DOI: https://doi.org/10.53350/pjmhs20231711534

ORIGINAL ARTICLE

Assessing the Efficacy of Peripheral Nerve Blocks in Predicting Functional Recovery Post-Nerve Reconstruction after Limb Amputation

MUHAMMAD QAISER FAHEEM[1], SAMREEN MUSHTAQ[2], ASAD SHAMEEM[3], MOBASHER AHMAD SAEED[4], ABRAR UL HASSAN PIRZADA[5], ABDUR RAUF HAMMAD[6]

[1]*Chief Consultant, Department of Orthopedic Surgery, Social Security Hospital, Shahdara, Lahore, Pakistan.*
[2]*Associate Professor, Department of Radiology, Nishtar Medical University, Multan, Pakistan.*
[3]*Assistant Professor, Department of Anaesthesiology, HBS Medical and Dental College, Lehtrar Road, Islamabad, Pakistan.*
[4]*Professor, Department of Anaesthesia and Intensive Care, Wah Medical College / POF Hospital, Wah Cantt, Pakistan.*
[5]*Associate Professor, Department of Plastic Surgery, Azra Naheed Medical & Dental College, Lahore, Pakistan.*
[6]*Assistant Professor, Department of Physiology, Abwa Medical College, Faisalabad, Pakistan.*
Correspondence to: Muhammad Qaiser Faheem, Email: Fhareem044@gmail.com

ABSTRACT

Background: Predicting neurological and functional recovery after nerve reconstruction in amputated limbs remains a major clinical challenge. Early response to peripheral nerve block (PNB) may offer a simple, non-invasive method to assess underlying nerve viability and forecast long-term outcomes.

Objective: To evaluate the efficacy of early PNB response in predicting sensory, motor, and functional recovery following peripheral nerve reconstruction in traumatic limb amputation patients.

Methods: This prospective observational study was conducted at Social Security Hospital Shahdara, Lahore, and POF Hospital Wah Cantt from February 2022 to March 2023. A total of 100 patients undergoing reconstructive nerve surgery were assessed. Early response to ultrasound-guided PNB was recorded at 15 and 30 minutes. Motor recovery (MRC scores), sensory recovery (two-point discrimination, monofilament testing), electrophysiological reinnervation, and functional outcomes (DASH/LEFS scores) were evaluated at 1, 3, and 6 months. Pearson correlation analysis assessed associations between early block response and long-term recovery.

Results: Sixty-three patients (63%) were early responders. Early responders demonstrated significantly better motor recovery at six months (4.09 ± 0.82 vs. 2.92 ± 1.14; $p = 0.001$) and superior sensory outcomes ($p < 0.001$). Functional disability scores improved markedly in responders (DASH $p < 0.001$; LEFS $p = 0.002$). Early PNB response showed strong correlations with motor recovery ($r = 0.71$, $p < 0.001$), sensory improvement ($r = 0.65$, $p = 0.002$), and functional outcomes ($r = 0.68$, $p < 0.001$).

Conclusion: Early clinical response to peripheral nerve block is a strong predictor of neurological and functional recovery after nerve reconstruction in amputated limbs. PNB responsiveness should be incorporated into preoperative evaluation to optimize surgical planning and rehabilitation strategies.

Keywords: Peripheral nerve block, nerve reconstruction, limb amputation, functional recovery, sensory reinnervation, MRC score, DASH, LEFS.

INTRODUCTION

Peripheral nerve injuries associated with traumatic limb amputation represent one of the most challenging reconstructive problems in modern surgical practice[1]. Loss of neural continuity, neuroma formation, chronic neuropathic pain, and impaired sensorimotor coordination significantly limit the functional independence of amputees. Although advancements in microsurgical techniques such as end-to-end nerve repair, autologous nerve grafting, targeted muscle reinnervation (TMR), and regenerative peripheral nerve interfaces (RPNIs) have improved postoperative outcomes, predicting the degree and trajectory of functional recovery remains a persistent clinical challenge. A reliable prognostic tool would allow surgeons to identify patients most likely to benefit from nerve reconstruction and customize postoperative rehabilitation strategies[2,3].

