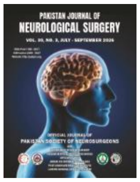

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Original Research

Radial Nerve Palsy Following Humeral Shaft Fractures: A Prospective Evaluation of Management Strategies and Neurological Recovery

Aimal Sattar[1], Muhammad Yahya[1], Yaseen Ahmad[1], Hamid Nawaz[1], Kashif Kareem[1], Ibrahim Ashiq[2]

[1]*Department of Orthopaedics, Lady Reading Hospital (LRH), Peshawar*

[2]*Department of Neurology, Lady Reading Hospital (LRH), Peshawar- Pakistan*

ABSTRACT

Objective: Humeral shaft fractures are known to be associated with radial nerve palsy, which is a major clinical issue because of the effects on the functionality of the upper limbs. The research aimed to assess management interventions and test the neurological recovery outcomes of affected patients.

Materials & Methods: The study was designed as a prospective observational study to be carried out at Lady Reading Hospital, Peshawar. Two hundred and twenty patients with humeral shaft fractures and radial nerve palsy were selected. Neurological assessment and imaging findings were noted during clinical evaluation. Patients with open fractures, vascular injury, severe fracture displacement, suspected nerve entrapment or transection, or failure to demonstrate neurological recovery during follow-up were selected for surgical management, while the remaining patients received conservative treatment. Clinical indicators were used to treat patients through a conservative or surgical approach. A six-month follow-up was done to assess recovery.

Results: Among the 220 patients (mean age 34.5 ± 11.2 years), 140 (64%) were managed conservatively, and 80 (36%) underwent surgical treatment. Complete neurological recovery was achieved in 100/140 (71%) patients in the conservative group and 65/80 (81%) in the surgical group after six months. The mean recovery time was 12.5 ± 4.2 weeks in the conservative group compared with 10.3 ± 3.8 weeks in the surgical group. Early intervention was significantly associated with improved neurological recovery ($p = 0.02$), and fracture characteristics were also significantly associated with recovery outcomes ($p = 0.04$).

Conclusion: Radial nerve palsy is a complication of humeral shaft fractures, which can be effectively addressed by a well-chosen method of treatment. Earlier diagnosis and intervention enhance functional outcome and neurological recovery.

Keywords: Neurological Recovery, Trauma Management, Radial Nerve Palsy, Injury, Humeral Shaft Fracture, Nerve Injury.

Corresponding Author: Muhammad Yahya
Department of Orthopaedics, Lady Reading Hospital (LRH), Peshawar, Pakistan
Email: yahyatarakai346@gmail.com

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INTRODUCTION

Radial nerve palsy is known to be a common complication of humeral shaft fractures. The radial nerve is in proximity to the humerus because of the anatomy of the nerve. This association exposes the nerve to damage during fracture incidents. The radial nerve passes through the spiral groove and becomes susceptible when the bone fragments are moved.[1] The impairment caused by functional loss after nerve injury is loss of wrist extension and loss of sensation on the back of the hand.

Humeral shaft fractures are usually experienced in the trauma environment. High-energy processes like road traffic accidents and falls from height are usually the causes of these fractures. Direct trauma or indirect compression may affect the radial nerve in this type of fracture, with varying rates across populations. This disparity has been explained by differences in the injury patterns and access to healthcare.

In Pakistan and other low- and middle-income countries, humeral shaft fractures are frequently encountered in tertiary trauma centers due to the high incidence of road traffic accidents, occupational injuries, and falls. Young adults, particularly males, constitute the majority of affected patients because of greater exposure to high-energy trauma. Despite the considerable burden of these injuries, prospective local data on radial nerve palsy associated with humeral shaft fractures remain limited. Differences in healthcare resources, delayed presentation, and restricted access to advanced diagnostic modalities may influence management decisions and neurological outcomes in the local population. Therefore, evidence generated from regional settings is essential to guide clinical practice and optimize patient care.

Radial nerve palsy has a clinical picture that is characterized by weakness of the muscles and loss of sensation. Wrist drop is regarded as a typical symptom. The impairment of the senses is normally seen in the posterior part of the forearm and hand.[3] The symptoms are determined by the nerve injury type. Temporary conduction block is linked to neuropraxia, which is normally reversible. Axonotmesis is characterized by destruction of the axon and preservation of surrounding connective tissue. Neurotmesis is total rupture of the nerve, and it needs surgery to be repaired.

