

# Evidenced Based Case Reports: Radial Nerve Palsy Associated with Closed Humeral Shaft Fractures

Andi Setiadi<sup>1</sup>, Andreas S<sup>2</sup>, Surya Adisthanaya<sup>3</sup>, Karl Heinz Leonhardt Rowika<sup>4</sup>

**Abstract:** Fracture of humeral shaft often caused by a fall directly or direct blow to the arm or shoulder. It has an impact on personal function especially associated with radial nerve palsy. Radial nerve palsy as an early complication of humeral shaft fracture will cause varying degree lack of function from mild muscle weakness and the worst case causes permanent disabilities. This injury can be treated by conservatively or operatively. However, the optimal management for radial nerve palsy in the setting of humeral shaft fracture remain debatable. There is no consensus for treatment of radial nerve palsy associated with humeral shaft fracture. We reported 3 cases closed humeral shaft fractures in adults that showed sign of radial nerve palsy. The purpose of this study to discuss management strategy, management options and outcome radial nerve palsy associated with closed humeral shaft fracture. Conclusion Radial nerve palsy associated with closed humeral shaft fracture can be treated either by conservative or operative method. There is no significant outcome in recovery and onset to recover between conservative and operative management. The waiting time of 16 to 24 weeks before early exploration is recommended.

**Keywords:** Radial nerve palsy, humeral shaft fracture, management, recovery

## 1. Background

Fracture of humeral shaft has an impact on personal function especially associated with radial nerve palsy. It will cause varying degree lack of function from mild muscle weakness and the worst case cause permanent disabilities. A humerus fracture is often caused by a fall directly on the shoulder or arm. The incidence rates of humerus fracture in US approximately 370.000 ED visits in 28 million all ages population. Humerus shaft fracture incidence set in 3<sup>rd</sup> position after proximal humerus fracture and distal humerus fracture as the most common site of fracture, females more common than males.<sup>1</sup>

Humeral shaft Fractures usually occurs in elderly women as result of simple fall on the arm and young adults as a result of a direct blow to the humerus. A fall on the hand may twist the bone and causing a spiral type fractures. The sport injury or direct blow to the humerus may cause an oblique or transverse type fracture either comminuted or not.<sup>2</sup>

The mechanism of humerus fracture was 88% caused by falling, the next most common mechanism of injury were motor vehicle accidents (8%) and injury from a direct blow by an object or person (5%).<sup>1</sup> In direct blow case, the fractures tends to be transverse or comminuted while in the case caused by falling, usually produce a spiral fracture pattern of the humeral shaft. The pattern of fractures in Humeral Shaft fracture decides the option how to manage the patient. Radiograph examination could help us to see the fracture pattern.

Radial nerve injury can be differentiated into three lesions based on etiology and clinical manifestation. it differs to (1) Low Lesion (injury at the elbow), (2) High Lesion (injury at the Humerus) and (3) Very High Lesion (Injury at the shoulder or axilla). Radial nerve injury associated with fractures of the shaft of the humerus is the most common nerve lesion complicating fracture of long bones. Most fracture site associated with radial nerve injury happened in the middle third of the humeral shaft. The Clinical Features are weakness of the radial extensors of the wrist causing wrist drop, the thumb cannot be extended, and clumsiness.

The nerve injuries can be treated conservatively or operatively.<sup>3,4</sup> However, the optimal management for radial nerve palsy in the setting of humeral shaft fracture remain debatable. There is no consensus for treatment of radial nerve palsy. The purpose of this study to discuss management strategy, management options and outcome radial nerve palsy associated with closed humeral shaft fracture

## 2. Case Scenario 1

A 24 year old man was submitted to the ER after a motorcycle accident with complaints of pain in right arm after a motorcycle accident. There were no injuries to the head and there are no concussions or alteration of mental status. During physical examination, there is deformity at the fracture site as well as bruises and excoriations, but there are no open wounds. Radial nerve examination shows that the patient was struggling to extend his elbow, unable to extend his wrist and fingers. The patient was unable to make the thumb sign. X ray shows oblique fracture of the middle third of right humerus shaft with no comminution. X rays of the thorax and pelvis were also done without any significant findings. The patient then appointed to next day surgery of open reduction and internal fixation of plate and screws and radial nerve exploration.