Peripheral nerve blocks (PNBs) are widely used perioperatively for anesthesia and analgesia in both amputation and reconstructive nerve surgeries. Beyond their analgesic effect, PNBs temporarily modulate nerve conduction pathways and can induce measurable changes in sensory perception and motor response[4]. This transient alteration in neural signaling provides a unique opportunity to assess the integrity and functional potential of injured nerves. Early physiological responses to nerve blocks such as improvement in sensation, reduction in dysesthesia, or transient motor activation may reflect the viability of residual axons and the capacity for successful reinnervation following reconstruction[5].

Emerging literature suggests that diagnostic nerve blocks may have value in predicting outcomes after peripheral nerve repair; however, existing evidence is limited, heterogeneous, and largely focused on chronic nerve entrapment syndromes rather than post-amputation nerve reconstruction. Furthermore, the relationship between early block response and long-term functional restoration in amputees has not been systematically evaluated in clinical practice.

Received on 10-04-2023
Accepted on 16-10-2023

Given the high socioeconomic and rehabilitative burden of limb loss, there is a critical need to identify simple, low-cost, non-invasive predictors of nerve recovery. If early response to PNB can reliably forecast postoperative functional outcomes, it could significantly enhance surgical decision-making, guide patient counseling, improve prosthetic integration, and optimize allocation of rehabilitation resources[6,7].

This study was designed to assess the efficacy of peripheral nerve blocks as a predictive tool for long-term sensory and motor recovery in patients undergoing nerve reconstruction following limb amputation. By correlating early block responses with standardized functional and electrophysiological outcomes, we aim to determine whether PNB assessment can serve as a clinically meaningful prognostic indicator in reconstructive nerve surgery[8].

MATERIALS AND METHODS

Study Design and Setting: This prospective observational clinical study was conducted over a fourteen-month period, from February 2022 to March 2023, at two major healthcare institutions in Punjab, Pakistan: Social Security Hospital Shahdara, Lahore, and POF Hospital Wah Cantt. Both hospitals are well-established centers for orthopedic trauma, reconstructive procedures, and microsurgical nerve repair. A unified research protocol was implemented at both sites to ensure consistency in patient selection, intervention, and follow-up evaluation.

Study Population and Sampling: The study included a total of 100 adult patients recruited through consecutive non-probability sampling. All participants had sustained traumatic limb amputations and were scheduled to undergo peripheral nerve reconstruction surgery. The sampling technique ensured that every eligible patient presenting during the study window was enrolled until the sample size was achieved.

Eligibility Criteria: Patients aged 18 to 60 years with either upper or lower limb amputations of traumatic origin were included. Only individuals planned for nerve reconstruction such as end-to-end nerve repair, nerve grafting, targeted muscle reinnervation, or regenerative peripheral nerve interface were considered eligible. All patients were required to provide informed written consent and have no history of neurological or neuromuscular disorders. Patients were excluded if they had diabetic neuropathy, peripheral vascular disease, chronic opioid dependency, psychotropic medication use, local infection at the nerve block site, cognitive impairment affecting sensory evaluation, autoimmune neuropathies, or if they were lost to follow-up before the completion of postoperative outcome assessments.

Baseline Assessment: Before administration of the peripheral nerve block, each patient underwent a comprehensive baseline evaluation. Pain levels were documented using the Visual Analog Scale (VAS). Sensory function was assessed through two-point discrimination, monofilament testing, and vibration sensation analysis. Motor strength was graded using the Medical Research Council (MRC) scale. Electrophysiological studies, including nerve conduction assessments and electromyography, were performed to determine the underlying neural integrity. Demographic and clinical information, including age, gender, level of amputation, mechanism of injury, and time since trauma, was recorded. All assessments were conducted by trained neurologists and physiotherapists following standardized procedures.

Peripheral Nerve Block Procedure: Peripheral nerve blocks were administered preoperatively to evaluate early neural responsiveness and examine the potential predictive value of block response on long-term recovery. All blocks were performed under ultrasound guidance by consultant anesthesiologists to ensure accurate deposition of local anesthetic around the targeted nerve or plexus. The type and level of nerve block corresponded to the site of amputation, including brachial plexus blocks for upper limb injuries and femoral, sciatic, or popliteal blocks for lower limb amputations. A standardized concentration of 0.5% bupivacaine was used within recommended safety limits. Sensory and motor responses were assessed at fifteen and thirty minutes following the block. Based on these responses, patients were categorized as early responders if they exhibited at least 50% improvement in sensation, reduction in pain, or return of motor flicker, while those with less than 50% improvement were considered non-responders.

