

# World Journal of *Clinical Cases*

*World J Clin Cases* 2021 September 26; 9(27): 7963-8279



## Contents

Thrice Monthly Volume 9 Number 27 September 26, 2021

## EDITORIAL

7963 *Exophiala dermatitidis**Usuda D, Higashikawa T, Hotchi Y, Usami K, Shimozawa S, Tokunaga S, Osugi I, Katou R, Ito S, Yoshizawa T, Asako S, Mishima K, Kondo A, Mizuno K, Takami H, Komatsu T, Oba J, Nomura T, Sugita M*

## REVIEW

7973 Gastric neuroendocrine neoplasms: A review

*Köseoglu H, Duzenli T, Sezikli M*

## MINIREVIEWS

7986 Coronavirus disease 2019 and renal transplantation

*Nassar M, Nso N, Ariyaratnam J, Sandhu J, Mohamed M, Baraka B, Ibrahim A, Alfshawy M, Zheng D, Bhangoo H, Soliman KM, Li M, Rizzo V, Daoud A*

7998 Impact of COVID-19 on liver

*Su YJ, Chang CW, Chen MJ, Lai YC*

## ORIGINAL ARTICLE

## Case Control Study

8008 Association of gestational anemia with pregnancy conditions and outcomes: A nested case-control study

*Sun Y, Shen ZZ, Huang FL, Jiang Y, Wang YW, Zhang SH, Ma S, Liu JT, Zhan YL, Lin H, Chen YL, Shi YJ, Ma LK*

## Retrospective Cohort Study

8020 Clinical stages of recurrent hepatocellular carcinoma: A retrospective cohort study

*Yao SY, Liang B, Chen YY, Tang YT, Dong XF, Liu TQ*

## Retrospective Study

8027 Accuracy of ultrasonography in diagnosis of fetal central nervous system malformation

*Pang B, Pan JJ, Li Q, Zhang X*

8035 Analysis of ocular structural parameters and higher-order aberrations in Chinese children with myopia

*Li X, Hu Q, Wang QR, Feng ZQ, Yang F, Du CY*

8044 Radial nerve recovery following closed nailing of humeral shaft fractures without radial nerve exploration: A retrospective study

*Yeh KL, Liaw CK, Wu TY, Chen CP*

8051 Bridging therapy and direct mechanical thrombectomy in the treatment of cardiogenic cerebral infarction with anterior circulation macrovascular occlusion

*Ding HJ, Ma C, Ye FP, Zhang JF*

- 8061** Endu combined with concurrent chemotherapy and radiotherapy for stage IIB-IVA cervical squamous cell carcinoma patients

*Zhao FJ, Su Q, Zhang W, Yang WC, Zhao L, Gao LY*

### CASE REPORT

- 8071** Primary pancreatic paraganglioma harboring lymph node metastasis: A case report

*Jiang CN, Cheng X, Shan J, Yang M, Xiao YQ*

- 8082** Retraction of lumbar disc herniation achieved by noninvasive techniques: A case report

*Wang P, Chen C, Zhang QH, Sun GD, Wang CA, Li W*

- 8090** Mixed neuroendocrine carcinoma of the gastric stump: A case report

*Zhu H, Zhang MY, Sun WL, Chen G*

- 8097** Diploic vein as a newly treatable cause of pulsatile tinnitus: A case report

*Zhao PF, Zeng R, Qiu XY, Ding HY, Lv H, Li XS, Wang GP, Li D, Gong SS, Wang ZC*

- 8104** Acute myocardial infarction and extensive systemic thrombosis in thrombotic thrombocytopenic purpura: A case report and review of literature

*Şalaru DL, Adam CA, Marcu DTM, Şimon IV, Macovei L, Ambrosie L, Chirita E, Sascau RA, Statescu C*

- 8114** Limited thoracoplasty and free musculocutaneous flap transposition for postpneumonectomy empyema: A case report

*Huang QQ, He ZL, Wu YY, Liu ZJ*

- 8120** Paraneoplastic focal segmental glomerulosclerosis associated with gastrointestinal stromal tumor with cutaneous metastasis: A case report

*Zhou J, Yang Z, Yang CS, Lin H*

- 8127** Acute coronary syndrome with severe atherosclerotic and hyperthyroidism: A case report

