How Reliable is Manual Muscle Testing and Does it Correlate with Functional and Quality of Life Outcomes in Patients with Upper Brachial Plexus Injury and Cervical Spine Pathology: A Protocol

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Abstract

Objectives: Measurement of muscle force using the Medical Research Council (MRC) Grades (0 to 5) is frequently used to evaluate the outcome following a brachial plexus injury (BPI). BPIs result in significant functional and psychosocial issues. It is unclear whether improvements in muscle force correlate with functional and quality of life (QoL) outcomes. Our aim is to assess the inter-rater reliability of the MRC grading system with patients with upper trunk BPIs and weakness from C5/6 cervical pathology and to explore whether the grading systems correlate with function and QoL. **Methods:** Forty participants with upper trunk BPIs and those with weakness secondary to cervical C5/C6 pathology will be recruited. Two clinicians will assess muscle power using the MRC muscle grading scale. Each clinician will be blinded to the others' score. Each participant will complete a quick Disabilities of the Arm, Shoulder, and Hand (DASH) and also a EuroQol five-dimensional scale. **Statistical Analysis:** Inter-rater reliability of the MRC manual testing will be calculated using a weighted kappa. To assess for the correlation between the DASH and QoL and the muscle testing results, a Spearman correlation will be used.

Keywords: Brachial plexus injury, Medical Research Council, muscle assessment, outcome measurement, quality of life

Introduction

Adult traumatic brachial plexus injuries (BPIs) are devastating injuries and result from high-speed motor vehicle accidents in the majority of cases.[1] These injuries typically occur in young males in their 20s and early 30s[2,3] and present with a wide variety of disabilities, which lead to functional limitations in their daily life and ongoing psychosocial issues.[4-6] Kretschmer *et al*.[7] found in a group of patients with BPIs (n = 70) that only 55% returned to their previous occupation.

Treatment for BPIs is focused on improving the use of the affected limb. Individuals often undergo reconstructive surgeries and rehabilitation over many months or years, and the burden on family and society can be considerable.[8] Determining the most cost-effective forms of management and monitoring treatment outcome is, therefore, of importance to patients, health-care professionals, hospital administrators, and commissioners.

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Conservative management is warranted in low-energy injuries where clinical examination suggests that physical nerve sheath continuity and spontaneous nerve regeneration is to be anticipated. High-energy injuries and those cases where conservative management has failed require prompt surgical exploration, and a number of reconstructive microsurgery options are employed including nerve repair, nerve grafting, and nerve transfer surgery. There is an increasing body of evidence that indicates that advances in microsurgical

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techniques result in increased strength of individual muscles, and therefore, movement at individual joints.[3,9,10] Indeed, nerve transfer surgery is often the mainstay of treatment for patients with upper brachial plexus lesions affecting the shoulder and elbow (C5/C6). This surgery has demonstrated good motor recovery.[3,11,12]

Assessing muscle strength is commonly assessed following BPIs and insults to the upper cervical spine. Indeed, 94% of published BPI studies report motor function after surgical treatment.[13] Clinicians assess muscle strength regularly to identify early reinnervation, monitor progress, and reason through an appropriate rehabilitation program. Therapists and doctors reviewing patients following infraclavicular BPI can also recognize, with muscle charting, when progress may have plateaued. This timely evaluation assists with subsequent decision-making regarding late salvage surgical intervention.

The Medical Research Council (MRC) muscle grading system is the most widely used muscle assessment in clinical practice.[14,15] This system ranges from Grade 0 (no contraction) to 5 (normal) and is a quick and easy tool to evaluate muscle strength in BPI patients. Furthermore, the MRC has been proven to be a reliable method of assessing peripheral nerve injury (PNI) weakness in the distal part of the upper limb.[16] Paternostro-Sluga *et al*.[16] assessed 31 patients with paralysis of the wrist and finger extensors and found that it had good inter-rater reliability (weighted kappas-finger extension: 0.77; wrist extension: 0.78). There is recent evidence that MRC grading is not reliable in patients with elbow flexion weakness;[17] however, there is a paucity of evidence available on the inter-rater reliability of assessing both the shoulder and elbow muscle groups using the MRC grading scale. There is a need to evaluate this method due to the increase in microsurgery for the nerve injuries around the shoulder and elbow in the past decade and the consistent use of the MRC as the index of outcome globally.[18-20]

There are few studies confirming that strength gains translate into a better ability to perform daily tasks that require complex positioning and holding of multiple joints in space.[21,22] The Disabilities of the Arm, Shoulder, and Hand (DASH) is an upper limb functional assessment questionnaire, which has been identified in the literature as an appropriate patient-reported outcome measure (PROM) for patients with nerve injury in the upper limb.[23] Novak *et al*.[23,24] used the DASH to assess disability in patients with long-standing traumatic upper extremity nerve injury.