**Picture 1:** Radiograph Examination show complete oblique fracture middle third shaft of humerus

During the surgery, the radial nerve is intact, the fragments were reduced and an 8 hole 4.5mm narrow plate was implanted. After the surgery, there were no improvements on the radial nerve functions with the wrist and the fingers were still unable to extend. Treatments of methylprednisolone of 125mg per 8 hours were given for 3 days. Physiotherapy unit was also consulted for a cock-up splint, exercises, and 3 times a week of electrical stimulation (faradic and galvanic stimulation) was added to the routines. The patient was discharged 3 days after the operation and given an appointment after 5 days. During the visit to the office 8 days after surgery, improvements are still absent. The cock-up splint is retain and faradic and galvanic therapy were continued and an EMG exam is scheduled 2 months after surgery.

### Case Scenario 2

A 21-year-old male presents to the emergency department complaining right arm pain after falling from a motorcycle. He fell on his hand with the elbow slightly flexed position while the motorcycle is still moving. The right arm appears swelling in the middle third area, the patient also felt tingling sensation and numbness along the lateral side of the right forearm to the thumb. There are no further injury affecting patient in other crucial areas such as head, chest, abdomen, lower limb, or the opposite upper limb. Neither history of previous illness nor surgical history according to the patient. From the physical examination, at the right arm region, based on inspection there are bruising on the lateral aspect of the arm and also swelling, palpation shows tenderness along the right arm and numbness along the lateral side of the arm to the thumb. Movements are limited, especially on the elbow, wrist, and thumb region, limitation of movement of the elbow caused by pain, but felt weak, numb, and tingling sensation along the wrist and thumb, especially when the patient tries to extend his wrist or thumb. No significant abnormality shown in the blood test. Plain radiographic examination is taken and shows a middle third right humeral shaft fracture.



**Picture 2:** Radiograph Examination show complete oblique fracture middle third shaft of humerus

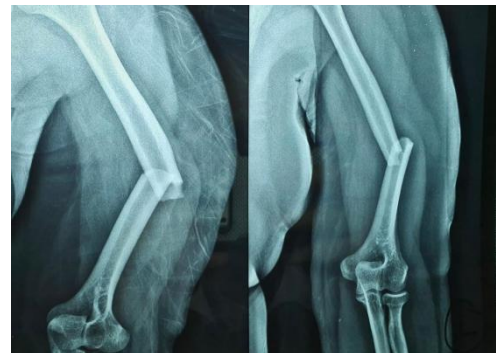
The patient received a temporary fixation of the arm, fixing the shoulder and the elbow region and also analgesic drug. Surgical approach is taken for the patient, as the patient went on an open reduction and internal fixation using plate and screws and also exploration for radial nerve palsy the following day. Intra-operative we found the radial nerve was intact. Post-operative management consist of intravenous antibiotic (Ceftriaxone), steroids (Methylprednisolone), and analgesic. Even though patient

went on operative management and early radial nerve exploration, the poor outcome still inevitable. Feeling stiff and numb along the medial side of the forearm, unable to extend his thumb, and also experiencing wrist drop on his right wrist.

Rehabilitation program is scheduled for the patient after the post-operative assessment and being handled right away by the rehabilitation team. After followed up 1 month, there is no evidence of nerve recovery. We plan an EMG examination 2-4 months after the procedure.

### Case Scenario 3

AS, a 20-year-old male who was involved in a motor vehicle collision one day prior to presentation at emergency department. He was initially treated at an outside hospital for a closed left humeral shaft fracture and a splint was placed with no reduction, unfortunately radial nerve function was not examined at the time of treatment (the patient had continued pain in the arm and was brought to our emergency department by his father for further evaluation). Upon evaluation in the emergency department, this was an isolated closed injury, and the patient experienced difficulty on extending his left thumb, finger, and wrist. Initial radiographs showed a displaced midshaft humeral fracture.