*Zhu HM, Zhang Y, Tang Y, Yuan H, Li ZX, Long Y*

- 8135** Gastric cancer with calcifications: A case report

*Lin YH, Yao W, Fei Q, Wang Y*

- 8142** Value of eosinophil count in bronchoalveolar lavage fluid for diagnosis of allergic bronchopulmonary aspergillosis: A case report

*Wang WY, Wan SH, Zheng YL, Zhou LM, Zhang H, Jiang LB*

- 8147** Asymptomatic gastric adenomyoma and heterotopic pancreas in a patient with pancreatic cancer: A case report and review of the literature

*Li K, Xu Y, Liu NB, Shi BM*

- 8157** Successful treatment of gastrointestinal infection-induced septic shock using the oXiris® hemofilter: A case report

*Li Y, Ji XJ, Jing DY, Huang ZH, Duan ML*

- 8164** Streptococcal pneumonia-associated hemolytic uremic syndrome treated by T-antibody-negative plasma exchange in children: Two case reports  
*Wang XL, Du Y, Zhao CG, Wu YB, Yang N, Pei L, Wang LJ, Wang QS*
- 8171** Subclavian steal syndrome associated with Sjogren's syndrome: A case report  
*Hao LJ, Zhang J, Naveed M, Chen KY, Xiao PX*
- 8177** Metachronous mixed cellularity classical Hodgkin's lymphoma and T-cell leukemia/lymphoma: A case report  
*Dong Y, Deng LJ, Li MM*
- 8186** Duodenal perforation after organophosphorus poisoning: A case report  
*Lu YL, Hu J, Zhang LY, Cen XY, Yang DH, Yu AY*
- 8192** Surgical treatment of abnormal systemic artery to the left lower lobe: A case report  
*Zhang YY, Gu XY, Li JL, Liu Z, Lv GY*
- 8199** Madelung's disease with alcoholic liver disease and acute kidney injury: A case report  
*Wu L, Jiang T, Zhang Y, Tang AQ, Wu LH, Liu Y, Li MQ, Zhao LB*
- 8207** Anesthetic technique for awake artery malformation clipping with motor evoked potential and somatosensory evoked potential: A case report  
*Zhou HY, Chen HY, Li Y*
- 8214** Multiple hidden vessels in walled-off necrosis with high-risk bleeding: Report of two cases  
*Xu N, Zhai YQ, Li LS, Chai NL*
- 8220** Non-small-cell lung cancer with epidermal growth factor receptor L861Q-L833F compound mutation benefits from both afatinib and osimertinib: A case report  
*Zhang Y, Shen JQ, Shao L, Chen Y, Lei L, Wang JL*
- 8226** Successful removal of two magnets in the small intestine by laparoscopy and colonoscopy: A case report  
*Oh RG, Lee CG, Park YN, Lee YM*
- 8232** Acute lower extremity arterial thrombosis after intraocular foreign body removal under general anesthesia: A case report and review of literature  
*Jeon S, Hong JM, Lee HJ, Kim E, Lee H, Kim Y, Ri HS, Lee JJ*
- 8242** Low-intensity extracorporeal shock wave therapy for midshaft clavicular delayed union: A case report and review of literature  
*Yue L, Chen H, Feng TH, Wang R, Sun HL*
- 8249** Treatment of bilateral granulomatous lobular mastitis during lactation with traditional Chinese medicine: A case report  
*Li ZY, Sun XM, Li JW, Liu XF, Sun ZY, Chen HH, Dong YL, Sun XH*
- 8260** Early acute fat embolism syndrome caused by femoral fracture: A case report  
*Yang J, Cui ZN, Dong JN, Lin WB, Jin JT, Tang XJ, Guo XB, Cui SB, Sun M, Ji CC*

- 8268** Combined fascia iliaca compartment block and monitored anesthesia care for geriatric patients with hip fracture: Two case reports  
*Zhan L, Zhang YJ, Wang JX*
- 8274** Bell's palsy after inactivated COVID-19 vaccination in a patient with history of recurrent Bell's palsy: A case report  
*Yu BY, Cen LS, Chen T, Yang TH*

**ABOUT COVER**

Editorial Board Member of *World Journal of Clinical Cases*, Sunil Kumar Gupta, MBBS, MD, Reader (Associate Professor), Department of Dermatology, Venereology and Leprology, All India Institute of Medical Sciences, Gorakhpur, Gorakhpur 273008, Uttar Pradesh, India. dr.sunil\_30@yahoo.co.in