The internal consistency of the DASH was high (Cronbach's alpha = 0.96) and thus supporting the use of this questionnaire in this patient group.[24]

It is also evident from patient reports that BPI results in significant social and functional disability[4-6,25] Patients report issues with discrimination, socializing, depression, and returning to previous employment.[8] Nevertheless, few studies have assessed the quality of life (QoL) following BPI[3,7,9] and specifically whether reestablishment of muscle strength has an effect on QoL. Hung *et al*.[26] investigated the validity of the EuroQol five-dimension (EQ5D) in patients with limb trauma ($n = 987$) and found that the EQ5D had sufficient construct and predictive validity as well as responsiveness to justify its use within research and clinical practice in the limb trauma group.

It is important, therefore, to assess whether the reestablishment of muscle strength has any correlation with function and QoL.

The aim of this study is to:

1. Evaluate the inter-rater reliability of the MRC in patients with C5/6/7 motor weakness following a BPI or secondary to cervical musculoskeletal disease
2. Determine whether muscle strength (using the MRC) with BPIs and C5/C6 correlates with QoL ratings using the EQ5D
3. Evaluate whether modified MRC correlates with function (DASH).

Materials and Methods

Patients admitted into the study will be:

- Adult patients (16 and over) sustaining
  - Traumatic BPI predominantly involving upper roots and those with isolated musculocutaneous, axillary, and suprascapular nerve injuries
  - Weakness in C5/C6 innervated muscles secondary to cervical musculoskeletal pathology.
- Treated conservatively or following nerve reconstruction
- Assessed as having a Grade 3 or above (as defined by the lead surgeon).

Patients will be excluded if they have:

- Persistent lower plexus involvement with significant impairment of hand function
- An inability to understand the assessment instructions due to diminished understanding or language barriers
- Coexisting chronic conditions, which may affect their QoL.

The lead investigator attends and helps run a PNI clinic and sees on average 1–2 patients with upper BPIs weekly. In addition, the unit at the University Hospital Birmingham has a PNI database, which includes data on 1200 patients. There are 192 patients with BPI currently on this database. The lead investigator will review the database ($n = 192$ patients with BPI) and identify patients who may be appropriate for inclusion in the study.

A two-pronged approach will be used for recruitment in this study. If the patients are no longer attending clinic, then they will be identified through the database, and the electronic clinical noting will be reviewed for the last appointment to establish what muscle strength (on MRC) each patient achieved. The lead surgeon will have documented this as part of normal clinical practice and notation.

Patients attending clinic

- Patients attending the PNI clinic, who meet the eligibility criteria, will be recruited face to face by

either of the two hand surgeons, nerve fellow or the lead physiotherapist
- This is a cross-sectional study, and the criteria of reaching a Grade MRC3 or above will be assessed as part of routine follow-up by the lead surgeon DP
- It will be made clear to the patient that it will have no impact on the patients' ongoing management whether they agree to take part in the study or not
- If the patient is interested, then a patient information leaflet will be provided. Patients will have adequate time to study the leaflet in clinic and to ask questions
- If patients are happy to be part of the study, then the testing procedure could be done while patients are waiting for their doctors' appointment or immediately after that, and this would have minimal impact of time spent in the hospital and on travel expenses. An appointment at a different time can be arranged if the potential participant wishes to have more time to consider the study and discuss it further with family and friends.

Patients who have been discharged from the clinic

A patient information leaflet will be posted out to all eligible patients (identified on the database) explaining the study and inviting them to participate. They will be provided with the contact number of the chief investigator (CM) and asked to contact this person if they are interested. At this point, the study will be explained in more detail, and if the individual agrees to participate, then an appointment at a convenient time will be arranged.

- At any time after receiving the patient information leaflet, they can decline and leave the study.

This study aims for a sample size of at least 40, which would give >80% power to detect a Spearman correlation of 0.5 (5% significance level).

