

General

Assessment of Motor Function in Peripheral Nerve Injury and Recovery

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Introduction

Peripheral nerve injuries can be difficult to diagnose, treat, and monitor given their highly variable presentation. When the status of nerves is not accurately assessed, treatment may be delayed or overlooked and can result in lasting functional deficits. As our understanding of nerve repair and generation evolves, so will tools for evaluating both the functional and morphological status of peripheral nerves.

Objective

There is currently no single article which provides a detailed, comprehensive view of the literature comparing the clinical utility of various assessment modalities. Furthermore, there is no consensus on the optimal assessment algorithm for peripheral nerve injuries.

Methods

We performed a literature review using a comprehensive combination of keywords and search algorithm. The search was focused on clinical data regarding the assessment of peripheral nerves

Results: This review may help to determine the appropriate tools that are currently available for monitoring nerve function both pre and postoperatively. Additionally, the review demonstrates possible roles and areas of improvement for each tool used to assess motor function.

Conclusion

As surgeons work to improve treatments for peripheral nerve injury and dysfunction, identifying the most appropriate existing measures of success and future directions for improved algorithms could lead to improved patient outcomes.

INTRODUCTION

Peripheral nerve injuries (PNIs) are common, with an estimated incidence of 16.9 per 100,000 citizens in the United States, and may present with a variety symptoms depending on the extent and mechanism of injury.¹ Nerve injuries can be broadly categorized as either neurotmetic, in which the nerve and the nerve sheath are disrupted, or axonometric, whereby the axons are damaged but the connective

tissues, endoneurium, perineurium and epineurium remain intact.² After axonotmesis or neurotmesis, the nerve will undergo Wallerian degeneration and subsequent axonal re-growth. Wallerian degeneration, while necessary for nerve regeneration,³ is known to incite inflammatory processes.⁴ Inflammation and concurrent disruption of blood flow can cause edema and increased intraneural pressure that potentially damage the myelin sheath.⁵ The elevated pressure can trigger a positive feedback loop by which blood flow is

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further restricted and further upregulation of inflammatory processes. This process is known as the “cumulative injury cycle”.⁵ In more severe injuries, such as a complete transection, the treatment algorithm is more straightforward. However, incomplete transections or nervous deficiency not caused by trauma can be difficult to diagnose, treat, and monitor given their often-subtle symptoms. When the functional and/or structural status of peripheral nerves is not accurately assessed, treatment of these injuries may be delayed or overlooked altogether. In many injury patterns, delayed diagnosis can preclude the optimal treatment option, and may result in long-lasting functional deficits with impaired quality of life.^{6,7} Nerve injuries left completely untreated rarely result in total functional recovery.⁸

Even when nerves are treated in a timely manner, they continue to present challenges for surgeons. Many solutions have been proposed to improve outcomes of peripheral nerve surgery in a variety of clinical contexts.^{9–11} New products and techniques are continually being developed to address the shortcomings of historical gold standards.⁸ As our understanding of nerve repair and regeneration evolves, so have tools for evaluating both the functional and morphological status of peripheral nerves.

Given that nerve assessment algorithms have the potential to impact diagnosis, intervention, and recovery of impaired nerves, a comprehensive view of the literature assessing their efficacy could ultimately assist surgeons in improving patient outcomes. We performed a literature review to consolidate the current evidence regarding motor assessment tools and techniques for peripheral nerves.

METHODS

DEVELOPMENT PROCESS

The authors performed a literature review across multiple databases using a comprehensive combination of keywords and search algorithm.¹² The literature search focused on clinical data regarding the tools used in the assessment of motor function in peripheral nerves.

LITERATURE SEARCH

A literature review was conducted in order to identify study abstracts for screening. The databases used included PubMed/MEDLINE, EMBASE, Cochrane, and Google Scholar databases using the controlled terms: “Humans” and “Peripheral nerve injuries” and “motor” or “function” or “assessment” or “recovery” or “outcome”. Manual additions to our search query were made using the key terms: “motor recovery”, “motor outcomes”, “motor assessment”, “motor testing”, “nerve assessment”, “nerve motor assessment”, “nerve motor testing”, “nerve testing”, “peripheral nerve assessment”, “nerve function testing”, “motor function”, and “motor function testing”. Search dates were from January 1960 to December, 2020. After assessment of eligibility, three authors extracted data from the marked articles. Important parameters that were recorded when available included: the year of the study, number of patients in the study, sensitivity and specificity of the tools assessed,

benefits and limitations of tools assessed, opportunities for improvement, and clinical roles in nerve recovery assessment.

