Research Article

Assessment of Nerve Regeneration in Post-Operative Median and Ulnar Nerve Injury Patients in Civil Hospital Karachi using Clinical Tools

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Abstract: Background: Traumatic upper limb peripheral nerve injuries are frequent and lead to long-term severe sensorimotor dysfunctions. An early, objective evidence of nerve regeneration is important for assessment of surgical results and rehabilitation especially in resource-poor settings where the sophisticated investigations may not be readily available.

Objective: To evaluate nerve regeneration in post-operative median and ulnar nerve injury patients using clinical assessment tools at Civil Hospital Karachi, Pakistan.

Materials and Methods: This prospective cohort study was carried out in the Department of Plastic Surgery, Dr. Ruth K.M. Pfau, Civil Hospital, Karachi, Pakistan, from 18th February 2025 to 15th December 2025. The ERC was obtained from Dow University of Health Sciences bearing number IRB-3684/DUHS/Approval/2024/67. Adults (≥18 years) who underwent primary repair of median and/or ulnar nerves in flexor zone V were enrolled by consecutive sampling. Surgery consisted of tension-free end-to-end neurorrhaphy or autologous nerve grafting. Patients were assessed at 1, 3, and 6 months post-operatively using the Visual Analogue Scale (VAS) for neuropathic pain and sensory recovery, Tinel's sign, and the Medical Research Council Manual Muscle Testing (MMT) scale; electrophysiological studies were performed selectively. SPSS version 23 was used to analyze the data.

Result: Sixty patients (mean age 30.96 ± 13.20 years) were included; males predominated (71.7%). Tinel's sign was positive in all patients at 1 month, 83.6% at 3 months, and all assessed at 6 months. Median (IQR) VAS improved from 5 (5–6) at 1 month to 8 (7–8) at 3 months and 8 (8–9) at 6 months ($p < 0.001$). MMT grades improved progressively, though differences between repair and grafting groups were not statistically significant ($p = 0.215$; $p = 0.280$).

Conclusion: Serial evaluation with VAS, Tinel's sign, and MMT provides a reliable clinical measure of nerve regeneration. Significant functional recovery was observed within six months post-repair.

Keywords: Peripheral nerve injury, Median nerve, Ulnar nerve, Nerve regeneration, Tinel's sign, Manual muscle testing, Visual analogue scale.

INTRODUCTION

Peripheral nerve injuries (PNIs) represent a significant clinical problem, characterized by damage to nerves outside the brain and spinal cord, and is associated with substantial morbidity and long-term disability among affected individuals [1, 2] Globally, the incidence of PNIs is between 13 to 23 per 100,000 cases annually, with the upper limb being the most commonly affected site (80% of all PNIs) [1, 2]. In many trauma series the hand and wrist are the most common sites of injury, and men are affected more frequently than women [3]. Median and ulnar nerve are the most commonly damaged nerves, and successful intervention is important in these nerve injuries [4]. Without timely intervention, PNIs may result in significant motor and sensory deficits, neuropathic pain and disability [4].

The pathophysiology of nerve damage is a complex, characterized by slow regeneration, and often poor prognosis, which significantly influence patient outcomes [5]. Recovery is influenced by the extent of injury, the distance to target muscles, patient age, comorbidities and the timeliness of repair [6]. Standard approach of clean peripheral nerve transections includes a tension-free direct neurorrhaphy; whereas extended gaps needed the use of synthetic conduits or autologous nerve grafts, each related with variable clinical outcomes. Modern reconstructive options include allografts, primary repair, auto graft, and various tendon, nerve, or free functional muscle [7].

Accurate assessment of nerve regeneration is essential to guide rehabilitation and detect failures early [8]. Common clinical tools include the Visual Analogue Scale (VAS), that captures the patient's perception of pain or sensation, Tinel's sign, in which percussion over a regenerating nerve produces tingling in its distribution, and manual muscle testing (MMT), graded 0–5 according to the Medical Research Council (MRC) scale [6, 7, 9]. Electro physiologic studies, such as nerve conduction and electromyography, provide objective data but are not always available in resource limited settings [6, 7, 9].