Following a discussion either through phone or face to face if the potential participant is interested in the study, they will be asked to attend an appointment for testing. The appointments will be organized to coincide with patient's attendance in peripheral nerve/therapy clinic if possible or at another convenient time for the participant. At the research appointment, a therapist will check all inclusion and exclusion criteria. If the potential participant is still eligible at this stage, then he/she will complete the informed consent procedure.

The participant will also be asked to complete the DASH and EQ5D before the other outcomes to minimize variability. The participant will have the opportunity to talk through the questionnaires with the investigator if they have any difficulty filling them out. It will be made clear in the patient information that data from the PROMs will not be used to inform patient care and that if a patient has concerns about their well-being, this should be flagged directly to the clinical team.

The motor MRC scale will be used, which has been fully described in O'Brien (2010) Aids to the Examination of the Peripheral Nervous System, 5th edition.[14] This version of the MRC described by O'Brien (2010) includes the 4−, 4, and 4 + grades, which are used to indicate movement against slight, moderate, and strong resistance, respectively.

The strength of the shoulder abductor, external rotator, and elbow flexor will be graded using the modified MRC (4−, 4, and 4+) system by two independent therapists allowing adequate time for recovery between each testing. Each therapist will be blinded to the results of each other's grading. A standardized testing procedure will be followed according to the movement being assessed.

A weighted kappa will be used to assess the inter-rater reliability of the MRC manual testing as this is ordinal data. To assess for correlation between the DASH and QoL and the muscle testing results, then a Spearman's correlation will be used.

Discussion

MRC muscle grading is used frequently to assess outcome following a traumatic BPI and following neurological dysfunction secondary to cervical spine degenerative changes. However, these conditions have significant functional and psychosocial effects. This study will identify whether MRC muscle grading is a reliable and valid outcome measure to use with patients with upper trunk traumatic BPIs and patients with weakness secondary to upper cervical spine degenerative changes. It will assess whether MRC muscle grades correlate with QoL and functional outcome.

The study will be conducted in a large PNI secondary care center, which will facilitate the recruitment of participants in a timely fashion. In studies involving participants with PNI, there are often substantial issues with long-term follow-up due to the time needed for final outcome after nerve injury. As all the measurements in this study are taken in one research appointment, there will be no risk of loss to follow-up. Therapists taking the measurements will complete standardized training to measure muscle strength as per the MRC scale and will follow a standard operating procedure. This will improve the rigor and robustness of the study.

The results of this study will help clinicians and researchers make decisions on which outcome measures to use to assess and monitor outcome following these severe injuries.

Ethical consideration

Ethical approval has been received (IRAS number: 206730) for this study. There will be minimal patient burden, as for many of the patients, they will be attending clinic anyway for follow-up appointments. The study appointment will coordinate with these appointments to minimize burden on the patient. All patients will provide written informed consent as approved by the NHS research ethics committee.

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Conflicts of interest

There are no conflicts of interest.

Author's contributions

CM involved in concept, design, literature search, data acquisition, manuscript preparation, editing and review. MH involved in design of the study, data acquisition, manuscript editing, and review. DMP involved in concept, design, literature search, data acquisition, manuscript preparation, editing, and review. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