**AIMS AND SCOPE**

The primary aim of *World Journal of Clinical Cases* (WJCC, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

WJCC mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

**INDEXING/ABSTRACTING**

The WJCC is now indexed in Science Citation Index Expanded (also known as SciSearch®), Journal Citation Reports/Science Edition, Scopus, PubMed, and PubMed Central. The 2021 Edition of Journal Citation Reports® cites the 2020 impact factor (IF) for WJCC as 1.337; IF without journal self cites: 1.301; 5-year IF: 1.742; Journal Citation Indicator: 0.33; Ranking: 119 among 169 journals in medicine, general and internal; and Quartile category: Q3. The WJCC's CiteScore for 2020 is 0.8 and Scopus CiteScore rank 2020: General Medicine is 493/793.

**RESPONSIBLE EDITORS FOR THIS ISSUE**

Production Editor: Ji-Hong Lin; Production Department Director: Xiang Li; Editorial Office Director: Jin-Lai Wang.

**NAME OF JOURNAL**

*World Journal of Clinical Cases*

**ISSN**

ISSN 2307-8960 (online)

**LAUNCH DATE**

April 16, 2013

**FREQUENCY**

Thrice Monthly

**EDITORS-IN-CHIEF**

Dennis A Bloomfield, Sandro Vento, Bao-Gan Peng

**EDITORIAL BOARD MEMBERS**

<https://www.wjnet.com/2307-8960/editorialboard.htm>

**PUBLICATION DATE**

September 26, 2021

**COPYRIGHT**

© 2021 Baishideng Publishing Group Inc

**INSTRUCTIONS TO AUTHORS**

<https://www.wjnet.com/bpg/gerinfo/204>

**GUIDELINES FOR ETHICS DOCUMENTS**

<https://www.wjnet.com/bpg/GerInfo/287>

**GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH**

<https://www.wjnet.com/bpg/gerinfo/240>

**PUBLICATION ETHICS**

<https://www.wjnet.com/bpg/GerInfo/288>

**PUBLICATION MISCONDUCT**

<https://www.wjnet.com/bpg/gerinfo/208>

**ARTICLE PROCESSING CHARGE**

<https://www.wjnet.com/bpg/gerinfo/242>

**STEPS FOR SUBMITTING MANUSCRIPTS**

<https://www.wjnet.com/bpg/GerInfo/239>

**ONLINE SUBMISSION**

<https://www.f6publishing.com>



Retrospective Study

# Radial nerve recovery following closed nailing of humeral shaft fractures without radial nerve exploration: A retrospective study

Kuei-Lin Yeh, Chen-Kun Liaw, Tai-Yin Wu, Chung-Pei Chen

**ORCID number:** Kuei-Lin Yeh 0000-0002-0541-6860; Chen-Kun Liaw 0000-0002-3159-8450; Tai-Yin Wu 0000-0001-6227-4865; Chung-Pei Chen 0000-0002-9300-6772.

**Author contributions:** Yeh KL and Chen CP designed and performed the experiments, provided essential mouse strains, analyzed the data, supervised the research, and cowrote the manuscript; Liaw CK, Wu TY, and Yeh KL performed the experiments; Chen CP, Wu TY, and Liaw CK conducted the transporter experiments; Yeh KL, Chen CP, and Wu TY performed the metabolomic analyses; Liaw CK, Yeh KL, and Wu TY designed the experiments and cowrote the manuscript.

**Institutional review board**

**statement:** This study was approved by the institutional review board of Shin Kong Wu Ho-Su Memorial Hospital on August 4, 2020 (Approval Number: 20200706R).

**Informed consent statement:** The requirement for informed consent was waived owing to the retrospective study design.

**Conflict-of-interest statement:** The authors declare no conflicts of interest.

**Kuei-Lin Yeh**, Department of Orthopedics, Shin Kong Wu-Ho Su Memorial Hospital, Taipei City 111, Taiwan

**Chen-Kun Liaw**, Department of Orthopedics, School of Medicine, College of Medicine, Taipei Medical University, Taipei City 11031, Taiwan

**Chen-Kun Liaw**, Department of Orthopedics, Shuang Ho Hospital, Taipei Medical University, New Taipei City 23561, Taiwan

**Chen-Kun Liaw**, Graduate Institute of Biomedical Optomechatronics, College of Biomedical Engineering; Research Center of Biomedical Device, Taipei Medical University, Taipei City 11301, Taiwan