Nerve Reconstruction Techniques: All nerve reconstruction procedures were performed within two to four weeks post-injury, depending on the condition of soft tissues and overall patient stability. Surgeries were conducted by consultant reconstructive surgeons at both hospitals using standardized microsurgical techniques. The procedures included direct end-to-end nerve repair for clean transections, interpositional autologous nerve grafting for segmental losses, targeted muscle reinnervation to improve motor reinnervation and reduce neuroma formation, and regenerative peripheral nerve interface procedures to enhance neuromuscular communication and reduce postoperative neuropathic pain.

Follow-Up and Outcome Evaluation: Patients were followed for six months after surgery, with evaluations conducted at one month, three months, and six months. Motor recovery was assessed using the MRC grading scale, and functional strength improvements were documented by rehabilitation physiotherapists. Sensory recovery was measured through repeated two-point discrimination tests, monofilament assessments, and documentation of dysesthesia or pain scores. Electrophysiological reinnervation was monitored using follow-up electromyography and nerve conduction studies. Functional disability outcomes were quantified using the Disabilities of the Arm, Shoulder and Hand (DASH) score for upper limb amputees and the Lower Extremity Functional Scale (LEFS) for lower limb amputees. All outcome assessors were blinded to the initial nerve block responses to minimize observer bias.

Data Management and Statistical Analysis: All data were entered into a secure database and analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Differences between early responders and non-responders were analyzed using independent sample t-tests. Pearson correlation coefficients were calculated to assess the relationship between early nerve block response and long-term functional recovery. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Review Boards of Social Security Hospital Shahdara, Lahore, and POF Hospital Wah Cantt. Written informed consent was obtained from all participants before enrollment. Confidentiality was strictly maintained, and all procedures adhered to the ethical principles of the Declaration of Helsinki.

RESULTS

A total of 100 patients were included in the study conducted from February 2022 to March 2023 at Social Security Hospital Shahdara, Lahore, and POF Hospital Wah Cantt. All patients completed the full six-month follow-up period. The mean age of participants was 35.8 ± 10.7 years, with a predominance of males (68%). Lower limb amputations accounted for 61% of cases, while upper limb amputations represented 39%. Regarding reconstructive procedures, 57 patients underwent end-to-end nerve repair, 28 required interpositional nerve grafting, 10 received targeted muscle reinnervation (TMR), and 5 underwent regenerative peripheral nerve interface (RPNI) surgery.

Early Response to Peripheral Nerve Block: Sixty-three patients (63%) demonstrated an early positive response to the peripheral nerve block (PNB), defined as at least 50% improvement in sensory perception, pain reduction, or motor flicker within 30 minutes of block administration. The remaining 37 patients (37%) were categorized as non-responders. Baseline demographic and clinical characteristics were statistically comparable between the two groups ($p > 0.05$), as shown in Table 1, indicating that differences observed during follow-up were attributable to clinical response patterns rather than baseline disparities.

Motor Recovery Outcomes: Motor function, assessed using the Medical Research Council (MRC) grading scale, showed markedly superior improvement in early responders compared with non-responders at each follow-up interval. At one month, early responders demonstrated a mean MRC score of 2.41 ± 0.73, significantly higher than the 1.96 ± 0.60 seen in non-responders ($p = 0.004$). This pattern persisted at three months, with early responders reaching 3.32 ± 0.79 compared to 2.48 ± 0.92 in non-responders ($p < 0.001$). By six months, early responders achieved a mean MRC score of 4.09 ± 0.82, while non-responders reached only 2.92 ± 1.14 ($p = 0.001$). These findings indicate that early improvement following PNB strongly predicts enhanced long-term motor recovery as shown in table 2 .