In Pakistan, PNIs contribute significantly to trauma related morbidity. Knife and gunshot wounds are leading causes, and

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many injuries involve the hands of young workers [10, 11]. Despite the high burden, there is little local data on recovery after surgical repair. This study therefore aimed to prospectively evaluate nerve regeneration in patients undergoing median and ulnar nerve repair at a tertiary hospital in Karachi, using simple clinical tools. We hypothesised that serial assessment with VAS, Tinel's sign and MMT would detect significant improvements within six months post operatively, and that outcomes would differ between tension free neurorrhaphy and nerve grafting.

MATERIALS AND METHODS

It was a prospective cohort study conducted at the Department of Plastic Surgery, Dr. Ruth K.M. Pfau, Civil Hospital, Karachi, Pakistan, from 18th February 2025 to 15th December 2025. The Ethical Review Committee (ERC) approval was obtained before start of study from the ERC of Dow University of Health Sciences bearing number IRB-3684/DUHS/Approval/2024/67, dated February 18, 2025.The Sample size was estimated as 60 patients using Open Epi Sample Size Calculator. By taking statistics of PNI due to gunshot injury as 57.5% [11], absolute precision as 10% and 95% confidence level.

Adult patients aged 18 years or older, of either gender, who underwent primary repair of the median nerve and/or ulnar nerve in flexor zone V within three weeks of injury were included in the study. Peripheral nerve injury was defined as damage or disruption of nerves extending from the spinal cord to peripheral structures resulting from trauma, compression, or disease and presenting with symptoms such as sensory loss, muscle weakness, or paralysis. Only patients with isolated median and/or ulnar nerve injuries were included in order to reduce confounding from complex injuries. Patients presenting with spaghetti wrist injuries involving multiple tendons, vascular injuries, traction injuries, injection injuries, generalized limb weakness, psychiatric illness, or those previously treated at another healthcare facility were excluded. Non-probability consecutive sampling technique was applied for sample selection.

Participants were informed about the purpose, procedures, potential benefits, and risks associated with the study and informed consent was obtained. After enrolment, baseline data including age, gender, type of surgery, nerve damage, and location of injury (from proximal wrist crease) were recorded using a structured proforma. All injuries were caused by sharp trauma like knife or glass injuries.

All surgical procedures were performed by consultant plastic surgeons within the same surgical unit using standardized microsurgical techniques. Surgical repair consisted of either tension-free end-to-end neurorrhaphy (coaptation) or autologous nerve grafting when direct repair was not feasible due to gap length.

Postoperatively, the operated limb was immobilized using a dorsal splint for approximately three weeks to protect the repair site. After splint removal, patients were advised gradual mobilization and were referred to hand therapy sessions, which included range-of-motion exercises and sensory re-education techniques. Patients also received written instructions for home-based rehabilitation exercises.

Each participant was followed up by the same clinical assessment team at 1, 3, and 6 months postoperatively. At each visit, patients were assessed for outcomes using three validated clinical tools i.e. VAS, Tinel's sign test, and MMT, with selective use of Electromyography (EMG) when required.

EMG was performed selectively in patients with absent or non-progressive clinical signs of regeneration to assess nerve continuity and reinnervation.

The Visual Analogue Scale (VAS; 0–10) was used to assess neuropathic sensory status following nerve repair. A score of 0 indicated complete absence of sensation or severe neuropathic discomfort, whereas a score of 10 indicated normal or near-normal sensation.

The Tinel's sign was elicited by tapping gently over the course of the repaired nerve; the test was considered positive when there was a tingling sensation radiating through a specific area of the body upon tapping the corresponding nerve. Serial progression of the Tinel's sign to more distal points was interpreted as a clinical indicator of nerve regeneration. MMT was used to evaluate motor recovery using the MRC muscle strength grading system as following Table **1**.

Table 1. MRC Scale For Muscle Strength [9].

Grade	Description
M0	No visible or palpable contraction
M1	Flicker or trace of contraction
M2	Active movement with gravity eliminated
M3	Active movement against gravity
M4	Active movement against gravity and resistance
M5	Normal muscle strength

STATISTICAL EVALUATION

Data were entered into IBM SPSS Statistics version 23. Continuous variables (age, VAS and MMT scores) were summarized as mean ± standard deviation/median and IQR, while categorical data (gender, type of surgery, nerve damage, location of injury and Tinel's sign progression) were expressed as frequencies and percentages. Intra-group changes in VAS and MMT over time were analyzed using Friedman test to assess trends across follow-ups. The Mc Nemar's test was applied to assess changes in Tinel's sign across serial follow-ups. Mann-Whitney U test compared VAS at 6 months with surgical techniques. Chi-square test was used to compared MMT grades at 6 months with surgical techniques. A p-value ≤ 0.05 was considered statistically significant for all analyses.