**Picture 3:** Radiograph Examination show complete transverse fracture middle third shaft of humerus

After discussion with the patient's family, a closed reduction under conscious sedation was performed, and a splint was placed. Post-reduction showed some mild distraction but with overall acceptable alignment. After the patient was fully awake, a thorough neurovascular examination was obtained which revealed that he had a dense motor and sensory radial nerve palsy with 0/5 strength in extensors of his thumb, fingers, and wrist. There was no pain with passive range of motion, and his compartments were soft and compressible. The team went on a discussion with the patient and patient's family about the outcome of the procedure.

After discussion, the team suggest for a surgical approach with internal fixation and radial nerve exploration, but the patient and the patient's family refuse to take a further surgical approach, they rather chose to go on a physiotherapy to regain back the motor function. After 2 weeks, there was no improvement in muscle motor, the patient and his family decided to take an operative exploration and internal fixation for the humerus. Intra-operative, the team found that the nerve was intact but a contusion around the nerve by fracture fragments.

Surprisingly, the outcome was astonishing, the nerve function showed signs to recover within 4 weeks after surgical exploration. The motor function of the thumb, fingers, and wrist were able to resist light resistance.

**Table 1:** PICO for the Literature Search

Population (P)	Intervention (I)	Comparison (C)	Outcome (O)
all ages diagnosed with closed humeral shaft fracture associated with Radial Nerve Palsy	treated by early surgical exploration	treated by conservative treatment	Recovery Rate and onset to recover

**Clinical Questions**

What is the appropriate management options for cases Radial Nerve Palsy associated with Humerus Shaft Fractures?

How long should we wait to take surgical exploration in Radial Nerve Palsy associated with close Humeral Shaft Fracture if we choose to conservative management?

How long should we wait for a nerve to show signs of recovery and make a decision to take further treatment for Radial Nerve Palsy?

**Methods**

To answer the clinical questions above, we were looking for a literature search conducted in Cochrane, Pubmed and Researches with the keywords “Radial Nerve Palsy”, “Humeral or Humerus Shaft fracture”, and “Outcome”. The inclusion criteria are relevant with PICO, using English as language reference, original study and cohort/ RCT/ meta-analysis / systematic review study. Exclusion criteria is the literature are not a full text.

**3. Results**

From Keywords, we found 2 articles were matched for this study. One systematic review, one retrospective cohort study was obtained:

**Table 2:** Critical Appraisal (PICO)

No	Author	Study Design	Population	Intervention	Comparison	Outcome	Study Limitation
1	Rebekah B (2019)	Retrospective Study	all ages group with Fracture Humeral Shaft associated with Radial Nerve Palsy	Radial Nerve Exploration in conjunction with open reduction and Internal Fixation	conservative treatment	Recovery Rate :100% patients presenting with Radial Nerve Palsy recovered	Retrospective study, subject to selection bias and cata collection limitation
						Onset to Recover: RNPc OP group was 16.5±25.1 weeks (Median 5.3 weeks) NONOP group was 25.2±10.4 weeks (median 26.4 weeks). RNPi OP group was 14.2±9.1 weeks (Med 13.4 weeks) RNPi NONOP group was 13.0 weeks ( Med 13.0 weeks only 1 patient)	lack of EMG data for each case of nerve palsy
2	Shao YC (2005)	Systematic Review 35 studies 1045 patients with radial nerve palsy	All Participant with Fracture humeral shaft associated with radial Nerve Palsy	Early exploration	Conservative initial spontaneous recovery	Recovery Rate: 1) 88.1% patients presenting with Radial Nerve Palsy recovered. 2) 70.7% patients recovered spontaneously in conservative treatment	There is no effective analysis of the role of electrophysiological examination from the data available
						Onset to Recover: 1) The mean Spontaneous Recovery onset time was 7.3 weeks (2w to 6.6mo). 2) The mean time to full recovery was 6.1 mo (3.4 mo to 12 mo)	From 35 studies there were no randomised, controlled trials, nor any non-randomised, comparative studies available. The bias is inevitable