Treatment of radial nerve palsy has been controversial. In closed fractures with intact nerve continuity, conservative treatment has been a common occurrence. It has been demonstrated that observation and physiotherapy lead to spontaneous recovery in a good number of patients,[4] but the time of observation and criteria to have the surgery have been inconsistent among the studies.

Certain clinical situations were indicated for surgical exploration. Severe displacement and failure of recovery after a specified period are considered an indication of the need to intervene, and surgical management is aimed at correcting the mechanical factors that inhibit nerve recovery. Such techniques as neurolysis, repair, and grafting are described. The results of these procedures relate to the time and level of injury.

Development of diagnostic modalities has enhanced the evaluation of nerve injuries. Radiographic analysis aids in the identification of fracture features. Electrophysiological examinations give data about the conduction of nerve and the reaction of the muscle.[6] The tools help clinicians to determine the severity of injury and design measures aimed at managing the injury. Whereas these breakthroughs have been made, there will always be doubt in decision-making.

Past studies have shown good results with a conservative approach in a very high percentage of cases,[7] though some studies have shown better results with early surgical exploration in a few patients. Variations in the methodology and patient selection have led to conflicting evidence.

This has resulted in inconsistency in clinical practice and lack of standardized guidelines.

Timing of intervention has been observed to be a very important factor affecting recovery. Early identification of cases that need surgical intervention is critical in achieving the best outcomes.[8] Late intervention could lead to irreversible harm and long-term disability. Thus, proper evaluation at the first presentation is very critical.

Recovery has been demonstrated to be affected by demographic factors like age and gender. There is better regenerative capacity has been reported in young patients. Fracture features such as location and pattern also influence the probability of nerve injury and recovery. These are aspects that should be taken into account when conducting clinical assessments.

Moreover, the presence of healthcare resources is also a factor in management decisions. Access to sophisticated diagnostic equipment and surgical skills is usually a problem in resource-constrained environments, which can lead to a delayed diagnosis and inappropriate treatment. So, information on such environments is needed to inform effective management strategies.

There have been previous studies reporting positive results from both conservative and surgical treatment of radial nerve palsy after humeral shaft fractures, but a lack of consistency in patient selection, treatment methods, and follow-up periods means that the results have been mixed. The majority of available studies are retrospective and have relatively small sample sizes, making it difficult to compare the management strategies in a standardized way. Beyond that, public health information is sparse, even when there are variations in the types of trauma, access to care, and diagnostic tools.

Additional prospective studies are required to better understand the link between fracture characteristics, time for intervention, management, and neurological recovery. Using a standardized assessment with clinical examination, imaging results and appropriate adjunctive investigations will enhance the patient's outcome and treatment planning.

The study aimed at an evaluation of the management strategies deployed for radial nerve palsy incurred after humeral shaft fractures and to estimate the outcomes of neurological recovery in a cohort of patients managed in a tertiary-level trauma centre prospectively.

MATERIALS AND METHODS

Study Design

A prospective observational study was used to determine the management and neurological outcomes of patients who presented with radial nerve palsy following humeral shaft fractures. The choice of the study design was due to the need to see the results over time and to determine the time-related correlations of the treatment methods and recovery patterns. The patients were recruited in sequential order so as to reduce selection bias and to represent clinical situations in the real world.

Setting and Time of Study

The research was conducted at Lady Reading Hospital, Peshawar, which is a tertiary care referral hospital that handles a significant number of trauma cases. The data were collected during a time frame that spans between December 2024 and June 2025. This time was sufficient to recruit enough patients and have enough follow-up time to evaluate neurological recovery. The hospital environment was able to provide multidisciplinary care such as orthopedic surgery, neurology, and rehabilitation services.

Sample Size and Sampling Technique

The study included 220 patients. The sample size was established using anticipated incidences of radial nerve palsy in humeral shaft injuries and practicality during the study period. It was sampled using a non-probability consecutive method. The patients who met the criteria were enrolled until the necessary sample size was attained. This was a way of ensuring that a wide population of patients was included and the sampling error was reduced.