Sensory Recovery Outcomes: Sensory recovery demonstrated similar trends. Early responders showed greater improvement in two-point discrimination (2PD), monofilament sensitivity, and pain reduction compared to non-responders. At six months, early responders improved their mean 2PD from 11.4 mm to 6.2 ± 1.7 mm, whereas non-responders improved from 11.8 mm to 8.9 ± 2.3 mm ($p < 0.001$). Monofilament sensitivity also improved significantly in early responders (3.2 ± 0.9 g vs. 4.7 ± 1.1 g; $p < 0.001$). Pain scores showed greater reduction among early responders as shown in table 3.

Electrophysiological Outcomes: Electromyographic evaluation at six months revealed significantly greater reinnervation activity among early responders. These patients demonstrated more polyphasic motor unit potentials, increased recruitment patterns, and improved conduction velocities. The differences between groups were statistically significant (p = 0.005), supporting the observed clinical improvements.

Functional Outcomes: Functional disability scores also favored early responders. Among upper limb amputees, the mean DASH score at six months was 32.4 ± 7.8 in early responders, compared to 48.1 ± 9.6 in non-responders (p < 0.001). For lower limb amputees, the LEFS score was significantly higher among early responders (48.6 ± 10.4) than non-responders (36.2 ± 11.8; p = 0.002). These improvements indicate better mobility, dexterity, and overall functional independence as shown in table 4.

Correlation Between PNB Response and Overall Recovery: Pearson correlation analysis demonstrated strong associations between early PNB response and long-term recovery measures. Early response showed the strongest correlation with motor recovery at six months (r = 0.71, p < 0.001). Sensory recovery also correlated significantly (r = 0.65, p = 0.002). Functional disability scores (DASH and LEFS) showed a strong inverse correlation (r = 0.68, p < 0.001), indicating better functional ability in early responders. These results, summarized in Table 5, confirm the predictive value of early PNB response.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population

Variable	Early Responders (n=63)	Non-Responders (n=37)	p-value
Mean Age (years)	35.1 ± 11.0	36.9 ± 9.8	0.42
Gender (M/F)	43/20	25/12	0.88
Upper Limb Amputation	25 (39.6%)	14 (37.8%)	0.86
Lower Limb Amputation	38 (60.3%)	23 (62.1%)	0.86
End-to-End Repair	35 (55.6%)	22 (59.4%)	0.71
Nerve Grafting	18 (28.6%)	10 (27.0%)	0.85
TMR	6 (9.5%)	4 (10.8%)	0.82
RPNI	4 (6.3%)	1 (2.7%)	0.38

Table 2: Comparison of Motor Recovery (MRC Scores) Between Groups

Time Point	Early Responders (Mean ± SD)	Non-Responders (Mean ± SD)	p-value
1 Month	2.41 ± 0.73	1.96 ± 0.60	0.004
3 Months	3.32 ± 0.79	2.48 ± 0.92	<0.001
6 Months	4.09 ± 0.82	2.92 ± 1.14	0.001

Table 3: Sensory Recovery Parameters at Six Months

Sensory Parameter	Early Responders	Non-Responders	p-value
2-Point Discrimination (mm)	6.2 ± 1.7	8.9 ± 2.3	<0.001
Monofilament Sensitivity (g)	3.2 ± 0.9	4.7 ± 1.1	<0.001
VAS Pain Reduction	4.6 ± 1.2	3.0 ± 1.3	<0.001

Table 4: Functional Disability Scores at Six Months

Functional Assessment	Early Responders	Non-Responders	p-value
DASH (Upper Limb)	32.4 ± 7.8	48.1 ± 9.6	<0.001
LEFS (Lower Limb)	48.6 ± 10.4	36.2 ± 11.8	0.002

Table 5: Pearson Correlation Between Early PNB Response and Recovery Outcomes

Outcome Variable	Correlation Coefficient (r)	p-value	Interpretation
Motor Recovery (MRC Score)	0.71	<0.001	Strong positive correlation
Sensory Recovery (2PD/Monofilament)	0.65	0.002	Moderate-to-strong correlation
Functional Scores (DASH/LEFS)	0.68	<0.001	Strong correlation

DISCUSSION

The present study evaluated the predictive value of early peripheral nerve block (PNB) response in determining long-term sensory, motor, and functional recovery following reconstructive nerve surgery in patients with traumatic limb amputations [7]. The findings demonstrated that an early positive clinical response to PNB defined as improvement in sensation, pain reduction, or the appearance of motor flicker was strongly associated with superior neurological and functional outcomes at six months. This highlights the potential of PNB responsiveness as an inexpensive, non-invasive, and clinically practical tool for prognostic assessment in reconstructive peripheral nerve surgery [8,9].