**Table 3:** Critical Appraisal for Validity

Study	Rebekah B (2019) <sup>5</sup>	Shao YC (2005) <sup>6</sup>
Study address clearly focussed issue	Yes	Yes
Method (appropriate to answer their question)	No	Yes (systematic Reviews)
Recruitment	Using Retrospective Study, the data was acquired from fracture database between 2007 and 2016 Both groups have a similar characteristic	Using Medical Search Engines (PubMed, Datastar, and Cochrane Database) published within the last 40 years
Both Groups measured in the same way	Yes, followed-up visits included neurological examination (sensory and motor), assess Range of Motion of shoulder, elbow, wrist	
Follow up period	2-76 months (Mean 12 Months) Followed-up	
Consistency of the study	Consistent	Consistent
Results	Valid	Valid



**Table 4:** Critical Appraisal for Importance

Study	Rebekah B (2019) <sup>5</sup>	Shao YC (2005) <sup>6</sup>
Result of The study	Different Duration of Recovery in both groups with complete Radial Nerve Palsy: p=0.433  Different Duration of Recovery in both groups with partial Radial Nerve Palsy: p=0.913	Different Duration of Recovery in both groups with primary Radial Nerve Palsy: p=0.116
NNT		25
Results	Important	important

**Table 5:** Critical Appraisal for Applicability

Study	Rebekah B (2019) <sup>5</sup>	Shao YC (2005) <sup>6</sup>
Settings	Data collected from fracture database of a single fellowship-trained orthopaedic trauma surgeon for patients with diaphyseal humeral shaft fracture	Data collected from Medical Search Engines. The following terms and Boolean operators were used in each search: 'humeral' or 'humerus' or 'shaft' or 'diaphysis' or 'fracture' or 'radial nerve' or 'palsy' or 'paralysis' 35 studies, 1079 patients with radial nerve palsy were identified
Results	Applicable	Applicable

#### 4. Discussion

Radial Nerve Palsy (RNP) is one of the most common complications of humeral shaft fracture. According to Li *et al*, who has reviewed thirty retrospective studies showed that based on thirteen studies described a total of 1882 fractures of the shaft of the humerus and 307 radial nerve palsies, giving an overall prevalence of radial nerve palsy of 16.3%.<sup>7</sup> Other review such as Shao *et al*, of 25 studies, 21 described a total of 4517 fractures of the shaft humerus and 532 radial nerve palsies, giving an overall prevalence of 11.8% of RNP. Based on the location of the fracture, when the length of the humerus is divided into three giving the prevalence of RNP was 1.8% (one of 57) proximally, 15.2% (27 of 178) in the middle, and 23.6% (37 of 157) distally, giving the distal third of the humerus fracture as the most common site for RNP. But, if the length of the humerus is divided into five-part, the data were 3.4% (three of 89) proximally, 10.5% (6 of 57) middle-proximally, 21.9% (48 of 219) middle, 20% (32 of 160), middle-distally, and 10.5% (8 of 76) distally.<sup>6</sup>

Other than the location of the humeral fracture, the type of fracture also plays an important role for the incidence of RNP. As to type of fracture, transverse fracture 21.2% (47 of 222) and spiral fracture 19.8% (19 of 96) had a significantly higher occurrence for RNP than oblique fracture 8.4% (15 of 179) and comminuted fracture 6.8% (26 of 382). These findings support the theoretical occurrence of RNP is commonly occur in oblique fracture at the junction of the middle and distal third of the bone (Holstein - Lewis fracture).<sup>6</sup>