Inclusion Criteria

The study included patients who had radiologically established fractures of the humeral shaft. Patients who showed clinical evidence of radial nerve palsy either at presentation or during treatment were included. There were both male and female patients. Eligible patients were those between 18 and 65 years of age. The study was limited to enrolling only those patients who consented to participate and who agreed to receive follow-up visits.

Exclusion Criteria

Cases of pre-existing neurological conditions involving the upper limb were not allowed. Pathological fractures were excluded because they were deemed to confound the effects of underlying disease processes. Patients who were multiple injured in the same limb that would be a barrier to the neurological assessment were excluded. Cases that had no final medical record or loss to follow-up were also not included in the final analysis.

Data Collection Procedure

A structured proforma was used to collect the data. All patients gave a detailed history, including the time of any associated trauma, mechanism of trauma, and presenting symptoms. The clinical examination was directed towards a thorough evaluation of motor and sensory functions of the radial nerve. Motor function was assessed by measuring wrist extension, finger extension, and thumb abduction; sensory function was assessed on the dorsum of the hand and posterior aspect of the forearm. Neurological deficit was documented at presentation and at each follow-up visit using a standardized clinical examination.

Standard radiographs of the humerus were used for radiographic assessment, both anteroposterior and lateral views. Fractures were described in terms of the anatomical location and fracture pattern, and further imaging was undertaken if clinically indicated to assess for associated injuries. Nerve conduction studies and electromyography (EMG) were not performed routinely. These investigations were reserved for patients who had impaired neurological function that persisted, and for patients who had unclear clinical signs or symptoms, or suspected severe nerve injury that might require further imaging before the surgery. EMG and nerve conduction studies were used, when indicated, 3–4 weeks after the injury to detect denervation changes and to help with further management planning. The clinical examination and radiographical data were the main tools used for diagnosis and treatment planning, with electrophysiological studies being used as a complementary investigation when clinically appropriate.

Conservative and surgical management were assigned on the basis of pre-defined clinical criteria. Conservative treatment involved functional bracing, immobilization, analgesia and physiotherapy for closed fractures where there was no evidence of nerve transection or vascular damage and where the alignment was acceptable. Surgical treatment included open reduction and internal fixation with or without radial nerve exploration in patients with open fracture, vascular injury, severe fracture displacement, suspected nerve entrapment or transection, and failure to demonstrate neurological recovery at follow-up. The surgeries were carried out by highly experienced orthopedic surgeons and according to a standard management protocol in the institution. The clinical indications for fracture fixation and radial nerve exploration, as well as postoperative rehabilitation, were predetermined to reduce treatment variation.

The early intervention group included any intervention that began within 14 days of injury, and the delayed intervention group included the interventions that began more than 14 days after injury. The relationship between treatment time and neurologic recovery was assessed using this definition.

Follow-Up and Outcome Assessment

Follow-ups of the patients were conducted over six months after they were first treated. Regular follow-up visits were to be made. At every visit, neurological recovery was evaluated. The recovery was classified in terms of complete recovery, partial recovery, or no recovery (with regard to motor and sensory recovery). Time to recovery was also noted. The outcomes of functional activities were measured in terms of the ability to carry out daily activities and the recovery of limb functioning.

Outcome Measures

Neurological recovery of radial nerve function was the major outcome measure. Secondary outcome measures were also time spent recovering and improving the functioning of the affected limb. Other parameters like the association between fracture type, management strategy, and recovery outcome were also assessed.

Statistical Analysis

Data were entered and analyzed using statistical software. Continuous variables such as age were expressed as mean and standard deviation, while categorical variables were presented as frequencies and percentages.

A chi-square test was applied to assess the association between categorical variables, including early intervention and fracture type, with neurological recovery outcomes. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study received ethical approval from the Institutional Review Board of Lady Reading Hospital, Peshawar **(Ref: NO. 562/ LRH /MTI)**. Everything was done in line with the ethical considerations. All participants were informed about the study and gave their informed consent before being included in it. Patients were educated on the aim of the study and their right to withdraw at will. Patient confidentiality was ensured during the study.

