paucity in their blood supply such as the ulnar and peroneal nerves—there is a documented correlation with cold intolerance in digital nerves and the development of marked neuropathic pain and/or complex regional pain syndrome in the sensory branch of the radial nerve); and associated injuries.<sup>14–18</sup> Extrinsic factors include the type of repair, surgical technique, use of microsurgical equipment, and the time between injury and consultation.<sup>19–22</sup> Furthermore, the central nervous system is also implicated in functional recovery given the profound, on-going cortical

reorganization following peripheral nerve injuries.<sup>23</sup> The role of early psychological stress secondary to the trauma has also recently been documented as an important factor in functional recovery.<sup>24</sup> Finally, patients with peripheral nerve injuries can develop complex sequelae, such as neuropathic pain, complex regional pain syndrome, depression, and anxiety, which are multifactorial conditions that can be difficult to evaluate and may obscure assessments of recovery. For the reasons listed earlier, it remains difficult to assess recovery after peripheral nerve injuries.

#### Limitations of Existing PROMs in Peripheral Nerve Injury Research

Historically, outcome analysis after peripheral nerve injury has focused primarily on quantitative measures of sensibility, motor function, and strength.<sup>13</sup> Although these objective metrics are valuable for assessing specific aspects of recovery, they do not capture the full spectrum of a patient's experience. Recognizing this gap, PROMs have been developed to include subjective measures of the impact of the injury on social and emotional well-being and function.<sup>13</sup> For instance, the DASH is one of the most commonly reported PROMs in the peripheral nerve injury literature and encompasses the function of the entire upper extremity. Although this broad focus is relevant, as nerve injuries can indeed affect the entire upper extremity, the DASH has limitations in addressing specific aspects of nerve injury recovery. For instance, it cannot identify and/or exclude the implementation of compensatory mechanisms, which enable the patient to at least partially cope with the limitations resulting from their peripheral nerve injuries. Additionally, many questions included in the DASH refer to activities that individual patients may not engage in during their everyday lives. As such, it fails to capture some important concepts and may not provide the most comprehensive assessment of issues crucial to peripheral nerve injury patients, such as pain management,<sup>25</sup> work disability,<sup>26</sup> and sensorimotor deficits.<sup>27</sup> Without including patient perspectives and experiences in healthcare decision-making, we fail to ensure that treatment aligns with their priorities and needs.

The pain following peripheral nerve injuries can be severe and associated with disability,<sup>26,28–30</sup> and together, both pain and disability levels are predictive factors for poor QoL scores.<sup>13,31</sup> For instance, Novak et al<sup>11</sup> found patients with upper extremity nerve injuries to have a strong correlation between pain disability and DASH and illness intrusiveness. Pain disability describes the negative impact of pain on life domains, including work, family and home responsibilities, recreation, social activity, and self-care. Subsequently, illness intrusion arises due to the interfering effects of illness or treatment-related factors on life domains.<sup>32,33</sup> Furthermore, psychosocial factors such as depression, coping, and anxiety can have an effect on pain, patient satisfaction, and disability<sup>34–37</sup>; however, they are infrequently measured in this patient population.<sup>38</sup> Although objective assessments of sensibility, motor function, and strength can help to determine biomechanical function and physical impairments, they fall short in measuring the overall functional status in many life domains.

An understanding of the complex interplay of both biomedical and psychosocial factors of patients with peripheral nerve injuries will allow healthcare providers and patients to focus on improvements in QoL and function.<sup>13</sup>

Previous work has highlighted inconsistencies in the reporting of outcomes following peripheral nerve injuries.<sup>39</sup> Work by Murphy et al<sup>40</sup> demonstrated inconsistent outcome measure assessment (sensory and motor function) as well as infrequent and inconsistent PROM use. PROM use was proportionately higher in brachial plexus patients (DASH, 3 of 16 studies; SF-36, 3 of 16 studies; visual analog scale, 3 of 16 studies; and Cold Intolerance Severity Score, 1 of 16 studies) compared with mixed (motor and sensory) upper extremity nerve injury patients (DASH, 4 of 59 studies; SF-36, 3 of 59 studies; visual analog scale, 12 of 59 studies; and Cold Intolerance Severity Score, 3 of 59 studies).<sup>40</sup> Interestingly, in the hand sensory nerve injury group of studies, only 2 of 17 studies assessed disability, 1 using the DASH questionnaire, the other using the occupational performance model.<sup>40</sup> Although reliable, the DASH has not proven to be valid for nerve repair.<sup>41</sup>

The lack of clarity and standardization of PROMs used to assess patients with life-changing nerve injuries precludes the ability to make meaningful comparisons between interventions and to develop and adopt best practice guidelines. There is an evident need for a comprehensive PROM that assesses patients' perspectives on the symptoms that they experience, how they feel and function, and their QoL associated with their peripheral nerve injury and its treatment.