Conservative and operative management in radial nerve palsy associated with closed humeral shaft fracture have a high rate of recovery following primary radial nerve palsy. Previous study reported high recovery rate in groups, 89% of patients recovered spontaneously in conservative group and 84.7% of patients recovered in operative group. Rebekah B *et al*, also reported high recovery rate of nerves injury, from 27 patients treated by conservative and operative have 100% recovery rate. The onset of recovery in the operative group is  $16.5 \pm 25.1$  weeks (Median 5.3 weeks) and non operative group is  $25.2 \pm 10.4$  weeks (median 26.4 weeks). Although both groups show good results, the onset of recovery in operative group faster than non operative group. Conservative strategy can be considered as an initial

expectant management of radial nerve palsy and delayed exploration can be performed if no signs of recovery of the nerves. Some authors recommend conservative strategy is a good choice.<sup>5,6</sup>

The decision to operate after conservative treatment is still a debate and most likely is a preference of each surgeon with time to late exploration surgery ranging from 1 to 15 months with a mean of 4.1 months in closed humerus fractures according to Shao *et al*, an immediate exploration with associated open fracture<sup>11</sup> or within 2 weeks in open fractures or high-energy closed fracture.<sup>7</sup> Wait and see strategy is also widely accepted and early nerve exploration is only recommended in special situations like open fractures or high-energy trauma.<sup>12</sup> The proposed indications for immediate exploration of the radial nerve are open fractures requiring debridement and stabilisation, irreducible fractures or unacceptable reduction, associated vascular injuries, radial nerve palsy after manipulation, and intractable neurogenic pain suggesting nerve entrapment or compression.<sup>9</sup>

Understanding that there are no significant outcomes for both treatments, either treatment may be practiced. Any risks including secondary iatrogenic trauma due to medical intervention should be reevaluated whether the risk is proportionate to the patient's benefit, therefore discussions between the surgeon and the patient should be done before any treatment is conducted.

In our cases, we perform operative treatment in patient who suffered close humeral shaft fracture associated with radial nerve palsy. The goal of our treatment are to stabilize the bone with internal fixation, to explore and examine the integrity of radial nerves. We decide for operative rather than conservative management in our cases, because the type of injury is high energy closed humeral shaft fracture with sign of primary radial nerve palsy and patients characteristics which is productive young adults. After 1 month followed up, first and second cases have no signs of nerve recovery. While the third case show sign of nerves recovery within 1 month after the operation. Although the radial nerve is intact in all cases, but the results show differences.

The optimum time for nerve recovery is still debatable, although Korompilias et al suggesting in account the time of insufficient reinnervation within 12 - 18 months after injury may cause degeneration of motor endplate and irreversible muscle atrophy, it is suggested that closed fractures associated with radial nerve palsy may be managed expectantly for 16 - 18 weeks followed by surgical intervention.<sup>9</sup>

Advanced surgical intervention like transfers of tendon or nerves transfer in radial nerve palsy accompanied with humerus shaft fracture can be considered in patients with radial nerve palsy with likeness of nerve recovery of unlikely, no recovery following nerve repair surgery, and failure to achieve recovery after a period of non-surgical management. According to Richford et al, the surgical intervention is varied from 1 month to 19 years after surgery.<sup>10</sup> Korompilias et al suggested that surgical intervention including nerve transfer, tendon transfer, and stable fixation for the humerus shaft was indicated if functional recovery of the radial nerve was not present after 16 - 18 weeks of expectant management accounting into consideration the after surgery follow up was done 4 and 6 years after surgery where recovery in radial nerve was still absent.<sup>9</sup> The outcome for the tendon transfer can be measured with a 30- item self-report questionnaire to measure the disability of the Arm, Shoulder, and Hand or, DASH score. The scoring system is designed to assess the patient's health status during previous week. The items inquire about the difficulties of daily activities using functions of the shoulder, arm, and hand problems.

Nerve transfer that can be done by transfers from median to the radial nerve. This transfers is the most technically difficult but has the best result. There are two onsets to do exploration, early or late.