ETHICAL CONSIDERATION

As this review is a narrative review, ethical review or approval was not required. No patient information or identifying features were included in this study.

RESULTS

INJURY EVALUATION

NERVE CONDUCTION STUDIES (NCS)

Aims / Advantages: Nerve conduction studies assess motor, sensory, and mixed nerve functional status by sending electrical pulses to the skin while recording action potentials at a distant point of the same nerve or at a distal target muscle for that nerve.^{13–15} NCS can reveal the location of neurologic compromise, whether the nerve has an axonal or demyelinating lesion, and to what degree the injury has hampered nerve conduction. These studies are able to show specific pathologies that are difficult to differentiate using MRN and have been used to monitor nerve recovery following injury and/or repair.^{13–16} Furthermore, NCS can distinguish between mononeuropathy from a polyneuropathy.¹³

Disadvantages / Criticisms: NCS is operator-dependent, and it is often difficult to obtain responses in small sensory nerves.^{14,17} Needle electrodes that placed in a small area of muscle can give data that is difficult to interpret.¹⁵ While NCS can detect nerve injury in the first 10 days of injury, it cannot be used to predict nerve injury recovery as Wallerian degeneration has not occurred yet.¹⁴ Furthermore, NCS is a temperamental tool as results can be confounded by low skin temperature, improper electrode positioning, stimulus artefacts, or overstimulation.¹⁵ Examiner mistakes in over- or under-interpretation of the results can also mischaracterize a nerve injury.¹⁵ Given the lack of a definitive ‘normal’ or ‘abnormal’ baseline reading, interpretations of abnormality may be skewed.¹⁷

Role in nerve assessment algorithm: In conditions where NCS has demonstrated high sensitivity, there are other gold-standard measuring tools that are simpler and more cost-effective. Consequently, NCS should be used in cases where results of more common clinical tests are unclear and less as a first line diagnostic tool.¹⁷ NCS can be performed in tandem with electromyography to differentiate between a complete and incomplete lesion, as well as axonal versus demyelinating lesion.¹³ These distinctions can assist in determining the optimal treatment plan.¹⁵

ELECTROMYOGRAM (EMG)

Aims / Advantages: The concept of recording electrical activity produced by skeletal muscles has been around for approximately 130 years.^{18,19} EMG detects electric potentials generated by muscle contraction which are recorded as Motor Unit Action Potentials (MUAPs). The shape and fre-

quency of MUAPs provides insights on the functional status of motor nerves.²⁰ EMGs can measure a variety of domains including maximum voluntary contraction and muscle fatigue.²⁰

Disadvantages / Criticisms: Because EMG requires voluntary activation of muscle, it is not informative for patients who are less compliant to testing, younger populations (e.g., children and infants), and patients presenting with paralysis. In addition, deeper muscles require intramuscular wires, making it an invasive procedure. It has also been shown that adipose tissue can affect EMG recordings; EMGs are typically more accurate for patients with lower body fat. EMG signals from nearby muscles can interfere with the area of interest and alter readings.²¹

Improvements: Efforts have been made to isolate the signals from EMGs through improved postprocessing and noise reduction, however, these techniques are not currently used in clinical settings.^{22,23}

Role in nerve assessment algorithm: When the status of nerve function and/or recovery is unclear after sensory and/or motor testing in clinic, EMGs may be used as an adjunct to help determine the extent of motor dysfunction.

MAGNETIC RESONANCE NEUROGRAPHY (MRN)

Aims / Advantages: MRN is a subset of Magnetic Resonance Imaging (MRI) used to evaluate the structural status of nerves. MRN can identify nerve abnormalities, lesions, entrapments, hereditary neuropathies, and other pathologies.^{24–27} Increased signal on MRN has been correlated with abnormal EMGs findings.²⁷ MRN can reveal neuropraxic injury, axonotmesis, and neurotmesis, as well as the status of muscle targets supplied by the nerve in question.²⁵ MRN is an objective imaging modality that does not rely on operator skill.²⁴

Disadvantages / Criticisms: Nerves and vasculature within a bundle or those in close proximity may be difficult to differentiate.²⁴ Furthermore, it is difficult to distinguish a newly regenerating nerve from a chronically degenerating nerve.²⁴ MRN imaging is also expensive and poorly tolerated by children and patients who are claustrophobic.²⁸

