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Evaluation and Outcome of Delayed Repair of Post Traumatic Peripheral Nerve Injuries

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ABSTRACT

Background: Peripheral nerve injury (PNI) remains a significant clinical concern, frequently resulting in partial or complete functional impairment.

Objective: This study was designed to investigate the effectiveness of various surgical techniques and to assess the outcomes associated with delayed repair of post-traumatic PNIs.

Patients and Methods: A prospective study that was conducted on 23 patients presenting with post-traumatic PNI. Preoperative evaluations included physical examination, electrophysiological testing, and ultrasound imaging to confirm the diagnosis and to assess the severity of the injury. These assessments were repeated at 3 and 6 months postoperatively to objectively measure nerve function recovery.

Results: Among the 23 patients, 20 (86.96%) were male and 3 (13.04%) were female, with a mean age of 23.13 ± 12.46 years. The majority (86.96%) had upper limb involvement, predominantly affecting the right side (78.2%). At 6-month follow-up, sensory recovery was classified as good in 18 patients (85.71%) and satisfactory in 3 patients (14.29%), with statistically significant improvement ($P < 0.001$). Regarding motor recovery at 6 months, 6 patients (31.57%) achieved good outcomes, 8 (42.1%) had satisfactory recovery, 4 (21.1%) showed moderate recovery, and 1 patient (5.88%) had poor recovery. By one year, motor function had improved significantly ($P < 0.001$), with 11 patients (57.82%) achieving good recovery, 6 patients (31.57%) demonstrating satisfactory recovery, and 2 patients (11.6%) showed moderate recovery.

Conclusions: PNI remains a considerable source of morbidity and functional limitation. A variety of surgical approaches can contribute to improved outcomes. Favorable prognostic factors included younger age, distal location of the injury, and timely surgical intervention. In cases of delayed, proximal injuries, nerve transfer techniques may offer promising results for functional restoration.

Keywords: Peripheral nerve injuries, Traumatic nerve injury, Delayed nerve repair.

INTRODUCTION

Nerve injuries represent a significant clinical challenge, often resulting in functional impairments that may be long-lasting or even permanent, carrying substantial socioeconomic consequences for affected individuals [(1-3)].

Peripheral nerve injuries (PNIs) can lead to varying degrees of motor and/or sensory dysfunction, and their incidence has been steadily increasing over recent decades [(4)].

Following a PNI, the continuity of the nerve is frequently disrupted, necessitating the bridging of the gap between the proximal and distal nerve stumps without introducing tension. This is crucial to facilitate effective nerve regeneration and to optimize the restoration of lost sensory or motor functions [(5)].

Several key factors influence the success of nerve repair. Younger patients typically exhibit more favorable outcomes. Additionally, the anatomical location of the injury plays a critical role, as nerves tend to differentiate into predominantly motor or sensory fibers more distally. The timing of surgical intervention is also vital; delays in repair are often associated with adverse changes such as muscle atrophy, fibrosis, and joint stiffness, which may hinder recovery [(6)].

Electrophysiological testing and ultrasound imaging serve as essential tools in the preoperative evaluation process. These modalities assist in localizing the lesion, assessing the severity of axonal damage, and guiding clinical decisions regarding both treatment strategies and prognosis [(6-7)].

This prospective study was designed to investigate the effectiveness of various surgical techniques and to assess the outcomes associated with delayed repair of post-traumatic PNIs.

PATIENTS AND METHODS

This prospective study included 23 patients who sustained post-traumatic PNIs between 4 weeks and 1 year prior to presentation. All patients were managed in the Department of Neurosurgery at Tanta University Hospitals during the study period from August 2023 to March 2025.

Exclusion criteria: Patients with compressive neuropathies, those deemed unfit for surgery, injuries exceeding one year in duration, and cases exhibiting severe muscle wasting, contractures, or joint stiffness.

All patients underwent comprehensive clinical evaluation including detailed medical history, neurological examination, and assessment of muscle strength using the Medical Research Council (MRC) grading scale. Sensory function was evaluated using the Mackinnon-Dellon scale [(6)].

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Routine laboratory investigations were also performed.

Electromyography (EMG), nerve conduction studies (NCS) and high-resolution ultrasound imaging were conducted preoperatively to confirm the diagnosis and to determine the extent of nerve injury. These assessments were repeated at 6 and 12 months postoperatively to objectively evaluate functional nerve recovery.