**Tai-Yin Wu**, Department of Family Medicine, Zhongxing Branch, Taipei City Hospital, Taipei City 10341, Taiwan

**Tai-Yin Wu**, Institute of Epidemiology and Preventive Medicine, National Taiwan University, Taipei City 10055, Taiwan

**Tai-Yin Wu**, National Taipei University of Nursing and Health Science, Taipei City 11219, Taiwan

**Chung-Pei Chen**, Department of Orthopedics, Cathay General Hospital, New Taipei City 221, Taiwan

**Corresponding author:** Chung-Pei Chen, MD, Doctor, Department of Orthopedics, Cathay General Hospital, No. 2 Lane. 59, Jiancheng Road, Xizhi District, New Taipei City 221, Taiwan. [nowforever@gmail.com](mailto:nowforever@gmail.com)

## Abstract

### BACKGROUND

Radial nerve palsy due to humeral shaft fracture is the most common peripheral nerve injury associated with long bone fractures. An antegrade nailing surgical technique is becoming popular for the fixation of these fractures with minimal invasiveness. We analyzed nerve recovery in patients with humeral shaft fracture and radial nerve palsy treated with humeral nail fixation without nerve exploration.

### AIM

**Data sharing statement:** The technical appendix, statistical code, and dataset are available from the corresponding author at [nowforever@gmail.com](mailto:nowforever@gmail.com). All participants provided informed consent for data sharing.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Manuscript source:** Unsolicited manuscript

**Specialty type:** Orthopedics

**Country/Territory of origin:** Taiwan

#### Peer-review report's scientific quality classification

Grade A (Excellent): 0  
Grade B (Very good): B, B, B  
Grade C (Good): 0  
Grade D (Fair): D  
Grade E (Poor): 0

**Received:** April 15, 2021

**Peer-review started:** April 15, 2021

**First decision:** April 27, 2021

**Revised:** May 8, 2021

**Accepted:** August 20, 2021

**Article in press:** August 20, 2021

**Published online:** September 26, 2021

**P-Reviewer:** Cao X, Chisthi MM, Samara AA

**S-Editor:** Liu M

**L-Editor:** A

**P-Editor:** Wang LYT



To assess the radial nerve recovery rate and time from humeral shaft fracture with surgical treatment using close nailing.

## METHODS

We retrospectively collected data of patients who underwent surgical nail fixation for humeral shaft fractures between October 1, 2016, and March 31, 2020. Subsequently, we analyzed the primary or secondary radial nerve palsy recovery rate and radial nerve motor function recovery time.

## RESULTS

The study included 70 patients who underwent surgical treatment for closed- or Gustilo type I open humeral shaft fractures using a nail fixation technique without radial nerve exploration. The patients suffered from primary ( $n = 5$ ) and secondary ( $n = 5$ ) radial nerve palsy. A 100% radial nerve recovery rate was achieved. The mean recovery time was 4.3 mo.

## CONCLUSION

The study results indicate full recovery of radial nerve palsies from humeral shaft fracture using close nailing treatment. Surgeons need not be concerned about the occurrence of permanent nerve palsies.

**Key Words:** Humeral shaft fracture; Radial nerve palsy; Close nailing fixation; Nerve exploration

©The Author(s) 2021. Published by Baishideng Publishing Group Inc. All rights reserved.

**Core Tip:** The study results indicate full recovery of radial nerve palsies from humeral shaft fracture using close nailing treatment. Surgeons need not be concerned about the occurrence of permanent nerve palsies.

**Citation:** Yeh KL, Liaw CK, Wu TY, Chen CP. Radial nerve recovery following closed nailing of humeral shaft fractures without radial nerve exploration: A retrospective study. *World J Clin Cases* 2021; 9(27): 8044-8050

**URL:** <https://www.wjgnet.com/2307-8960/full/v9/i27/8044.htm>

**DOI:** <https://dx.doi.org/10.12998/wjcc.v9.i27.8044>

## INTRODUCTION

Humeral shaft fractures account for about 3% of all adult fractures, and management includes conservative and surgical treatments. Conservative treatment involves wearing functional braces and is generally applied in a large proportion of patients, achieving a high union rate (94.5%) and a short union time (mean: 10.7 wk)[1,2]. However, the rapid development of locking nail and plate designs over the past few decades has resulted in an increasing number of surgical interventions for treating humeral shaft fractures. In the surgical treatment of humeral fractures using rigid fixation, early range of motion (ROM) training is recommended for patients to prevent prolonged immobilization associated with joint stiffness[3].