The results showed that early responders consistently exhibited higher MRC motor scores during all follow-up intervals compared with non-responders[10]. By the six-month endpoint, early responders achieved near-normal MRC grades in many cases, whereas non-responders showed more limited improvement. This suggests that neural pathways capable of showing rapid functional alteration following local anesthetic administration may also possess better intrinsic regenerative potential. These findings align with the physiological premise that preserved axonal continuity or partial nerve integrity allows transient conduction changes after PNB, thereby predicting favorable postoperative reinnervation[11,12].

Sensory recovery patterns mirrored the motor findings, with early responders showing significant improvements in two-point discrimination, monofilament sensitivity, and pain reduction. These results reinforce the concept that early block response reflects underlying sensory fiber viability[13]. The enhanced electrophysiological reinnervation observed in early responders provides objective validation of these clinical outcomes. Previous studies have described diagnostic nerve blocks as a means to predict surgical outcomes in entrapment neuropathies and chronic pain conditions; however, evidence in post-amputation nerve reconstruction has been limited. The present study adds to the growing body of literature by demonstrating that diagnostic PNBs can also serve as a reliable prognostic modality in the context of traumatic nerve repair[14].

Functional outcomes including DASH for upper limbs and LEFS for lower limbs were substantially better among early responders, indicating that early neural responsiveness translates into meaningful improvement in daily functioning and mobility[15]. Functional performance outcomes are crucial in amputee rehabilitation, as patients with optimized nerve recovery often experience reduced prosthetic complications, enhanced limb coordination, and greater independence in daily activities. The strong correlation between early PNB response and functional scores highlights its role not merely as a neurological marker but also as a predictor of broader rehabilitation success[16].

The correlation analysis further confirmed the robust predictive relationship between early PNB response and long-term outcomes. Strong correlations were observed for motor, sensory, and functional parameters, emphasizing that PNB responsiveness captures multiple dimensions of neural recovery. These findings have important implications for surgical decision-making[17]. Patients demonstrating minimal or absent early block response may have more extensive nerve damage or limited regenerative capacity and may benefit from adjunctive interventions, earlier initiation of alternative reconstructive strategies such as targeted muscle reinnervation, or more intensive rehabilitation planning[18].

This study has several strengths, including its prospective design, standardized procedures across two major medical centers, blinded outcome assessment, and comprehensive evaluation of both clinical and electrophysiological measures[19]. However, limitations must also be acknowledged. The study was conducted in only two hospitals, which may limit generalizability to broader populations. The follow-up period was six months, and although clinically meaningful, nerve regeneration continues for up to 18–24 months; thus, longer follow-up would provide additional insight. Furthermore, the degree of tissue scarring, variability in injury pattern, and differences in rehabilitation engagement may have influenced recovery trajectories[20].

Despite these limitations, the study provides compelling evidence that early clinical response to peripheral nerve block is a valuable predictor of sensory, motor, and functional outcomes after nerve reconstruction in amputated limbs. Incorporating PNB-based assessment into preoperative evaluation may help surgeons better stratify patients, refine surgical planning, counsel patients realistically, and optimize rehabilitation strategies[17-20].

CONCLUSION

Early response to peripheral nerve block is a strong and reliable predictor of long-term neurological and functional recovery following reconstructive peripheral nerve surgery in patients with traumatic limb amputations. Patients who demonstrated ≥50% improvement in sensory or motor function shortly after PNB achieved significantly better motor strength, superior sensory reinnervation, and improved functional scores at six months compared with non-responders. These findings indicate that PNB responsiveness reflects underlying nerve viability and regenerative potential, making it a practical, low-cost, and clinically meaningful tool for prognostication. Integrating early PNB assessment into surgical workflows may enhance patient selection, guide individualized rehabilitation, and improve overall clinical outcomes in amputee care. Further multicenter studies with longer follow-up periods are recommended to validate these results and expand their applicability.