Surgical technique:

All patients underwent total intravenous anesthesia without the use of muscle relaxants to allow for intraoperative assessment of nerve function using a nerve stimulator (STIMPOD NMS410/450X). The patient's positioning and the site of skin incision were individualized based on the location of the injured nerve and any pre-existing traumatic or surgical scars.

In cases where a neuroma in continuity was identified, external neurolysis was performed if the nerve maintained conductivity, as verified by intraoperative nerve stimulation (Figure 1a). For non-conductive neuromas or terminal neuromas indicative of neurotmesis, the affected segment was excised using the bread loaf technique with an 11 blade until healthy fascicular tissue was exposed (Figure 1b). When no nerve gap was present or when the gap measured less than 2 cm—a tension-free end-to-end epineurial anastomosis was carried out.

This technique involves placing fine microsutures through the epineurium without disturbing the internal fascicles (Figure 1c). For gaps exceeding 2 cm, the required graft length was customized based on the measured distance between the nerve ends and the number of graft cables needed (Figure 1d).

In all such cases, autologous sural nerve grafts were used (Figures 1e & 1f), which can typically provide lengths between 30 and 40 cm. Both epineurial suturing and grafting were performed using 7/0 Prolene under magnification with surgical loupes. Fibrin glue was applied at the repair site to reinforce the anastomosis and to reduce the number of required sutures (Figure 1g).

Wound closure was achieved using interrupted layered sutures, with a surgical drain placed as needed based on intraoperative assessment.