Quality Control Measures

Clinical assessment and data recording were done using standardized protocols. Trained clinicians were used to carry out all examinations to provide consistency. Data were checked periodically to detect and rectify mistakes. Patient counseling and reminder systems were used to promote follow-up compliance. These were put in place to increase the reliability and validity of the study results.

RESULTS

Patient Demographics and Clinical Profile

The demographic evaluation of the 220 patients revealed that the majority were male and belonged to the younger age group. The mean age of the patients was 34.5 ± 11.2 years. Most injuries were related to high-energy trauma such as road traffic accidents, followed by falls. Radial nerve palsy was present at presentation in most cases, while a smaller number developed it during treatment. These baseline characteristics are summarized in **Table 1**.

Table 1: *Patient Demographics and Clinical Features.*

Variable	Value
Total patients	220
Mean age (years)	34.5 ± 11.2
Male	150 (68%)
Female	70 (32%)
Road traffic accidents	130 (59%)
Falls	90 (41%)

Fracture Characteristics and Pattern Distribution

Transverse fractures were the most common type, followed by spiral and oblique fractures. Mid-shaft involvement was predominant, consistent with the anatomical course of the radial nerve. The distribution of fracture patterns is shown in **Table 2**.

Table 2: *Fracture Characteristics and Distribution.*

Fracture Type	Frequency	Percentage
Transverse	95	43%
Spiral	65	30%
Oblique	60	27%
Mid shaft involvement	140	64%
Proximal shaft	40	18%
Distal shaft	40	18%

Management Strategies and Treatment Allocation

Patients were managed either conservatively or surgically based on clinical indications. Conservative treatment was more commonly used, particularly in closed fractures without nerve transection. Surgical intervention was reserved for open fractures, severe displacement, or lack of improvement. Treatment distribution is presented in **Table 3**.

Table 3: *Management Strategy Distribution.*

Treatment Type	Number of Patients	Percentage
Conservative	140	64%
Surgical	80	36%

Neurological Recovery Outcomes

Neurological recovery over six months showed favorable outcomes in both groups. Complete recovery was more frequent in both conservative and surgical groups, with slightly better outcomes in surgically managed patients. These findings are summarized in **Table 4**.

Table 4: *Neurological Recovery Outcomes.*

Outcome	Conservative (n=140)	Surgical (n=80)	P-value
Complete recovery	100 (71%)	65 (81%)	0.09
Partial recovery	30 (21%)	10 (12%)	
No recovery	10 (8%)	5 (7%)	

Chi-square test: $\chi^2 = 4.67$, $p = 0.09$

Although complete neurological recovery was observed more frequently in the surgical group, the difference in overall recovery outcomes between the conservative and surgical groups did not reach statistical significance.

Time to Neurological Recovery

The mean time to neurological recovery was shorter in the surgical group compared to the conservative group, suggesting potential benefit of early surgical intervention in selected cases. Details are shown in **Table 5**.

Table 5: *Time to Neurological Recovery.*

Group	Mean Time (weeks)
Conservative	12.5 ± 4.2
Surgical	10.3 ± 3.8

Treatment-related complications were uncommon during the six-month follow-up period. In the conservative group, a small number of patients developed delayed fracture union and transient wrist stiffness that improved with continued physiotherapy. In the surgical group, superficial wound infection occurred in three patients and was successfully managed with antibiotics and local wound care, while two patients experienced temporary postoperative radial nerve neuropraxia that resolved during follow-up. No cases of deep infection, implant failure, compartment syndrome, or permanent neurological deterioration were observed.

Table 6: *Association Between Early Intervention and Neurological Recovery.*

Early Intervention	Complete Recovery	Partial Recovery	No Recovery	Total
Yes (Early)	120	25	5	150
No (Delayed)	45	15	10	70
Total	**165**	**40**	**15**	**220**

Chi-square (χ^2) = 7.85, p = 0.02

Statistical Analysis

A chi-square test was used to assess associations between categorical variables, while an independent-samples t-test was used for age comparison. A p-value < 0.05 was considered statistically significant.

Table 6 presents the association between early intervention and neurological recovery outcomes. Chi-square analysis demonstrated a statistically significant association (χ^2 = 7.85, p = 0.02), indicating that patients who received early intervention had higher rates of complete neurological recovery than those with delayed intervention.