Improvements: High resolution scanners (3T MR) have been used successfully to identify compression nerve injury such as carpal tunnel.²⁴ Use of Dixon techniques and T2 weighted imaging improve signal-to-noise ratio in areas with increased fat deposition.²⁴ Diffusion tensor imaging (DTI) and tractography have recently been used in combination with to improve detection of proximal and/or multifocal nerve lesions.²⁹

Role in nerve assessment algorithm: MRN to provide additional data when common clinic tests are inconclusive.²⁷ It is currently the gold standard for imaging of compressive neuropathy.²⁷ MRN is faster to perform than an EMG and can be used for presurgical localization of neurologic compromise.^{24,26} Compared to EMG, MRN may be superior for early post-operative cases as it yields high quality data, is less invasive.²⁴ MRNs should be considered if diagnosis requires more precise imaging than can be provided via ultrasound.^{24,25} MRNs are most useful when imaging is acquired within 1 year of nerve injury.²⁷

ULTRASOUND (US)

Aims / Advantages: Ultrasound was first used to evaluate peripheral nerves in the 1980s and has since been utilized as a non-invasive technique for dynamic imaging of nerves.^{24,28} US provides detailed anatomic imaging without the discomfort associated with EMG and MRN (to a lesser extent).³⁰ Due to its higher spatial and edge-to-edge resolution compared to MRI, US has shown greater utility in visualization of smaller nerves.^{25,30,31} Many digital nerves can be visualized using linear array US with a small footprint and high-frequency.³¹

Disadvantages / Criticisms: Quality of imaging is operator-dependent. Scarring and shadows from nearby calcifications can obscure the nerve image. Even with high-frequency linear transducers, these issues can complicate imaging of deeper nerves.^{24,25}

Role in nerve assessment algorithm: US can be used as a screening and monitoring tool due to its portability, speed of image acquisition, and relatively low cost.^{28,31} It may be used to evaluate suspected compressive neuropathy when clinical exams are inconclusive.³⁰ US tools are the preferred imaging modality for procedural guidance as they provide morphologic rather than conductance data.²⁵ These images may be used to localize the site of neurologic compromise prior to electrodiagnostic studies.³⁰

MOTOR ASSESSMENT

BRITISH MEDICAL RESEARCH COUNCIL (BMRC)–RIDDOCH ET AL. (1943)³²

Aims / Advantages: In 1943, the British Medical Research Council (BMRC) developed a grading system that assessed contractile muscle strength on a scale from 0 – 5 with high scores indicating greater strength. The BMRC provides a holistic picture of the motor recovery in a limb following nerve injury and/or repair. It is best suited for assessing nerve injuries of the upper arm and the upper third of the forearm, but less useful for distal nerve injuries.³²

Disadvantages / Criticisms: It is difficult to accurately record deficiencies of distal muscles when proximal muscle function is intact given that the BMRC grades the entire limb as a single unit.³⁵ This grading system relies on visual grading of muscle atrophy which may take many weeks to present, with a greater susceptibility in type 1 muscles than in type 2 muscles.³⁴ Studies reappraising the scale have noted that strength increments are not evenly distributed (e.g. grade 4/5 strength represents up to 96% of potential strength).³⁵

Improvements: Grading qualifiers (e.g. 4+, 5-, 5, 5+) have been introduced to improve precision, though ratings remain subjective.³⁶ Further modifications (percentage strength estimates, isolating individual muscle strength during testing) are currently being investigated.³⁵

Role in nerve assessment algorithm: With its ease and ubiquity of use in a variety of specialties, the BMRC scale may serve as a crude measure of motor function and/or recovery. However, more quantitative tests are recommended to delineate the functional status of peripheral nerves.