RESULT

Table **2** presents the baseline characteristics of the enrolled post-operative patients. The mean age of patients was 30.96 ± 13.20 years and most of them were males (n=43, 71.7%). In majority of the cases, direct nerve repair was done (n=44, 73.3%). Combined median and ulnar nerve was present in 24 (40%) cases. Injuries were most frequently 2 cm above the proximal wrist crease (n=20; 33.3%), followed by 3 cm above (n=12; 20.0%) and 1 cm above (n=10; 16.7%), respectively. Of the 60 patients, 5 were lost to follow-up at 3rd and 13 patients were lost to follow-up at 6 month post-operatively.

Tinel's sign showed a progressive trend of nerve regeneration. All patients (100%) had positive Tinel's sign at 1st month. At 3rd months, 46 (83.6%) remained positive and by 6 months, all 47 patients who completed follow-up assessed again exhibited positive signs (Fig. **1**) Electrophysiological assessments were performed selectively. Most patients (81.7%) had absent compound muscle action potentials (CMAPs) and motor unit action potentials (MUAPs) at 3 months, while a minority demonstrated positive conduction by 3–4 months, confirming early reinnervation.

Pain and sensory recovery evaluated using VAS, showed a significant improvement over the period of 6 months. The median (IQR) VAS increased from 5 (5–6) at 1 month to 8 (7–8) at 3 months and 8 (8–9) at 6 months. Friedman's test revealed a statistically significant difference across follow-up intervals (p=0.001) (Fig. **1**).

Motor function recovery assessed using the MRC scale also showed significant improvement over six months. Between 1 and 3 months, 80% of patients with an initial grade of II improved to grade III, and a further 4.3% reached grade IV. Similarly, by 6 months, 33.3% of those who started at grade II had reached grade IV, and 5.1% achieved grade V. However, the association between initial (MMT grade at 1st month) and subsequent (MMT at 3rd and 6th months) grades was not statistically significant (p=0.320 and p=0.690, respectively) (Table **3**).

When outcomes were compared by type of surgery, patients who underwent direct nerve repair showed better motor recovery at six months. Among them 14 patients achieved grade 4 and 2 patients reached grade 5 strength, whereas only 1 patient with graft reached grade 4. However, this difference was not statistically significant (p=0.215). Additionally, the median VAS score was similar between the groups, with no statistically significant difference in pain and sensory recovery (p=0.280).

Table 2. Baseline Characteristics (n=60).

Variable	n (%) or Mean ± SD
Age, years	30.96 ± 13.20
Gender	
Male	43 (71.7)
Female	17 (28.3)
Surgical technique	
Direct repair	44 (73.3)
Nerve grafting	16 (26.7)
Nerve involvement	
Median Nerve	23 (38.3)
Ulnar Nerve	13 (21.7)
Median+Ulnar Nerve	24 (40)
Injury level (from proximal wrist crease)	
1 cm above	10 (16.7)
1 cm below	6 (10)
2 cm above	20 (33.3)
3 cm above	12 (20)
4 cm above	7 (11.7)
5 cm above	5 (8.3)

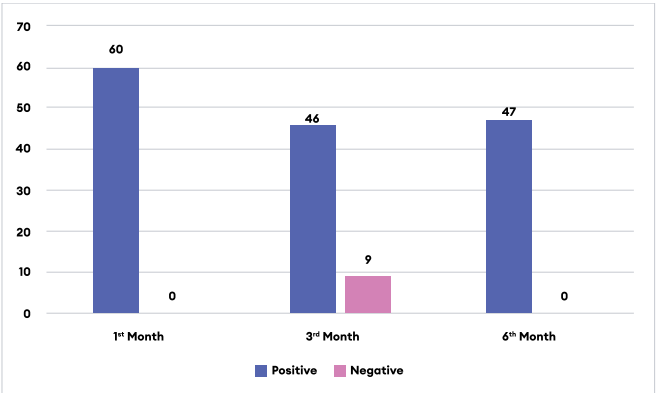

Fig. (1). Tinel's Sign at 1st (n=60), 3rd (n=55) and 6th (n=47) Months.