Authors' Contributions: M.Q.F. designed the study and finalized the manuscript. S.M. collected data and assisted in drafting. A.S. performed statistical analysis. M.A.S. verified clinical data. A.U.H.P. reviewed and revised the manuscript. A.R.H. assisted with interpretation and proofreading. All authors approved the final manuscript.

Conflict of Interest: The authors declare no conflict of interest.

Funding: No external funding was received for this study.

Acknowledgements: The authors acknowledge the cooperation of the clinical and research staff who assisted in data collection and patient management.

REFERENCES

1. Kovar A, Barinka L, Suchy T, et al. Advances in peripheral nerve repair and regeneration. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2022;166(1):1–12.
2. Ladak A, Olson J, Tredget EE. Advances in peripheral nerve regeneration: A systematic review. J Reconstr Microsurg. 2021;37(2):151–66.
3. Griffin MF, Malahias M, Hindocha S, Khan W. Peripheral nerve injury: Principles for repair and regeneration. Open Orthop J. 2016;10:94–103.
4. McCrary HC, Jiang S, Liddell RS, Souza JM. Predictive factors in nerve regeneration after reconstruction. Plast Reconstr Surg. 2020;146(4):581e–592e.
5. Isaacs J. Nerve reconstruction strategies for complex injuries. J Hand Surg Am. 2017;42(5):399–408.
6. Meena M, Joy PJ. Targeted muscle reinnervation in amputees: A review of outcomes. Injury. 2021;52(3):315–22.
7. Souza JM, Cheesborough JE, Ko JH, Cho MS. Regenerative peripheral nerve interface surgery: Indications and outcomes. J Hand Surg Am. 2020;45(7):647–57.
8. Daneshjou R, Jassar S, Mu L. Advances in electromyography for evaluating nerve repair. Muscle Nerve. 2019;60(6):634–44.
9. Wolff AL, Herzog J. Diagnostic nerve blocks: Utility in predicting surgical outcomes. Reg Anesth Pain Med. 2017;42(5):654–60.
10. Abdallah FW, Brull R. The role of peripheral nerve blocks in perioperative care. Anesthesiology. 2017;126(5):1043–63.
11. Heineman J, Day CS, Higgins JP. Sensory recovery measurement in nerve reconstruction. J Hand Surg Am. 2015;40(7):1442–50.
12. Dellon AL, Hoopes J, DeJesus RA. Pain and sensory outcomes after nerve injury and repair. Plast Reconstr Surg Glob Open. 2019;7(1):e2052.
13. Bowen JB, Ruter D, Wee CE. Functional outcome measures after nerve reconstruction in amputees. J Plast Reconstr Aesthet Surg. 2021;74(4):799–807.
14. Hsueh YH, Chen KH, Lin YW. Predictive value of nerve conduction and EMG in nerve regeneration. Clin Neurophysiol. 2018;129(4):751–8.
15. Fridman V, Bundy B, Reilly MM, et al. Motor and sensory correlations in peripheral neuropathies. Neurology. 2018;91(16):e1456–e1464.
16. Zuo KJ, Gordon T, Chan KM. Mechanisms of nerve regeneration and functional recovery. Neurosurgery. 2016;79(5):671–82.
17. Thakkar SC, Thakkar RS, Lee DH. Outcomes of nerve grafting vs. repair. Hand Clin. 2016;32(2):153–65.
18. Wiggins ME, Zamorano DP, Osei DA. Predictive factors for functional recovery after nerve repair. J Hand Surg Am. 2020;45(10):944.e1–944.e10.
19. Ali ZS, Heuer GG, Faught RW, et al. Upper extremity nerve repair outcomes: A 10-year cohort. Neurosurgery. 2015;77(4):543–52.
20. Alolabi N, Wessel LE, Leland H, et al. Long-term functional outcomes following peripheral nerve reconstruction. Plast Reconstr Surg. 2022;149(2):349–59.

This article may be cited as: Faheem MQ, Mushtaq S, Shameem A, Saeed MA, Pirzada AUH, Hammad AR: Assessing the Efficacy of Peripheral Nerve Blocks in Predicting Functional Recovery Post-Nerve Reconstruction after Limb Amputation. Pak J Med Health Sci, 2023;17(11):534-537.