MANUAL MUSCLE TESTING (MMT)—MARTIN AND LOVETT (1915)³⁷

Aims / Advantages: MMT assesses multiple domains of motor recovery and was described in the literature as early as 1915.³⁷ More recently, it has been used to help determine the extent of nerve injury by assigning a grade to muscle contraction (as perceived by an observer).³⁸ MMT can evaluate both large and small muscles and is used in conjunction with the BMRC muscle strength scale to define range of motion, resistance, and strength of intrinsic muscles of the hand.³⁹ Current manual muscle tests have shown excellent reliability.⁴⁰

Disadvantages / Criticisms: MMT only indicates muscle weaknesses in severe cases as even very low levels of innervation can develop a contraction. Its connection to the BRMC scale leads to uneven distribution of strength increments.³⁵ As a result, once a patient is able to develop a contraction during their recovery, a dynamometer is recommended to assess motor recovery.³⁸ Some measures using MMT (e.g. power grip) require muscle coordination and thus lead to difficulties determining isolated dysfunction.⁴¹ MMTs should not be used when wound healing is not complete or in situations where testing elicits pain as results may be skewed by increased sensitivity to pressure.⁴²

Role in nerve assessment algorithm: MMTs, along with the BRMC, can assess recovery of neuromuscular function across a variety of muscles and are accessible by many specialties. In complex and/or more distal injuries, additional tests are needed to adequately assess motor function.

PINCH STRENGTH TEST

Aims / Advantages: The key pinch strength test is commonly used to assess ulnar nerve function as it requires thumb adduction. Tip-to-tip and/or tripod pinches can assess extent of nerve injury or recovery in the median nerve.³⁸ Pinch strength tests are frequently used as a measure of motor function following carpal and/or cubital tunnel release.³⁹ The Preston pinch gauge has good validity and reliability; however, when using the gauge, it is recommended to record multiple trials.⁴³ Use of digitalized Pinch Dynamometers have reliability equivalent to the Preston Pinch Gauge. Studies have shown high inter-instrumental reliability with high correlation of measurements between the two tools.⁴⁴ The digitized pinch dynamometer may also be utilized to evaluate real time pinch strength and offer user feedback (i.e. patients can watch the force readings rise and fall as they squeeze) which can affect patients' strength exertion.^{45,46}

Disadvantages / Criticisms: Key pinch, the most common type assessed, involves synergistic interaction of multiple muscles.⁴² Compensating mechanisms may confound testing of a particular nerve, especially in cases where neurologic compromise is not severe.⁴²

Role in nerve assessment algorithm: Pinch strength tests, taken via manual pinch gauges or digitized dynamometers provide precise data, particularly when assessing thumb adduction. While these tests are not comprehensive, they are

critical to evaluate motor function of the median and/or ulnar nerves.

MUSCLE DYNAMOMETER—MANNERFELT (1966)⁴⁷

Aims / Advantages: Mannerfelt first outlined the use of dynamometry for peripheral nerve assessment in 1966.⁴⁷ Early tests utilized a breaking force technique in which the patient resisted force on a spring loaded device with strength measured as the force at which they could no longer hold. This test allows for individualized action assessment such that surgeons can identify the activity of particular muscle movements/groups, especially in ulnar nerve repair patients.⁴⁸ Dynamometry can also measure the ability of the intrinsic and extrinsic hand muscles to work together (e.g. power grip).³⁹ In clinic, a power grip dynamometer is often used to assess gross motor function in median and ulnar nerve injury/recovery.⁴²

Disadvantages / Criticisms: While the measurements of a power grip dynamometer are more precise than the BRMC, compensatory strength supplied by motor units of uninjured nerves may still confound nerve assessment. There are specialized dynamometers that measure intrinsic muscle activity, however, the necessary distinction between extremely small force increments reduces reliability of these tools. Furthermore, the specialized dynamometer is difficult to use and expensive, leading some to prefer the less quantitative BMRC Muscle Power Grading (0-5) for simple, cost-effective motor assessment.⁴⁸

Improvements: Updated dynamometers (e.g., NK Digits-Grip) can assess damage severity and even isolate the deficit to radial and ulnar digits. Recently, computerized grip strength devices have been developed to measure the activity and strength of individual digits.^{38,49,50}

Role in nerve assessment algorithm: Muscle dynamometers are currently indicated for assessing grip strength, and if available, newer devices can give accurate measurements that quantify loss of grip strength and distribution between radial and ulnar digits of the hand.⁵¹ While these newer tools are adequate to measure strength, additional tests such as Sollerman's grip test or the Jebsen-Taylor Hand Function test are needed to provide a complete picture of motor function.