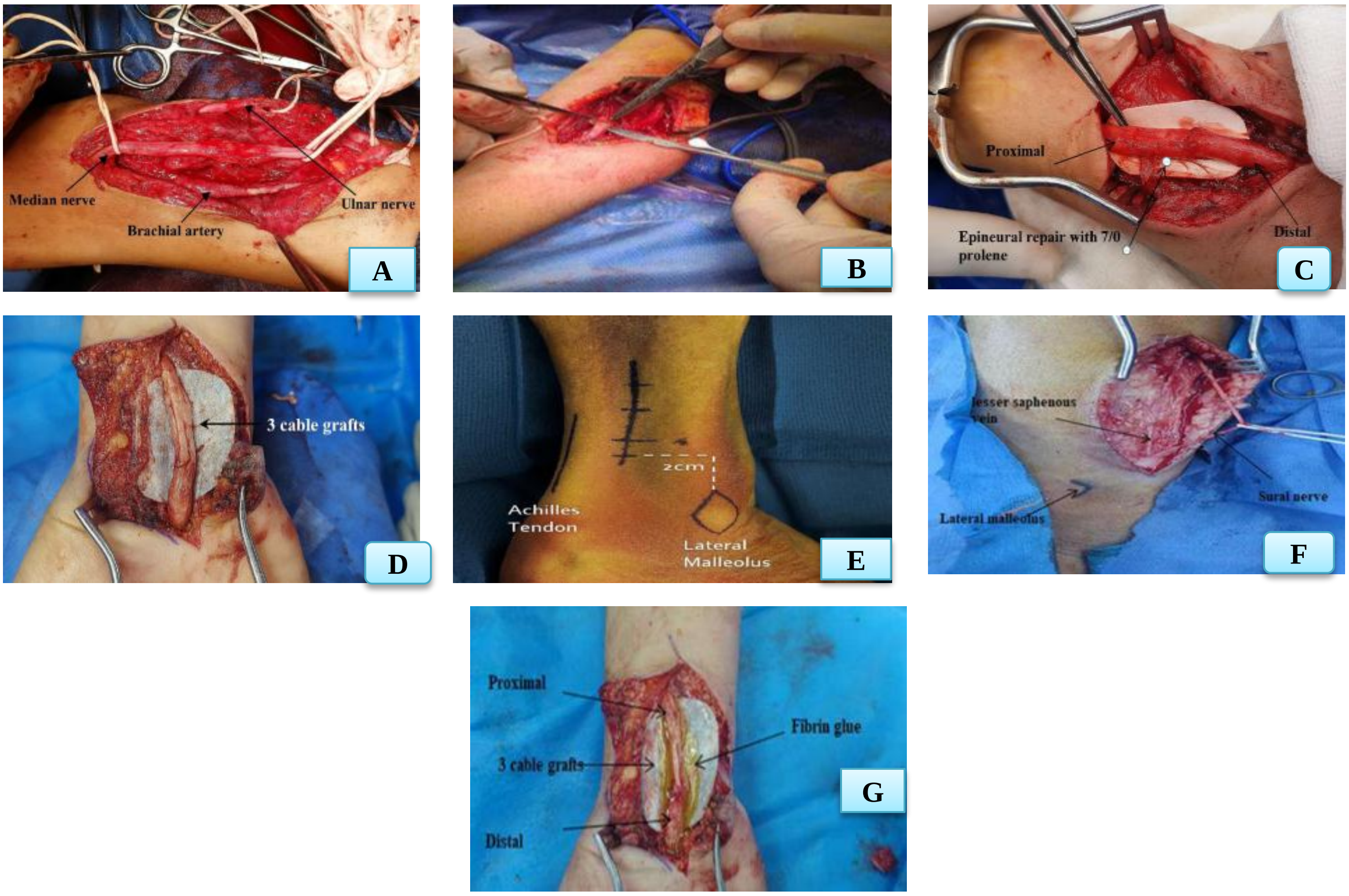

Figure (1): (A) External neurolysis and decompression of ulnar and median nerve, (B) Resection of both ends of neuroma till reaching healthy fascicles by bread loaf maneuver. (C) End to end epineural repair of median nerve injury at wrist, (D) 3 cable graft repairs for median nerve, (E) Sural nerve surface landmark, (F) Sural nerve dissection and relation to lesser saphenous vein, (G) Fibrin glue after epineurial repair.

Postoperative care: Following nerve repair, all patients were immobilized using a bulky soft dressing and splint for a period of 3 weeks to prevent tension on the repair site and avoid disruption of the microsutures. A personalized rehabilitation program was developed for each patient based on their compliance and anticipated timeline for neurological recovery.

Follow up: Patients underwent neurological evaluations, monitoring for potential complications, and electrophysiological assessments at intervals of 3, 6, and 12 months postoperatively. The outcome was classified as Good (S3+or S4 andM4or M5), Satisfactory (S3 and M3), Moderate (S2 and M2) and Bad as (S0 or S1and M0 or M1).

Sonographic evaluation: Ultrasound assessments were performed using linear array transducers with frequencies ranging from 7.5 to 16 MHz. These evaluations focused on detecting fascicular regeneration, measuring the cross-sectional area (CSA) in millimeters, and identifying adverse local factors associated with poor outcomes. Such factors included the formation of neuromas, infections near the nerve, and dense scar tissue potentially causing compression.

Ethical approval: Informed written consent was obtained from each participant or from parents/guardians in the case of pediatric patients. The study received ethical approval from Tanta University Hospitals Ethical Committee. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis:

Statistical analysis was conducted using SPSS software version 26.0. The Shapiro–Wilk test and histograms were employed to assess the normality of data distribution. Parametric quantitative data were expressed as means ± standard deviations (SD) and analyzed using paired t- tests. Categorical variables were summarized as frequencies and percentages and compared using the Chi-square test. A two-tailed p-value ≤ 0.05 was considered indicative of statistical significance.

RESULTS

This study included a total of 23 patients: 20 males (86.96%) and 3 females (13.04%), with a mean age of 23.13 ± 12.46 years. Among them, 11 patients (47.83%) were smokers. Upper limb injuries were observed in 20 patients (86.96%), with the right side affected in 18 cases (78.2%). The mechanisms of trauma were as follows: Assault in 6 patients (26.09%), domestic accidents in 8 patients (34.78%), iatrogenic causes in 5 patients (21.74%), and miscellaneous causes in 4 cases. The average time from injury to presentation was 3.74 ± 2.4 months. **In terms of nerve involvement in the upper limb**, the median nerve was affected in 7 patients (30.43%), the ulnar nerve in 6 patients (26.09%), the radial nerve in 3 patients (13.04%), both the median and ulnar nerves in 2 patients (8.7%), the posterior interosseous nerve (PIN) in 1 patient (4.35%), and the digital nerve of the index finger in 1 patient (4.35%). In the lower limb, the common peroneal nerve was involved in 2 patients (8.7%). and sciatic nerve injured in one patient (4.35%). **Injury location** was classified as proximal or distal relative to the elbow or knee joint, respectively. Nine patients (39.13%) had proximal injuries, while 14 (60.87%) had distal injuries.