References

1. Midha R. Epidemiology of brachial plexus injuries in a multitrauma population. Neurosurgery 1997;40:1182-8.
2. Jain DK, Bhardwaj P, Venkataramani H, Sabapathy SR. An epidemiological study of traumatic brachial plexus injury patients treated at an Indian centre. Indian J Plast Surg 2012;45:498-503.
3. Estrella EP. Functional outcome of nerve transfers for upper-type brachial plexus injuries. J Plast Reconstr Aesthet Surg 2011;64:1007-13.
4. McDonald J, Pettigrew J. Traumatic brachial plexus injury: The lived experience. Br J Occup 2014;77:154-7.
5. Wellington B. Quality of life issues for patients following traumatic brachial plexus injury – Part 2 research project. Int J Orthop Trauma Nurs 2010;14:5-11.
6. Choi PD, Novak CB, Mackinnon SE, Kline DG. Quality of life and functional outcome following brachial plexus injury. J Hand Surg Am 1997;22:605-12.
7. Kretschmer T, Ihle S, Antoniadis G, Seidel JA, Heinen C, Börm W, *et al.* Patient satisfaction and disability after brachial plexus surgery. Neurosurgery 2009;65:A189-96.
8. Franzblau LE, Shauver MJ, Chung KC. Patient satisfaction and self-reported outcomes after complete brachial plexus avulsion injury. J Hand Surg Am 2014;39:948-55.e4.
9. Dolan RT, Butler JS, Murphy SM, Hynes D, Cronin KJ. Health-related quality of life and functional outcomes following nerve transfers for traumatic upper brachial plexus injuries. J Hand Surg Eur Vol 2012;37:642-51.
10. Tung TH, Mackinnon SE. Nerve transfers: Indications, techniques, and outcomes. J Hand Surg Am 2010;35:332-41.
11. Leechavengvongs S, Witoonchart K, Uerpairojkit C, Thuvasethakul P, Malungpaishrope K. Combined nerve transfers for C5 and C6 brachial plexus avulsion injury. J Hand Surg Am 2006;31:183-9.
12. Teboul F, Kakkar R, Ameur N, Beaulieu JY, Oberlin C. Transfer of fascicles from the ulnar nerve to the nerve to the biceps in the treatment of upper brachial plexus palsy. J Bone Joint Surg Am 2004;86-A: 1485-90.
13. Dy CJ, Garg R, Lee SK, Tow P, Mancuso CA, Wolfe SW, *et al.* A systematic review of outcomes reporting for brachial plexus reconstruction. J Hand Surg Am 2015;40:308-13.
14. Medical Research Council. Aids to the Investigation of the Peripheral Nervous System. London: Her Majesty's Stationary Office; 1943.
15. Dyck PJ, Boes CJ, Mulder D, Millikan C, Windebank AJ, Dyck PJ, *et al.* History of standard scoring, notation, and summation of neuromuscular signs. A current survey and recommendation. J Peripher Nerv Syst 2005;10:158-73.
16. Paternostro-Sluga T, Grim-Stieger M, Posch M, Schuhfried O, Vacariu G, Mittermaier C, *et al.* Reliability and validity of the Medical Research Council (MRC) scale and a modified scale for testing muscle strength in patients with radial palsy. J Rehabil Med 2008;40:665-71.
17. Marei A, Doi K, Hattori Y, Sakamot S. Quantitative assessment of elbow flexion by handheld dynamometry in brachial plexus palsy. J Hand Surg Eur Vol 2018;1753193418814430. DOI: https://doi.org/10.1177/1753193418814430.
18. Yang G, Chang KW, Chung KC. A systematic review of outcomes of contralateral C7 transfer for the treatment of traumatic brachial plexus injury: Part 2. Donor-site morbidity. Plast Reconstr Surg 2015;136:480e-9e.
19. Witoonchart K, Leechavengvongs S, Uerpairojkit C, Thuvasethakul P, Wongnopsuwan V. Nerve transfer to deltoid muscle using the nerve to the long head of the triceps, part I: An anatomic feasibility study. J Hand Surg Am 2003;28:628-32.
20. Lee JY, Kircher MF, Spinner RJ, Bishop AT, Shin AY. Factors affecting outcome of triceps motor branch transfer for isolated axillary nerve injury. J Hand Surg Am 2012;37:2350-6.
21. van Meeteren J, van Rijn RM, Selles RW, Roebroeck ME, Stam HJ. Grip strength parameters and functional activities in young adults with unilateral cerebral palsy compared with healthy subjects. J Rehabil Med 2007;39:598-604.
22. Michielsen ME, de Niet M, Ribbers GM, Stam HJ, Bussmann JB. Evidence of a logarithmic relationship between motor capacity and actual performance in daily life of the paretic arm following stroke. J Rehabil Med 2009;41:327-31.
23. Novak CB, Anastakis DJ, Beaton DE, Katz J. Patient-reported outcome after peripheral nerve injury. J Hand Surg Am 2009;34:281-7.
24. 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;93:929-36.
25. Brown H, Johnson K, Gilbert A, Quick T. The lived experience of motor recovery of elbow flexion following oberlin nerve transfer: A qualitative analysis. Hand Ther 2018;23:130-8.
26. Hung MC, Lu WS, Chen SS, Hou WH, Hsieh CL, Wang JD, *et al.* Validation of the EQ-5D in patients with traumatic limb injury. J Occup Rehabil 2015;25:387-93.