JEBSEN-TAYLOR HAND FUNCTION TEST (JTHFT)—JEBSEN ET AL. (1969)⁵²

Aims / Advantages: The Jebsen-Taylor Hand Function test (JTHFT) was developed in 1969 and quantifies hand function on standardized tasks.⁵³ It is a timed test that consists of seven tasks to test fine motor, weighted and non-weighted hand function. The mean time to complete a task is recorded to assess a patient's level of hand dysfunction.⁵⁴

Disadvantages / Criticisms: While this test has high validity, the reliability of the test decreases with increased number of trials as patients improve with increased practice.⁵⁵ Concerns about current clinical utility of JTHFT have been raised due to outdated norm scores for both men and women.⁵²

Improvements: Updated cutoff values for the JTHFT have been established. Additional analyses have established weak positive correlations between JTHFT total scores (higher score = worse function) and DASH-T total scores and weak negative correlations between JTHFT score and grip strength.⁵⁶

Role in nerve assessment algorithm: The JTHFT can be used to clinically assess patients' hand functions and to distinguish between impaired and unimpaired hand function in assessing nerve injury. When adequate strength measurements must be provided by another tool, the JTHFT may be used to provide data on dexterity.

SOLLERMAN'S GRIP TEST—SOLLERMAN (1980)⁵⁷

Aims / Advantages: The Sollerman's grip test is used to understand the quality of hand grip and to correlate that grip with difficulty in performing a task.⁴⁸ Sollerman's grip test evaluates grip strength across 20 different common daily activities and has been used extensively to assess upper limb function in hemiplegic populations.^{39,58–60} Detailed information regarding grip strength is valuable for nerve assessment as changes in strength are known to be proportional to decreased motor unit activation.³⁸

Disadvantages / Criticisms: While grip strength is useful in understanding hand function, it does not provide data on individual muscle strength. Furthermore, patients learn to compensate for reduced muscle activity, and grip weakness may be masked until the nerve has undergone severe degeneration. Due these potentially confounding variables, Sollerman's grip test is not highly sensitive³⁴ and is not applicable to brachial plexus injuries.⁶¹

Role in nerve assessment algorithm: Sollerman's grip test may be used to provide a comprehensive picture of the motor function in an injured hand, however, additional tests are needed to fully assess motor function and/or recovery of peripheral nerves.⁶²

ROSEN AND LUNDBORG SCALE—ROSEN AND LUNDBORG (2000)⁶³

Aims / Advantages: The Rosen and Lundborg scale, developed by Bigitta Rosen and Goran Lundborg, assesses outcomes of median and ulnar nerve repair via motor, sensory, and pain domains.^{63–65} Within this outcome scale is the SWM and shape identification tests for sensory status, MMT and grip strength testing for motor status, and a four-point self-report scale for pain status.^{38,63–66} The Rosen-Lundborg scale has high reliability and validity in assessing nerve function.^{40,63} Since the scale takes into account multiple tests, the effect of confounding variables in any one test is minimized.⁶³

Disadvantages / Criticisms: Some disadvantages of the scale arise from the issues present in each individual subtest. To calculate the entire score, multiple tests have to be run which can place a burden on both clinician and respondent. Furthermore, some hand movements can receive assistance from forearm muscles that can hide intrinsic hand function deficits and yield a faulty functional status score.⁶³ Of note, scores generated for median nerve injury

repair are not comparable to those for an ulnar nerve injury.⁶³

Improvements: Within the scale's sensory domain, SWM has been recommended over 2PD as it is more responsive.⁴⁰ Additionally, due to its goal of providing a full picture of a patient's recovery, some have suggested that the scale could be improved by accounting for socioeconomic factors and quality of life.⁶³

Role in nerve assessment algorithm: The Rosen and Lundborg scale should be used when physicians need to assess more than two dimensions of hand function. This battery of tests provides the most comprehensive view of nerve functional status and changes over time.⁶³

DISCUSSION

Injury-specific characteristics, such as number of structures and vessels involved, location, type of damaged nerve, and type of trauma, influence functional recovery.^{67,68} Motor function tests measure muscle strength and/or coordination to evaluate the status of peripheral nerves known to supply these end targets. There are many measurement tools that help clinicians and surgeons gauge success and progress after an upper extremity intervention, but selecting the optimal test(s) is difficult and lacks standardization across the field. This review of peripheral nerve assessments aims to give an overview of current outcome measurements for motor function with a particular focus on the strengths, weaknesses, and clinical application for each technique.