Preoperative nerve conduction studies (NCS) and electromyography (EMG) revealed complete nerve degeneration in 14 patients (60.87%) and partial degeneration in 9 patients (39.13%). **Regarding surgical interventions**, 13 patients (56.52%) underwent nerve grafting, 8 patients (34.78%) had external neurolysis with decompression, 1 patient (4.35%) had internal neurolysis, and 1 patient (4.35%) underwent neuroma excision with end-to-end repair. Among the 13 graft cases, 2 sural nerve cables were used in 8 patients (34.78%), and 3 cables in 5 patients (21.39%), tailored to match the size of the injured fascicles. The sural nerve served as the donor in all graft cases. The mean gap between the two nerve ends was 2.88 ± 1.62 cm (Table 1).

Table (1): Baseline characteristics and clinical data and operation type of the studied patients

Sex	**Male**	20 (86.96%)
	Female	3 (13.04%)
Affected limb	**Right**	18 (78.2%)
	Left	5 (21.8%)
Mode of trauma	**Assault**	6 (26.09%)
	Domestic	8 (34.78%)
	Falling on ground	1 (4.35%)
	Iatrogenic	5 (21.74%)
	MVA	1 (4.35%)
	Occupational	2 (8.7%)
Nerve injured	**Median**	7 (30.43%)
	Ulnar	6 (26.09%)
	Radial	3 (13.04%)
	Median& Ulnar	2 (8.7%)
	Common peroneal nerve	2 (8.7%)
	Sciatic nerve	1 (4.35%)
	Digital nerve to index	1 (4.35%)
	PIN	1 (4.35%)
Site of injury	**Proximal**	9 (39.13%)
	Distal	14 (60.87%)
Preoperative NCS, EMG	**Complete axonal degeneration**	14 (60.87%)
	Partial axonal degeneration	9 (39.13%)
Operation type	**Graft**	13 (56.52%)
	External neurolysis and decompression	8 (34.78%)
	Internal neurolysis	1 (4.35%)
	Excision neuroma and end to end repair	1 (4.35%)
Number of cables	**2 cables**	8 (34.78%)
	3 cables	5 (21.39%)

Data presented as mean ± SD or frequency (%), DM: diabetes mellitus, MVA: motor vehicle accident, PIN: posterior interosseous nerve, NCS and EMG: Nerve conduction studies and electromyography.

Sensory dysfunction was observed in 21 patients. Preoperative sensory grading showed S0 in 9 patients (39.13%), S1 in 5 patients (21.74%), and S2 in 7 patients (30.43%). Trophic skin changes were noted in 8 patients (34.78%), all of whom had S0 sensory status.

Motor deficits were present in 19 of the 23 patients, including 2 patients (PIN and CPN) who exhibited motor symptoms exclusively. Preoperative motor grading revealed G0 in 11 patients (57.89%), G1 in 5 patient (26.3%), G2 in 2 patients (10.52%), and G3 in 1 patient (5.26%). The latter had combined ulnar and median nerve injuries, with complete loss of function (Grade 0) in the ulnar nerve and partial motor function (Grade 3) in the median nerve distribution (Table 2).

Table (2): preoperative neurological examination of the studied patients

Preoperative Neurological status		**Total (n=23)**
Preoperative sensory examination (n=21)	**S0**	9 (39.13%)
	S1	5 (21.74%)
	S2	7 (30.43%)
	S4(normal)	2 (8.7%)
Preoperative motor examination (n=19)	**G0**	11 (57.89%)
	G1	5 (26.3%)
	G2	2 (10.52%)
	G3	1 (5.26%)
Site of injury (n=19)	**Proximal**	7 (36.8%)
	Distal	12 (63.2%)

Motor involvement by nerve type was as follows: ulnar nerve in all 6 cases (100%), median nerve in 4 out of 7 cases (57.1%), radial nerve in all 3 cases (100%), combined median and ulnar nerves in both cases (100%), posterior interosseous nerve (PIN) in 1 case (100%), common peroneal nerve in 2 cases (100%), and the sciatic nerve in 1 case (100%).

Among those with motor deficits, 7 (36.8%) had proximal injuries and 12 (63.2%) had distal injuries. **At the 6-month follow-up**, sensory recovery was rated as satisfactory in 3 patients (14.29%) and good in 18 patients (85.71%), reflecting statistically significant improvement ($P < 0.001$). All patients with trophic changes (n = 8) showed clinical improvement, with a mean recovery time of 2.88 ± 1.55 months.