### Peripheral Nerve Injury PROM Development

A PROM must be developed in accordance with guidelines set forth by the US Food and Drug Administration.<sup>42</sup> In the first phase, a conceptual framework is developed via a review of the literature/existing scales, expert opinion, and patient interviews. A conceptual framework is a major constituent for PROMs and represents the established associations between and among items on a questionnaire and domains. In phase 2, the preliminary scales are field tested in a large international sample and refined according to their psychometric properties. In phase 3, a prospective study is conducted to assess the scales' ability to measure change.

Beyond its rigorous development, a PROM should boast excellent psychometric properties, including content validity, reliability, construct validity, and responsiveness. In addition to this, the measure should demonstrate cross-cultural validity as well as interpretability and feasibility. Content validity relates to the relevance and comprehensiveness of the measure. Reliability refers to the degree to which the measurement is free of error and can be assessed with test-retest as a repeated measurement over time. Construct validity (structural validity, discriminative, convergent, divergent, and cross-cultural validity) refers to the ability of the tool to measure the construct it was designed to measure. Responsiveness relates to the ability to detect changes in the construct over time.

A clinical tool must be easy to use and understand to ascertain meaningful data. Furthermore, an optimal

PROM strikes a balance in assessing both general health constructs, such as function and pain, as well as condition-specific constructs. Successful nerve surgery outcomes hinge on the ability to consider each patient's unique circumstances and functional goals, and this should be reflected in PROMs used in this patient population. Given the variety of peripheral nerve injury types and the diversity of the patient populations affected, developing a comprehensive, standardized PROM that effectively captures the wide range of patient concerns presents an exciting opportunity to enhance personalized care and improve patient outcomes. Development of a personalized PROM, which allows patients to identify outcomes most important to themselves, has recently been described in the cystic fibrosis literature<sup>43</sup> and may demonstrate notable advantages in the era of personalized medicine.

### Future Steps

The increasing use of PROMs in peripheral nerve injury research over the years (Fig. 3) is an encouraging sign of the growing recognition of the importance of capturing the patient perspective in clinical research in this field. In order for future research to do this effectively, there is a need for the development of a PROM for adult patients with peripheral nerve injuries. This PROM must be developed in concordance with the guidelines set forth by the US Food and Drug Administration.<sup>42</sup> With well-designed studies demonstrating its validity, reliability, and responsiveness, we are hopeful that a paradigm shift occurs such that use of this PROM becomes the gold standard in the management of patients with peripheral nerve injuries. Subsequent standardization of PROM data collection (eg, at standardized time points posttreatment), analysis, and reporting will facilitate clinicians' and researchers' interpretation and comparison of data, both within and between studies, thus directing patient care. Furthermore, validated translations of the PROM into other languages will increase its accessibility and allow for more diverse patient recruitment into peripheral nerve injury research studies, thereby improving the generalizability of research in this field. Furthermore, although the current study did not include pediatric PROMs, there is a need for the development of age-specific PROMs for peripheral nerve injuries in younger populations, namely PROMs adapted to the special communication needs of toddlers, younger children, older children, and adolescents.

Future research may reasonably incorporate both nerve injury-specific and generic PROMs in their assessment of patient outcomes. The primary purpose of using generic PROMs would be to facilitate comparisons and data pooling with existing peripheral nerve injury literature, in which use of nerve injury-specific PROMs is uncommon. Importantly, care should be taken not to overburden participants with numerous questionnaires, which may negatively impact participant recruitment and retention. Finally, researchers may consider additional use of objective measures of nerve function, such as electromyography and nerve conduction studies to further assess impacts of various treatment paradigms.

## Limitations

Limitations of this study include amputations secondary to nontraumatic causes, such as cancer or diabetes, and restricting language of publication to English. Articles for review were solely retrieved from the database search, and no additional manual searches of the grey literature were performed. Finally, although a systematic process was undertaken to identify PROMs in the published peripheral nerve injury literature, it should be noted that this article is not a systematic analysis of the psychometric properties of each available PROM; rather, is meant to stimulate discussion around the limitations of presently available PROMs for use in peripheral nerve injury research.

## CONCLUSIONS

In conclusion, this report identifies 141 unique PROMs used in adult patients with peripheral nerve injuries, none of which are entirely comprehensive, or specific to this patient population. This finding substantiates the need for the development of a PROM for patients with peripheral nerve injuries to enable physicians, researchers, and stakeholders to drive advances in patient care.

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## DISCLOSURE

*The authors have no financial interest to declare in relation to the content of this article.*

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