A further analysis was performed to evaluate the relationship between fracture type and neurological recovery outcomes. The results are presented in **Table 7.**

A statistically significant association was observed between fracture type and neurological recovery (**χ^2 = 6.42, p = 0.04**), with transverse fractures showing better recovery outcomes compared to spiral and oblique fractures.

Table 7: *Association Between Fracture Type and Neurological Recovery.*

Fracture Type	Complete Recovery	Partial Recovery	No Recovery	Total
Transverse	70	20	5	95
Spiral	50	10	5	65
Oblique	45	10	5	60
Total	**165**	**40**	**15**	**220**

Chi-square (χ^2) = 6.42, p = 0.04

Table 8: *Comparison of Mean Age According to Neurological Recovery (Independent Sample t-test).*

Recovery Outcome	n	Mean Age (years)
Complete Recovery	165	**33.9 ± 10.8**
Partial/No Recovery	55	**36.2 ± 12.1**

Independent samples t-test: t = 1.29, p = 0.20.

DISCUSSION

Humeral shaft fractures, including radial nerve palsy, have been actively studied in clinical research. They have noted that the incidence differs with the mechanism of injury and fracture characteristics. In the current study, they observed that there is an increased number of cases in young male patients. This trend has been explained in previous literature in which trauma-associated injuries were found to occur more in active populations. The current findings, which are largely characterized by high-energy injuries, only serve to corroborate this finding as well as the weight of road traffic accidents in developing countries.

The anatomy of the radial nerve in relation to the humerus has been viewed as a significant contributor to its susceptibility. The nerve runs through the spiral groove and is in close contact with the bone surface.[13] In the displacement of a fracture, the nerve may be stretched, crushed, or trapped between fragments. The current research revealed that nerve involvement was higher in mid-shaft fractures as compared to the previous studies.

The traditional management of most radial nerve palsy cases with closed fractures has been conservative. A high percentage of patients have been reported to recover spontaneously.[14] In the present study, the conservatively treated group showed good results. Most patients were completely cured during the follow-up. This supports the idea that most nerve damage may be neuropraxia or mild axonal damage that can fully heal without any surgical intervention.

Surgical treatment is recommended in certain circumstances when the nerve may have structural damage. The present study showed good neurological improvement when surgery was performed on patients when clinically indicated, while the rest did not. Comparisons between conservative and surgical management should be viewed with caution, however, as treatment allocation was not randomised but was based on pre-defined clinical criteria. These cases were identified early, and mechanical factors that may hinder nerve regeneration were corrected in time. The low complication rate experienced was another indication of the safety of surgical intervention for the appropriate clinical indications, as observed in the present study. Superficial wound infection and transient postoperative neuropraxia were rare and were dealt with appropriately. There were no cases of deep infection, implant failure or permanent neurological deterioration, suggesting that surgical treatment can be safely carried out using a standard operative protocol and careful patient selection.

The time of intervention is a key determinant of outcome. In the present analysis, a significant correlation was observed between neurological recovery and early intervention in a number of studies. This observation emphasises the importance of early evaluation and judgement in patients who present with radial nerve palsy. Late management may lead to chronic dysfunction and the lack of total recovery.

Some patients may also have had delayed presentation to hospital, which could have helped their neurological recovery. In resource-challenged situations, delays may arise due to transport problems, peripheral health care facility dropouts, financial issues, or insufficient knowledge about the severity of the injury. These delays may lead to delayed fracture stabilization, neurologic evaluation, and/or rehabilitation, which could lessen the chances of optimal functional recovery. The time elapsed between the injury and presentation to the hospital was not analysed separately in the present study; however, this should be taken into account in future prospective studies to elucidate its effect on neurological outcome.

The injury of nerves has also been demonstrated to depend on fracture features. Transverse and spiral types of fractures have been linked with various mechanisms of injury in this study and even showed a higher rate of recovery. This can be attributed to the characteristics of immobilization and decreased chances of serious nerve injury. On the other hand, more severe fracture patterns could be linked to more soft tissue damage and worse outcomes.