Humeral shaft fractures are often complicated by radial nerve palsy, which has a reported incidence of 11.8% to 25.4%, representing the most common peripheral nerve injury associated with bone fractures[1,4]. Humeral shaft fractures are mainly treated by plating or nail fixation techniques.

There is no clear consensus on whether and when the nerve should be intraoperatively explored during plating for fixation of humeral mid-shaft fractures[5]. In a previous retrospective study involving 151 humeral shaft fractures, secondary radial nerve palsy was reported in patients postoperatively ( $n = 9$ , 6%). In five of the nine patients investigated, the radial nerve was not exposed during the initial surgery, consequently requiring revision surgery[5]. Some surgeons propose that the radial nerve may be compressed by the plate during surgical fixation using a plate[6], whereby intraoperative nerve exploration can decrease the possibility of secondary

radial nerve palsy.

Minimal invasiveness is a major advantage of nail fixation[7]. Closed nailing without nerve exploration causes less iatrogenic damage to the periosteum and thereby enables faster callus formation than using open nailing[8]. However, there have been no reports to date on the recovery rate and recovery time for primary or secondary radial nerve palsies. This study is a retrospective analysis of the prevalence and recovery outcomes of radial nerve palsies associated with humeral shaft fractures treated using humeral closed nailing without radial nerve exploration.

## MATERIALS AND METHODS

### *Patients*

A retrospective study was conducted using data collected from the orthopedic department of our institution involving patients whose trauma episodes occurred between October 2016 and March 2020. Patients with sustained humeral shaft fractures that were treated with humeral nails were included in the study. This study was approved by the institutional review board of Shin Kong Wu Ho-Su Memorial Hospital on August 4, 2020 (Approval number: 20200706R). The study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The requirement for informed consent was waived owing to the retrospective study design.

### *Indication for humeral nail fixation*

The fractures were classified according to the AO-Müller/Orthopedic Trauma Association (AO/OTA) classification. Fractures at the mid-shaft categorized within the AO/OTA classification as spiral (12 A1, B1), oblique (12 A2, B2), transverse (12 A3), or comminuted (12 C3) were included in the study. Only these four fracture patterns, in line with closed- or Gustilo type I open fractures, were considered for closed humeral nailing.

### *Nail fixation technique*

All surgeries were performed by experienced surgeons, that is, either attending physicians or senior resident physicians under the supervision of attending physicians. A skin incision was made, the exact nail entry point was located, and an awl was passed. Subsequently, a guidewire was placed under biplanar c-arm guidance, and closed reduction was performed. Reaming or unreaming was performed based on the patients' humeral canal size and bone quality, followed by the insertion of MultiLoc humeral implants (Figure 1). The patients were treated at our hospital using the closed nailing technique.

### *Radial nerve palsy evaluation*

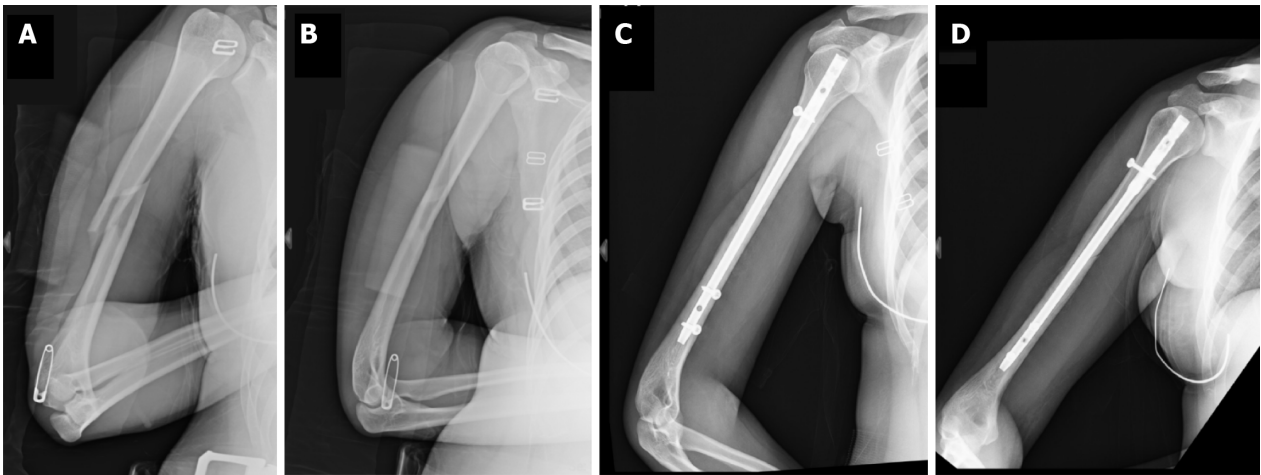
We routinely examined wrist and thumb function preoperatively and postoperatively for all humeral shaft fractures. The Medical Research Council (MRC) scale of muscle strength (Grade 0: No movement; Grade 5: Normal muscle contraction against full resistance) was used to evaluate the strength of the muscles (wrist and digit extensors and extensor pollicis longus and brevis)[9]. If the MRC grade was below Grade 2, we considered the patient to have primary or secondary (postoperative onset) radial nerve palsy.