Table 3. Comparison of MMT Grades between 1st and 3rd (n=55) and 1st and 6th (n=47) Months.

MMT at 1st month	MMT at 3rd Month			p-value
	II	III	IV	
II	8 (17.0%)	37 (78.7%)	2 (4.3%)	0.320
III	0 (0%)	7 (87.5%)	1 (12.5%)	
Total	8 (14.5%)	44 (80.0%)	3 (5.5%)	
MMT at 6 Month				
MMT at 1st month	**III**	**IV**	**V**	
II	24 (61.5%)	13 (33.3%)	2 (5.1%)	0.690
III	6 (75.0%)	2 (25.0%)	0 (0%)	
Total	30 (63.8%)	15 (31.9%)	2 (4.3%)	

DISCUSSION

This study evaluated sensory and motor recovery following repair of median and ulnar nerve injuries using simple clinical tools. The cohort consisted predominantly of young males, mir-

roring national and international patterns for PNIs [3, 10]. Our patients' mean age (31 years) and male predominance (72%) compare closely with a Pakistani series of 95 patients in which the mean age was 34.3 years and 76.8% were male [4], reflecting the higher exposure of men to occupational hazards and interpersonal violence. In that series, good motor recovery was achieved in two-thirds of patients and good sensory recovery in 62%[4], comparable to our findings where median VAS improved from 5 to 8 and MMT from grade II to grade III–IV over six months. A UK population-based study reported an incidence of 11.2 PNIs per 100 000 population per year and noted that males are at least twice as likely to sustain PNIs; most injuries occurred in distal upper-limb nerves and there was a rising trend in knife-related injuries [12]. These epidemiological data underscore the public health burden of upper-limb PNIs and highlight the need for efficient postoperative monitoring.

Our data show that inexpensive clinical tools can reliably track nerve regeneration. Tinel's sign, initially described by Jules Tinel, is elicited by percussing a regenerating nerve and produces a tingling sensation at the site of axonal growth [13]. In our cohort all patients were positive at 1 month; the sign persisted in 84% at 3 months and became universally positive distally by 6 months, echoing previous reports that Tinel's sign migrates distally at approximately the same rate as axonal regeneration [14]. A small proportion of patients who lost the sign prematurely later underwent EMG re-evaluation, supporting its usability for detecting failed regeneration.

Sensory and pain recovery, assessed using the VAS, followed the same pattern. Our patients reported a median pain score 5 at one month which increased to 8 at 6 months, reflecting rising neuropathic sensations frequently experienced during regeneration. Previous studies also suggest that regenerating axons can develop neuropathic pain; therefore, increased VAS may serve as surrogate indicator for axonal re-growth [15-17].

In our study, MMT showed that motor recovery lagged behind return of sensation. At 6 months, one-third of patients showed steady progression from graded II to grade IV. This slow motor recovery is in-line with the pathophysiology of PNI, when regeneration of nerve muscle fibres develops post sensory fibres have already reached skin coverage, and muscle atrophy could hamper functional recovery [18].

Comparison of surgical techniques, a trend toward better motor recovery was observed in patients who underwent direct neurorrhaphy. This trend is consistent with evidence by surgical principles stating that direct neurorrhaphy provides the most favourable environment for axonal regrowth [5]. In the RANGER registry, looking at nerve guidance conduits (NGCs), 82% patients achieved functional recovery across nerve gaps up to 70 mm and 91% for gaps <15 mm [19]. Though, NGCs have been commonly used for small sensory nerves, while their role in large mixed motor nerve remains limited. Autologous nerve grafts continue to be the standard for bridging larger defects, nevertheless our data propose that where direct coaptation is feasible it should be favored. No statistically significant differences in VAS between repairing techniques specifies that sensory recovery would be less affected by type of repair.

Our study supports the role of structural and early rehabilitation. Post 3 weeks of surgery, all patients received written instructions for exercises at home, along with attending hand therapy sessions. Previous studies also showed that early mobilization and sensory re-education improve functional recovery and prevent tendon adhesions and joint stiffness [20, 21]. An additional aspect of recovery following peripheral nerve repair is the patient's ability to return to normal daily activities and occupational duties. Although the present study focused primarily on neurological recovery using clinical indicators such as VAS, Tinel's sign, and MMT, functional recovery and return to work are important outcome measures that reflect the real-life impact of surgical intervention. Future studies should incorporate validated patient-reported outcome measures and occupational assessments to better evaluate functional independence and socioeconomic reintegration following peripheral nerve injury.