At the 6-month follow-up, motor recovery was classified as good in 6 patients (31.57%), satisfactory in 8 patients (42.1%), moderate in 4 patients (21.1%), and poor in 1 patient (5.26%). By the 12-month evaluation, 11 patients (57.89%) had achieved good motor function, 6 patients (31.57%) demonstrated satisfactory recovery, and 2 patients (10.52%) showed moderate improvement, reflecting statistically significant progress over time ($P < 0.001$) (Table 3).

Only one complication was reported: A diabetic patient developed a superficial wound infection, which resolved with one week of local wound care and oral antibiotics following suture removal.

Table (3): Postoperative sensory and motor recovery of the studied patients

		6 months	12 months	P value
Postoperative sensory recovery (n=21)	**Good**	18 (85.71%)	----	**<0.001***
	Satisfactory	3 (14.29%)	----	
	Moderate	0 (0%)	----	
	Bad	0 (0%)	----	
Postoperative motor recover (n=19)	**Good**	6 (31.57%)	11 (57.89%)	**<0.001***
	Satisfactory	8 (42.1%)	6 (31.57%)	
	Moderate	4 (21.1%)	2 (10.52%)	
	Bad	1 (5.26%)	0 (0%)	

*: significant.

DISCUSSION

This study aimed to assess the outcomes and surgical techniques used for the delayed repair of post-traumatic PNIs. Our cohort consisted of 23 patients, including 20 males and 3 females, with ages ranging from 8 to 50 years. These findings are comparable to those reported by **Garg *et al.*** [8] who included patients aged 9 to 52 years, with a similar male predominance (83%) and 4 females.

In our series, upper limb nerves were more frequently affected, accounting for 86.96% (20 out of 23 cases), with the right side being more commonly involved (78.6%). This aligns with **Castillo-Galván et al.** [9] who reported a PNI prevalence of 1.12%, with upper limb injuries comprising 61% of cases. Similarly, **Grinsell and Keating** [10] indicated that lower limb nerve injuries represented around 20% of all PNIs, with the common peroneal nerve involved in approximately 50% of those cases.

Orthopedic procedures emerged as the most common iatrogenic cause in our study, accounting for 4 out of 5 iatrogenic cases (80%). The remaining case (20%) was related to the excision of a forearm mass. These findings are in agreement with **Hara *et al.*** [11] who reported that most iatrogenic nerve injuries followed surgeries for bone fractures (58%), soft tissue tumor resections (22%), and carpal tunnel release (20%).

The average interval from trauma to clinical presentation was 3.74 ± 2.4 months. Preoperative neurophysiological evaluations (NCS and EMG) revealed complete degeneration in 60.87% of patients (14 cases), while 39.13% (9 cases) exhibited partial degeneration. Thirteen patients (56.52%) underwent nerve grafting, 8 (34.78%) had external neurolysis with decompression, and 1 patient each (4.35%) underwent internal neurolysis and neuroma excision with end-to-end repair. All patients with complete nerve degeneration received grafts or end-to-end repair, except for two who had functioning fascicles confirmed intraoperatively with a nerve stimulator, making neurolysis and decompression sufficient. **Althagafi and Nadi** [12] recommended exploratory surgery with intraoperative electrodiagnostic testing when reinnervation signs are absent by 3–4 months post- injury, as neurotmesis should then be suspected.

In our study, sural nerve autografts were used in all graft procedures due to their purely sensory nature, minimal donor site morbidity, and suitability for obtaining grafts of sufficient diameter and length. Additionally, the sensory deficit at the donor site tends to decrease over time as nearby sensory nerves compensate through collateral sprouting [13]. Among the 13 graft cases, 8 patients (34.78%) required two cable grafts, and 5 patients (17.39%) needed three cables, with the mean inter-stump distance being 2.88 ± 1.62 cm. **Zhu *et al.*** [14] in their study of 33 radial nerve injuries concluded that repairs performed within 6 months, with defects shorter than 5 cm and using at least three cables, were associated with better functional outcomes. They also noted that the number of cables used was more predictive of muscle strength recovery than the timing of reinnervation.