It is clear that one test alone is not able to give a full clinical picture of a patients' nerve injury and/or recovery, however, there are myriad practical considerations (time, expense, patient fatigue, etc.) that prevent clinicians from performing every test at each visit. There is a need for accurate injury assessment as seen in [Table 1](#) and motor recovery assessment as described in [Table 2](#). With this in mind, it is important to optimize the assessment algorithm to obtain the most accurate and relevant data regarding each patient's unique presentation.⁶⁹

To test motor function and extent of peripheral nerve recovery, it is important to gauge the preliminary gain of function and recovery and, if needed, define the degree of recovery quantitatively. The use of MMTs, is recommended for its practicality and applicability across many different nerves and ease of use by clinicians of many specialties. For hand function in particular, many different tests can be utilized to reach certain objectives. Jamar dynamometers, can provide precise measurements of digit function but are often limited in availability. While JTHFT can comprehensively gauge patients' hand functions and is easy to perform in a clinical setting, its results may be confounded due to the possibility of improved function through learning. Therefore, Sollerman's grip test may provide a better comprehensive assessment. For evaluating precise measures of hand function and utility, please refer to the algorithm presented in [Figure 1](#).

Of the different forms of imaging, morphologic imaging may be superior to electrophysiologic testing in assessing

Table 1. Motor Evaluations and associated information

Test	Description	Normals	Add. Information	Source
Nerve Conduction Studies (NCS)	Records action potentials conducted by nerves for quantification of motor, sensory, and mixed nerve functional status	Varies depending on nerve studied	Can differentiate between mononeuropathy and polyneuropathy. NCS is operator dependent and small sensory nerves are difficult to record. Additionally, incorrectly placed needle electrodes may not provide valuable information. Cannot be used to predict nerve injury recovery.	13,70
Electromyogram (EMG)	Records electrical activity of skeletal muscles whereby shape and frequency of action potentials describe functional status of motor nerves	50-60m/s (also varies by nerve)	Deeper muscles require intramuscular wires. May not be suitable in young populations (infants, young children). Preferable in patients with low body fat. CPT - 95860	18,20,71
Magnetic Resonance Neurography (MRN)	MRI evaluation of nerve structure	No evidence of nerve injury	Difficult to differentiate nerves and vasculature. Also difficult to assess nerve regeneration from chronic degeneration. Not well tolerated by children. It is the gold standard for compressive neuropathy. Faster to perform than EMG.	24-26,72
Ultrasound	Provides anatomic imaging of nerves.	No evidence of nerve injury	Better visualization of smaller nerves and better tolerated in patients.	72

extent of damage and in identifying type of damage. However, within morphologic imaging, we recommend use of US as it is currently more practical and cost-effective than MRN. As DTI continues to evolve, it may be used in combination with MRN to parse out complex cases of nerve dysfunction, however, it is currently impractical to obtain DTIs for most patients.

There is currently no consensus on the optimal assessment algorithm for peripheral nerve injuries. While many questions remain unanswered, this review may serve as a valuable resource for surgeons determining the appropriate tools to monitor nerve function both pre and postoperatively. As surgeons work to improve treatments for peripheral nerve injury and dysfunction, identifying the most appropriate measures of success may ultimately lead to improved patient outcomes.

LIMITATIONS

There are limitations to the design of our study. Further studies are encouraged in order to assess the necessity and ideal combination of tools when assessing peripheral nerve motor recovery. A large issue with assessing peripheral nerve assessment tools lies in both the variety of combinations of tools used by various physicians and in the idiosyncrasies of physicians when using these tools. This limitation leads to heterogeneity when performing a literature review on this topic, which can be ameliorated by standardization of peripheral nerve assessment tools.

CONCLUSIONS

Despite advances in motor assessment tools and methods, there still remains ambiguity in the optimal assessment algorithm. This review serves as a centralized reservoir of knowledge for surgeons to develop their own optimal systems. By improving the motor assessment algorithm, surgeons can better track and offer additional intervention for patients with peripheral nerve injuries.