Our results should be interpreted in light of certain limitations. First, the sample size was modest and drawn from a single center, which may limit generalizability. Second, 21.7% of patients were lost to follow-up by six months, although the trend lines remained consistent. Third, EMG was performed selectively in patients who demonstrated absent or non-progressive clinical signs of regeneration during follow-up. Routine EMG testing was not performed in all patients because early electrophysiological studies following nerve repair may not reliably demonstrate regeneration due to the time required for axonal growth and reinnervation. Therefore, EMG was primarily used as an adjunct investigation in cases where clinical assessment suggested delayed or failed regeneration. Finally, we did not measure quantitative sensory thresholds, which could have added objectivity to sensory assessments.

Emerging technologies hold promise of improving nerve repair outcomes. Experimental models using biodegradable conduits coated with growth factors aims to create bioactive scaffolds that encourage Schwann cell proliferation and axonal outgrowth [22]. Pharmacologic agents such as brain derived neurotrophic factor and erythropoietin have been shown in animal models to enhance nerve regeneration by reducing apoptosis and promoting remyelination [23]. Novel surgical approaches, including three dimensional printed nerve scaffolds and gene activated conduits, are under investigation [24, 25]. While these innovations are not yet widely available in resource constrained settings, they illustrate the future landscape of peripheral nerve repair. Until such technologies become mainstream, meticulous microsurgical technique, early intervention, structured rehabilitation and vigilant follow up remain essential to optimise outcomes in patients with PNIs.

CONCLUSION

Serial evaluation using the Visual Analogue Scale, Tinel's sign

and the MRC manual muscle testing scale offers a practical means of monitoring nerve regeneration after median and ulnar nerve repair. Significant improvements in sensation and muscle strength occurred within six months, and the distal progression of Tinel's sign correlated with axonal regrowth. Direct neurorrhaphy tended to produce better functional outcomes than autologous grafting, though differences were not statistically significant. These findings highlight the importance of early surgical repair, meticulous technique and structured rehabilitation. Larger multicentre studies incorporating objective electrophysiology and quantitative sensory testing are warranted to refine postoperative management of PNIs.

ABBREVIATIONS

CMAPs: Compound Muscle Action Potentials.

EMG: Electromyography.

ERC: Ethical Review Committee.

IQR: Interquartile Range.

MMT: Manual Muscle Testing.

MRC: Medical Research Council.

MUAPs: Motor Unit Action Potentials.

NCS: Nerve Conduction Studies.

NGCs: Nerve Guidance Conduits.

PNI: Peripheral Nerve Injury.

SPSS: Statistical Package for the Social Sciences.

VAS: Visual Analogue Scale.

AUTHORS' CONTRIBUTION

Sana Shoukat: Conceptualization, Study Design, Writing draft, Critical review and revision the manuscript.

Faisal Akhlaq Ali Khan: Study Design, Critical review and revision the manuscript, Final approval, final proof to be published.

Waqas Sami and **Seema**: Writing draft, Final approval, final proof to be published.

Erum Naz: Methodology, Data analysis and interpretation, Final approval, final proof to be published.

Hiba Moazzam: Methodology, Data analysis and interpretation, Writing draft.

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Declared none.

ETHICAL DECLARATIONS

Data Availability Statement

Data are available upon reasonable request. The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The study was approved by Dow University of Health Sciences, Dr. Ruth K.M. Pfau, Civil Hospital, Karachi, Pakistan, bearing number IRB-3684/DUHS/Approval/2024/67. [Dated: February 18, 2025].

Consent to Participate

Informed consented.

Consent for Publication

All of the authors give consent for publication of this manuscript.

Conflict of Interest

Declared none.

Competing Interest/Funding

Declared none.

Use of AI-Assisted Technologies

QuillBot was used solely as an AI-assisted language refinement tool to improve readability and correct grammatical and punctuation errors. The authors retain full responsibility for the manuscript's accuracy, integrity, and originality.

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