In our series, 21 patients (91.3%) presented with sensory deficits, while 2 patients (one PIN and one CPN injury) had purely motor symptoms (S4). Trophic changes were observed in 8 patients (34.78%) with complete sensory loss (S0). Motor deficits were observed in 19 patients (82.26%), while combined motor and sensory involvement was present in 17 cases (73.91%). Four patients exhibited purely sensory impairment; three of them had median nerve injuries. The remaining case involved an isolated digital nerve injury of the index finger. Among the three patients with median nerve injuries who did not exhibit motor deficits, one had a partial injury affecting only the sensory component.

This patient was treated with internal neurolysis, excision of the neuroma, and end-to-end anastomosis of the sensory component. The second case involved a neuroma in continuity, accompanied by trophic changes, which was managed with external neurolysis alone. The third case showed complete neurotmesis of the median nerve intraoperatively although there is no preoperative motor deficit. Electrical stimulation of the ulnar nerve confirmed preserved hand function suggesting the presence of a median-to-ulnar nerve anastomosis (Martin-Graber anastomosis).

We observed that sensory recovery was more favorable in median nerve injuries compared to ulnar nerve injuries and in distal lesions compared to proximal ones. The best sensory outcomes, in terms of both speed and degree of recovery, were seen in pure sensory nerve repairs, such as those involving the digital nerves. These observations align with findings by **Navarro *et al*.** [15] who reported that PNIs can lead to partial or complete loss of motor, sensory, and autonomic function due to axonal disruption, distal nerve fiber degeneration, and eventual neuronal death.

At the 6-month follow-up in our study, 3 patients (14.29%) achieved satisfactory sensory recovery, and 18 (85.71%) showed good recovery, this represented a statistically significant enhancement in sensory outcomes between the 3- and 6-month evaluations (P < 0.001). However, no statistically significant difference was observed between the 6- and 12-month sensory outcomes.

In terms of motor recovery at 6 months, 7 patients (41.18%) achieved good functional improvement, 4 patients (23.53%) had satisfactory recovery, another 7 patients (41.18%) demonstrated moderate improvement, and 1 patient (5.88%) exhibited poor motor recovery.at the final recovery a good level of motor function, 6 patients (31.5%) had satisfactory outcomes, and 2 patients (18.18%) continued to have moderate recovery. Of the two patients with moderate recovery; one had a high sciatic nerve injury in the upper thigh and presented 7 months after trauma, while the other sustained a high ulnar nerve injury and presented 9 months post-injury.

Our findings are supported by multiple studies. **John *et al.*** [16] noted significant improvement in motor function and resolution of trophic changes following peripheral nerve surgery. Similarly, **Lundeen and Wu** [17] reported meaningful gains in muscle strength within 6 months of surgery. **Luzhansky *et al.*** [18] and **Althagafi and Nadi** [12] also emphasized that surgical nerve repair aims to restore both motor function and sensation, even when initially lost.

We found that both motor and sensory recovery were better in cases involving distal nerve repair compared to proximal injuries—results that are in line with the findings of **Grinsell and Keating**[10]**.** For proximal injuries, with long delays (greater than one year), nerve transfer may be a promising alternative to improve outcomes by shortening the regeneration distance to the target muscle.

In our cohort, all patients with isolated median nerve injuries achieved satisfactory motor recovery (100%), in contrast to those with ulnar nerve injuries, where only 16.67% had good 66.67% had satisfactory, and 16.67% had moderate outcomes. This is consistent with the findings of **Bucknam *et al***. [19] who also reported superior motor recovery in isolated median nerve injuries compared to ulnar nerve injuries. This difference may be explained by anatomical and functional distinctions. The ulnar nerve has a more substantial motor component and is essential for fine motor control and hand coordination. Its terminal innervation targets the intrinsic muscles of the hand, which are located more distally than the flexor muscles innervated by the median nerve. These smaller intrinsic muscles are more susceptible to atrophy and fibrosis following denervation. Moreover, patients with median nerve injuries can often compensate through ulnar or dual-innervated muscles to maintain thumb opposition. In contrast, patients with ulnar nerve injuries have limited potential for functional compensation from other nerve territories [20].

LIMITATIONS

This study has certain limitations, including a relatively small sample size and a limited follow-up duration of up to 12 months. These factors may have reduced the statistical robustness of the findings. Moreover, being a single-center study may limit the external applicability of the results.