Patients with radial nerve palsies were required to visit our outpatient clinic every 2 wk postoperatively until recovery. The data of one patient who did not visit our outpatient department postoperatively were excluded from our analysis. Initial radial nerve assessment was performed using electromyography (EMG) and documented. Subsequently, EMG was performed once every 3 mo, as permitted by our public health insurance. Thus, radial nerve recovery was evaluated using two methods of assessment: active ROM of the wrist and an EMG test.

Patients were considered to have recovered from nerve palsy when the radial nerve motor function returned to normal (*i.e.*, the patient regained a muscle strength of grade 4 or 5 for wrist and thumb extension, indicating that the patient could move the joint and had full ROM under moderate resistance).

### *Implant usage*

The MultiLoc nailing system (Synthes, Umkirch, Germany) was used for nail fixation. No other products for humeral nail implants were available at our hospital.



**Figure 1 Preoperative and postoperative radiographs.** A and B: Show humeral shaft fractures with an AO-Müller/Orthopedic Trauma Association classification of 12 A3. Primary radial nerve palsy was diagnosed; C and D: Show fracture treatment with a close nailing surgical technique. Recovery from radial nerve palsy was complete 4 mo after the accident occurred.

## RESULTS

Seventy-two patients with closed- or Gustilo type I open humeral shaft fracture, with a spiral (12 A1, B1), oblique (12 A2, B2), transverse (12 A3), or comminuted (12 C3) AO classification, underwent closed humeral nail fixation between October 2016 and March 2020. We excluded the data of two patients who died within a month following surgery. Participants included 35 males and 35 females aged 18 to 82 years. Of the 70 patients, three had pathological fractures.

Of the 70 patients, five (7.1%) reported primary radial nerve palsy. Secondary radial nerve palsy was also observed in five patients (7.1%). Both patients with primary and secondary nerve palsy achieved 100% radial nerve recovery (Table 1).

The mean time to 80% functional recovery was  $4.4 \pm 0.4$  mo and  $4.2 \pm 1.3$  mo in patients with primary and secondary radial nerve palsy, respectively. The overall average recovery time was 4.3 mo.

## DISCUSSION

The nailing surgical technique for humeral shaft fracture is a minimally invasive procedure. In our experience, stab wounds often result in humeral fractures in patients. The surgical wounds are typically 1 cm to 1.5 cm in size. We have observed that reduced damage to the periosteum, soft tissue, and blood supply at the fracture site resulting from closed nailing decreases the time for bone healing compared to open nailing. Closed humeral nailing produces better cosmetic outcomes and causes less damage to the blood supply of the periosteum than open nailing. However, no studies have been published thus far on the primary or secondary radial nerve recovery rate following the use of the closed nailing technique.

Neuropraxia is the most common radial nerve palsy following humeral shaft fracture and is caused by transient nerve conduction interruption due to traction or compression of the radial nerve. Recovery from neuropraxia is expected to be spontaneous[10]. Axonotmesis, however, is more severe because direct pressure on the axons results in mechanical extrusion of myelin, Wallerian degeneration, and late recovery[11]. Neurotmesis refers to the complete destruction of the axons and Schwann cells, from which there is no chance of recovery without surgical intervention [12]. Fortunately, neurotmesis seldom occurs in humeral mid-shaft fractures complicated with radial nerve palsy.