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AUTHOR CONTRIBUTIONS

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Table 2. Motor Tests and associated information

Test	Description	Areas of Use	Normals	Add. Information	Source
British Medical Research Council (BMRC)	A grading system to assess contractile strength	Upper arm and Upper 1/3 of forearm	5 - normal strength, relative to patient	Scale ranges from 0-5 with higher scores indicating greater strength. Less useful in distal nerve injuries. Based on visual grading that can affect type 1 muscles differently than in type 2 muscles. Subjective test without standardized scaling.	32,34,35
Manual Muscle Testing (MMT)	Assess nerve injury by grading muscle contraction	Non-specific	5 - Normal, maximal resistance, relative to patient	Can only demonstrate muscle weakness in severe cases. Once a patient can contract, further assessment is best accomplished using a dynamometer. Cannot be done if patient has active wounds or pain on contraction.	38
Pinch Strength Test	Assess ulnar nerve function. If using tip-to-tip or tripod pinches, can also assess Median nerve injury	Hands (fingers)	Able to pinch tip to tip.	Often used to assess Carpal or cubital tunnel release. Highly recommended to be done with Pinch dynamometers.	38,39,44
Muscle Dynamometer	Individual assessment of muscle movement/ muscle group via assessment of grip strength.	Hand	Depends on age and sex (average ranges from 37 lb to 91.5 lb)	Most often used to assess median and ulnar nerve injury. Compensatory strength by other motor units can confound nerve assessment. Specialized dynamometers to measure intrinsic muscle activity are available but are expensive and difficult to use.	48,63
Jebsen-Taylor hand Function	Timed tests of seven tasks to test fine motor hand function	Hand	Dominant hand - ~45s Non-dominant hand - ~60s	Patients can improve their own scores with increased practice.	53,73
Sollerman's grip test	Qualifies the hand grip strength across 20 common daily activities	Upper limb and Hand	Dominant hand - 80/80 points Non-dominant hand - at least 77/80 points	Can be affected by compensation by other muscle groups. Not applicable in brachial plexus injuries	34,48,61
Rosen and Lundborg Scale	Provides motor, sensory, and pain assessment of median and ulnar nerve recovery.	Hand	Score of 3 (1 point each for normal sensory, motor, and pain/discomfort domains)	This scale is inclusive of MMT and grip strength testing.	63-65

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CONFLICTS OF INTEREST

None to report

Onset

Step 1 – Injury
Evaluation

Step 2 –
Subjective
Assessment

Step 3 –
Objective
Assessment

Step 4 –
Comprehensive
Assessment

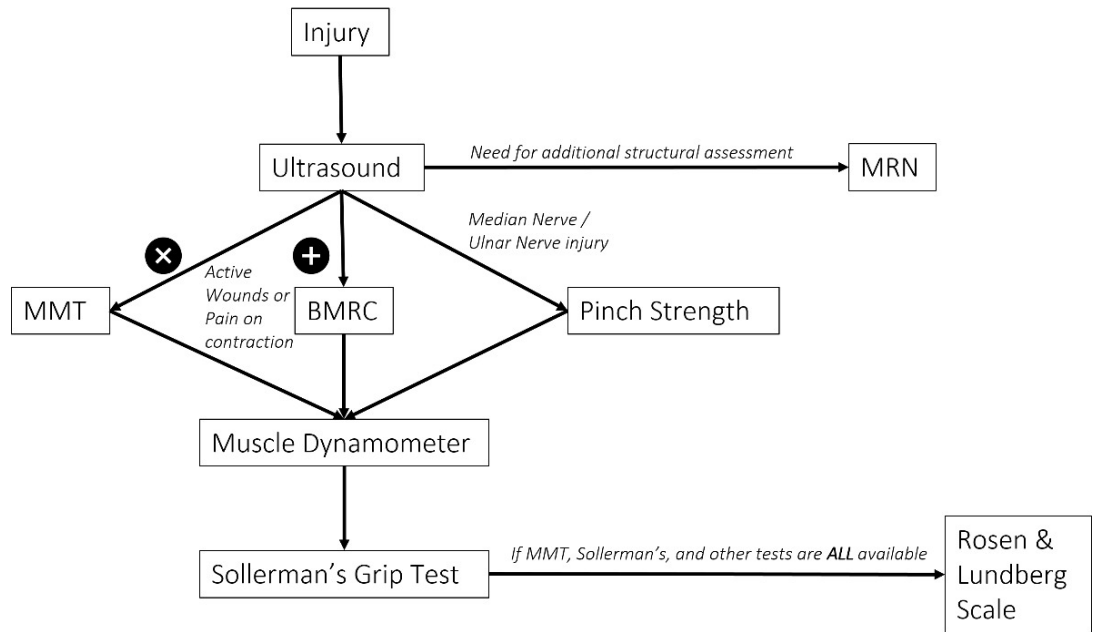


Figure 1. Suggested algorithm for Motor testing in peripheral nerve recovery

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