## 5. Conclusion

Radial nerve palsy associated with closed humeral shaft fracture can be treated either by conservative or operative method. There is no significant outcome in recovery and onset to recover between conservative and operative management. We considered to choose early exploration and internal fixation treatment in high energy humeral shaft fracture associated with primary nerve palsy.

The waiting time before early exploration varies greatly between authors and the research conducted during their time of writings. In our common practice, surgical intervention consists of fixation with plate and screws and radial nerve exploration is indicated whenever radial nerve palsy is accompanied with high energy humeral shaft fracture. The waiting time of 16 to 24 weeks is recommended before surgical treatment is planned for radial nerve palsy associated with closed humeral shaft fracture.

## References

- [1] Kim SH, Szabo RM, Marder RA. Epidemiology of Humerus Fracture in The United States: Nationwide Emergency Department Sample, 2008. American College of Rheumatology. 2012; 64(3): 407-414
- [2] Dieppe P, Blom A. Apley and Solomon's System of Orthopaedics and Trauma. 10<sup>th</sup> ed. Boca Raton, USA. 2018; CRC Press, p. 91; 2018.
- [3] Ricci FPF, Barbosa RI, Elui VMC, Barbieri CH, Mazzer N, Fonseca MCR. Radial Nerve Injury Associated with Humeral Shaft Fracture: A Retrospective Study. Acta Ortop Bras. 2015; 23(1):19-21. Available from URL: <http://www.scielo.br/aob>.
- [4] Salter RB. Textbook of Disorders and Injuries of Musculoskeletal System 3<sup>rd</sup> ed. Baltimore: Williams and Wilkins; 1999.
- [5] Belayneh R, Lott A, Haglin J, Konda S, Leucht P, Egol K. Final Outcome of Radial Nerve Palsy Associated with Humeral Shaft Fracture And Nonunion. J Othop Traumatology. 2019; 20:18
- [6] Shao YC, Harwood P, Grotz MR, Limb D, Giannoudis PV. Radial Nerve Palsy Associated with Fractures of The Shaft of The Humerus. J Bone Joint Surg Br. 2005; 87(12):1647-1652
- [7] Li YL, Ning GZ, Wu Q, Li Y, Feng SQ. Review of Literature of Radial Nerve Injuries Associated with Humeral Fractures: An Integrated Management Strategy. PLoS One. 2013; 8(11): e78576.
- [8] Mahabier KC, Vogels LMM, Punt BJ, Roukema GR, Patka P, Leshout EMM. Humeral shaft fractures: Retrospective results of non-operative and operative treatment of 186 patients. Injury, Int. J Care Injured. 2012; 44(2013): 427-430.
- [9] Korompilias AV, Lykissas MG, Kostas IP, Vekris MD, Soucacos PN, Beris AE. Approach to radial nerve palsy caused by humerus shaft fracture: Is primary exploration necessary? Injury, Int. J. Care Injured, 2013; 44(2013): 323-326.
- [10] Richford J, Abdullah S, Norhafizah M, Juliana I, Rashdeen F, Razana M. Outcome of Tendon Transfers for Radial Nerve Palsy in a Malaysian Tertiary Centre. Malaysian Orthopaedic Journal. 2018; 12(1).
- [11] Ring D, Chin K, Jupiter JB. Radial Nerve Palsy Associated With High-Energy Humeral Shaft Fractures. The Journal of Hand Surgery. 2004; 29(1): 144-147.
- [12] Schwab TR, Stillhard PF, Schibli S, Furrer M, Sommer C. Radial Nerve Palsy in Humeral Shaft Fractures with Internal Fixation: analysis of management and outcome. Eur J Trauma Emerg Surg. 2017; 44(2): 235-243.
- [13] Compton J, Owens J, Day M, Caldwell L. Systematic Review of Tendon Transfer Versus Nerve Transfer for the Restoration of Wrist Extension in Isolated Traumatic Radial Nerve Palsy. JAAOS Glob Res Rev. 2018; 2: e001.