A previous study revealed that a mean time to full recovery for primary radial nerve palsy of 6.1 mo, which is longer than that observed in our study ( $4.4 \pm 0.4$  mo and  $4.2 \pm 1.3$  mo in primary and secondary nerve palsy, respectively) and a mean spontaneous nerve recovery rate of 70.7% [13], which is much lower than that observed in our study (100%). In the aforementioned study[13], patients with humeral shaft fractures were conservatively treated. In these patients, callus formation may have impeded recovery from radial nerve palsies[1]. We could not control the area of callus

**Table 1 Characteristics of patients with humeral shaft fractures complicated with radial nerve palsy**

Patient number	Sex	Age (yr)	Primary nerve palsy	Secondary nerve palsy	Recovery time (mo)	Mechanism of injury
1	Female	21	-	+	3	Fall from a 1.5-m height
2	Male	20	+	+	4	Fall from a 2-m height
3	Male	18	+	+	4.5	Motor vehicle accident
4	Male	65	+	+	4.5	Fall from a 1-m height
5	Female	47	+	+	5	Slippage and fall
6	Male	53	-	+	5	Motor vehicle accident
7	Male	40	-	+	4	Motor vehicle accident
8	Female	62	-	+	6	Motor vehicle accident
9	Male	22	-	+	3	Motor vehicle accident
10	Female	24	+	+	4	Motor vehicle accident

The average functional recovery time was 4.3 mo. No patient suffered from persistent radial nerve palsy.

formation, and this factor contributed to an extended spontaneous radial nerve recovery time and a lower spontaneous radial nerve recovery rate.

No studies have been performed to determine the mean radial nerve recovery time for primary and secondary radial nerve palsies in patients with humeral fractures. However, Shao *et al*[13] concluded that the rate of spontaneous nerve recovery after secondary radial neuropathy was similar to that after primary radial neuropathy. These findings are in accordance with those reported by Wang *et al*[14]. Our comparative analysis revealed similar recovery times for primary and secondary radial nerve palsies.

In our study, secondary radial nerve palsy was observed in five patients (7.1%) following humeral shaft fractures. To the best of our knowledge, there have been no previous reports of the incidence of secondary radial nerve palsy in patients with humeral shaft fractures.

Note that neurotmesis affects spontaneous nerve recovery[2]. This condition is caused by direct trauma or iatrogenic damage. Once we eliminated the incidence of neurotmesis, the spontaneous radial nerve recovery rate increased. Radial nerve vulnerability is associated with the lateral intermuscular septum at the lower lateral aspect of the humerus and fractures at the posterior mid-shaft of the humerus where the nerve lies in contact with the bone[11,15-17]. If the trauma involves external rotation and the fracture site is at the proximal-distal or distal end of the humeral shaft based on dividing the shaft into fifths, primary radial nerve injury caused by direct radial nerve entrapment may occur[18]. In these situations, using the closed antegrade nailing technique to treat patients may increase the risk of failure of radial nerve spontaneous recovery.

Given the high incidence of secondary radial nerve palsy in patients undergoing nailing fixation, we emphasize surgical strategies to prevent iatrogenic radial nerve transection due to the potential impact on spontaneous nerve recovery. Distal locking screws for the MultiLoc nailing system are inserted using a free-hand fluoroscopic method. Overpenetration of the medial cortex with distal locking screws using anterior-posterior and lateral-medial locking techniques has been reported to be associated with an increased risk of neurovascular complications, including radial and lateral cutaneous nerve injuries[19,20]. White *et al*[21] suggested that posterior-to-anterior drilling for distal locking screws can prevent neurovascular injury. Moreover, adequate soft tissue dissection before drilling and the use of drilling protectors can reduce the occurrence of neurovascular complications. However, iatrogenic nerve damage is sometimes unpredictable.

The incidence of humeral shaft fractures is 3%, and some surgeons in our hospitals treat humeral shaft fractures using the plating technique. These factors contributed to the small sample size. Despite the small cohort studied, we concluded that surgeons need not be concerned about permanent radial nerve damage in cases of primary or secondary radial nerve palsies when managing patients with humeral shaft fractures. We will collect further data on patients treated with closed nail fixation for humeral shaft fractures. The results of the present observational study can provide guidance to

surgeons regarding the radial nerve recovery rate and the time to recovery and to patients in terms of expectations for recovery.