The significance of the diagnostic modalities in the evaluation of nerve injury has been highlighted in contemporary clinical practice. Radiographic assessment can reveal the location and displacement of fractures.[18] Electrophysiological analyses can give data about the functional condition of the nerve. Nonetheless, these studies might not be readily accessible in all places. The current research was based mostly on clinical assessment that represents the actual practice in resource-scarce settings.

Comparison to the data published previously showed similar recovery trends. Conservative management proved to be effective in most cases, whereas surgical intervention was beneficial in selected patients.[19] Reported variation might be due to differences in the sample size in the study design and duration of follow-up. The prospective nature of the present research is an added strength to the present study and renders a better estimation of the outcomes.

Recent prospective studies published after 2022 have reported findings consistent with the present study. Hegeman et al, demonstrated that most patients with radial nerve palsy associated with closed humeral shaft fractures achieved spontaneous neurological recovery with conservative management, while early surgical exploration was beneficial in carefully selected patients with suspected nerve entrapment or open injuries. Similarly, Bumbasirevic et al, emphasized that treatment decisions should be individualized according to fracture characteristics, clinical presentation, and evidence of nerve continuity, reporting high overall recovery rates with both conservative and surgical approaches. Our findings are consistent with these studies, demonstrating favorable neurological recovery in both treatment groups. Although a shorter recovery time was observed among surgically managed patients, this finding should be interpreted cautiously because treatment allocation was based on clinical indications rather than randomization. These similarities support current recommendations that careful patient selection and early clinical assessment are essential for optimizing neurological recovery.

Other factors like age and gender of patients have been mentioned in previous research. In the current study, age did not result in a strong relationship with recovery among younger patients. This observation indicates that the severity of injury and timeliness of treatment could be more important.

A multidisciplinary approach has been suggested to be the best way of handling radial nerve palsy. Early physiotherapy and rehabilitation are important to guarantee comprehensive care through collaboration between orthopedic surgeons, neurologists, and rehabilitation specialists to facilitate functional recovery and avoid complications like joint stiffness. The results in this research reinforce the need to have coordinated care in enhancing patient outcomes.

The necessity of uniform management procedures is also noted in the present research. Clinical practice variability has been noted as a result of not having an agreement on signs showing the need to intervene surgically.[22] Consistency of clear guidelines based on clinical and radiological findings may enhance decision-making and minimize variations in outcomes.

Despite the merits of this research, some limitations should be mentioned. The single-center design can be a limitation to the generalizability of findings. The lack of access to advanced diagnostic tools could have affected the analysis of the severity of nerve injury.

Future studies ought to consider bigger multicenter studies with a longer time to follow up. The best diagnostic methods ought to be integrated to enhance assessment accuracy. The creation of standardized treatment algorithms will improve clinical practice and patient outcomes.

The observational design of the present study should be considered when interpreting the comparative outcomes between treatment groups. Since patients were allocated to conservative or surgical management according to clinical indications rather than random assignment, the observed differences may have been influenced by baseline clinical characteristics and treatment selection. Therefore, causal conclusions regarding the superiority of one management strategy over the other cannot be drawn from the present findings.

Limitations

The study was conducted at a single center, which may limit the generalizability of the findings. The follow-up period of **six months** may not have been sufficient to capture late neurological recovery, as some patients with radial nerve palsy may continue to show functional improvement beyond this period. Advanced diagnostic modalities, including routine electrophysiological assessment, were not available for all patients, which may have limited the detailed characterization of nerve injury severity.

CONCLUSION

The findings of this study indicate that radial nerve palsy associated with humeral shaft fractures can be successfully managed with both conservative and surgical approaches. The results support the feasibility and effectiveness of both management strategies when applied to appropriately selected patients based on clinical presentation, fracture characteristics, and neurological assessment**.** Early diagnosis, careful patient selection, and timely intervention are essential for optimizing neurological recovery and functional outcomes. Standardized clinical evaluation and individualized treatment planning remain key to achieving favorable results.

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Additional Information

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AUTHORS CONTRIBUTIONS

Role	Contributing Author(s)	Role	Contributing Author(s)
Conceptualization	Aimal Sattar	Data Curation.	Hamid Nawaz
Methodology	Muhammad Yahya	Writing – Original Draft/Literature Review.	Kashif Kareem
Software	Yaseen Ahmad	Writing - Review & Editing.	Ibrahim Ashiq