RECOMMENDATIONS

Future research should involve larger, more stratified patient populations to improve the accuracy and generalizability of findings. Additionally, multi-center studies are encouraged to validate outcomes across diverse clinical settings.

CONCLUSION

Peripheral nerve injury (PNI) remains a significant contributor to long-term morbidity and disability. Various surgical approaches have been employed to enhance patient outcomes. Favorable prognostic indicators included younger age, distal location of injury, and early surgical intervention. In cases of proximal injuries with delayed presentation, nerve transfer techniques may offer a viable strategy to improve functional recovery.

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REFERENCES

1. **Beris A, Gkiatas I, Gelalis I *et al.* (2019):** Current concepts in peripheral nerve surgery. Eur J Orthop Surg Traumatol., 29: 263-269.
2. **Hill C, Riaz M, Mozzam A *et al.* (1998):** A regional audit of hand and wrist injuries. A study of 4873 injuries. J Hand Surg Br., 23: 196-200.
3. **Modrak M, Talukder M**, **Gurgenashvili K *et al.* (2020):** Peripheral nerve injury and myelination: Potential therapeutic strategies. J Neurosci Res., 98: 780-795.
4. **Liu Y, Wang H (2020):** Peripheral nerve injury induced changes in the spinal cord and strategies to counteract/enhance the changes to promote nerve regeneration. Neural Regen Res., 15: 189-198.
5. **Campbell W (2008):** Evaluation and management of peripheral nerve injury. Clin Neurophysiol., 119: 1951-1965.
6. **He B, Zhu Z, Zhu Q *et al.* (2014):** Factors predicting sensory and motor recovery after the repair of upper limb peripheral nerve injuries. Neural Regen Res., 9 (7): 661-672.
7. **Robinson L, Binhammer P (2022):** Role of electrodiagnosis in nerve transfers for focal neuropathies and brachial plexopathies. Muscle Nerve, 65: 137-146.
8. **Garg K, Sinha S, Satyarthee G *et al.* (2016):** Microsurgical outcome of post-traumatic peripheral

nerve injuries: An experience of 23 cases and review of literature. Turk Neurosurg., 26: 297-301.

9. **Castillo-Galván M, Martínez-Ruiz F, de la Garza-Castro O *et al.* (2014):** Study of peripheral nerve injury in trauma patients. Gac Med Mex., 150: 527-532.
10. **Grinsell D, Keating C (2014):** Peripheral nerve reconstruction after injury: A review of clinical and experimental therapies. Biomed Res Int., 14:698256. doi: 10.1155/2014/698256.
11. **Hara T, Tatebe M, Kurahashi T *et al.* (2021):** Iatrogenic peripheral nerve injuries–Common causes and treatment: A retrospective single-center cohort study. J Orthop Sci., 26: 1119-1123.
12. **Althagafi A, Nadi M (2023):** Acute Nerve Injury. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK549848/
13. **Bamba R, Loewenstein S, Adkinson J (2021):** Donor site morbidity after sural nerve grafting: A systematic review. J Plast Reconstr Aesthet Surg., 74: 3055-3060.
14. **Zhu S, Lei G, Pang Z *et al.* (2023):** Outcomes and prognostic factors for nerve grafting following high radial nerve injury. J Hand Surg., 48: 747-754.
15. **Navarro X, Vivó M, Valero-Cabré A (2007):** Neural plasticity after peripheral nerve injury and regeneration. Progress in Neurobiology, 82 (4): 163-201.
16. **John A, Rossettie S, Rafael J *et al.* (2022):** Assessment of motor function in peripheral nerve injury and recovery. Orthop Rev., 14: 34-90.
17. **Lundeen A, Wu E (2024):** Delayed repair of recurrent motor branch injury after carpal tunnel release. J Hand Surg Glob Online, 6: 45-50.
18. **Luzhansky I, Sudlow L, Brogan D *et al.* (2019):** Imaging in the repair of peripheral nerve injury. Nanomedicine, 14: 2659-2677.
19. **Bucknam R, Dunn J, Fernandez I *et al.* (2020):** Outcomes and return to work following complex nerve lacerations in the volar forearm in an underserved Spanish- speaking population. J Hand Surg Glob Online, 2 (2): 67-73.
20. **Noaman H (2007):** Management and functional outcomes of combined injuries of flexor tendons, nerves, and vessels at the wrist. Microsurgery, 27 (6): 536- 543.