## CONCLUSION

Primary or secondary radial nerve palsy is a common peripheral nerve injury complication in patients with closed- or Gustilo type I open humeral shaft fractures. In this single-hospital case series, primary and secondary radial nerve palsy occurred at equal incidences of 7.1% of humeral shaft fractures treated using closed nail fixation. Despite the high incidence of radial nerve palsies, a 100% radial nerve recovery rate was achieved following closed nail fixation of humeral shaft fractures. The mean recovery time and the recovery rate are crucial for guiding protocols regarding the expected waiting periods to be followed by surgeons in clinical settings.

## ARTICLE HIGHLIGHTS

### Research background

Humeral shaft fractures are commonly associated with radial nerve palsies. The emergence of innovative implants has made the minimally invasive nailing procedure increasingly popular. In this study, we surveyed the recovery time and recovery rate of patients with primary or secondary radial nerve palsies.

### Research motivation

No studies have been published on radial nerve recovery after nailing fixation treatment for humeral shaft fractures.

### Research objectives

The aim of this study was to evaluate the radial nerve recovery time and rate in primary or secondary radial nerve palsy patients treated for humeral shaft fracture with a nailing fixation technique.

### Research methods

In this observational study, we enrolled patients with sustained close or Gustilo open type I humeral shaft fractures who received close nailing fixation treatment between October 2016 and March 2020. We examined the wrist and thumb function preoperatively and postoperatively for all humeral shaft fractures.

### Research results

The study results demonstrated that all patients who suffered from radial nerve palsies recovered functionally (100%). The mean recovery time was 4.3 mo.

### Research conclusions

This observational study revealed that all patients with radial nerve palsies who underwent close nailing treatment for humeral shaft fracture achieved full recovery.

### Research perspectives

Although this observational study was conducted on a small sample, the high radial nerve recovery rate demonstrated that surgeons need not be concerned about permanent nerve injuries.

## REFERENCES

- 1 Sarmiento A, Kinman PB, Galvin EG, Schmitt RH, Phillips JG. Functional bracing of fractures of the shaft of the humerus. *J Bone Joint Surg Am* 1977; **59**: 596-601 [PMID: 873955]
- 2 Papasoulis E, Drosos GI, Ververidis AN, Verettas DA. Functional bracing of humeral shaft fractures. A review of clinical studies. *Injury* 2010; **41**: e21-e27 [PMID: 19523625 DOI: 10.1016/j.injury.2009.05.004]
- 3 Rämö L, Taimela S, Lepola V, Malmivaara A, Lähdeoja T, Paavola M. Open reduction and internal fixation of humeral shaft fractures vs conservative treatment with a functional brace: a study protocol of a randomised controlled trial embedded in a cohort. *BMJ Open* 2017; **7**: e014076 [PMID: 28511111]

- 28694341 DOI: [10.1136/bmjopen-2016-014076](https://doi.org/10.1136/bmjopen-2016-014076)]
- 4 **Holstein A**, Lewis GM. Fractures of the humerus with radial-nerve paralysis. *J Bone Joint Surg Am* 1963; **45**: 1382-1388 [PMID: [14069777](https://pubmed.ncbi.nlm.nih.gov/14069777/)]
- 5 **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* 2018; **44**: 235-243 [PMID: [28280873](https://pubmed.ncbi.nlm.nih.gov/28280873/) DOI: [10.1007/s00068-017-0775-9](https://doi.org/10.1007/s00068-017-0775-9)]
- 6 **Reichert P**, Wnukiewicz W, Witkowski J, Bocheńska A, Mizia S, Gosk J, Zimmer K. Causes of Secondary Radial Nerve Palsy and Results of Treatment. *Med Sci Monit* 2016; **22**: 554-562 [PMID: [26895570](https://pubmed.ncbi.nlm.nih.gov/26895570/) DOI: [10.12659/msm.897170](https://doi.org/10.12659/msm.897170)]
- 7 **Garnavos C**. Diaphyseal humeral fractures and intramedullary nailing: Can we improve outcomes? *Indian J Orthop* 2011; **45**: 208-215 [PMID: [21559099](https://pubmed.ncbi.nlm.nih.gov/21559099/) DOI: [10.4103/0019-5413.67117](https://doi.org/10.4103/0019-5413.67117)]
- 8 **Tahririan MA**, Andalib A. Is there a place for open intramedullary nailing in femoral shaft fractures? *Adv Biomed Res* 2014; **3**: 157 [PMID: [25221760](https://pubmed.ncbi.nlm.nih.gov/25221760/) DOI: [10.4103/2277-9175.137870](https://doi.org/10.4103/2277-9175.137870)]
- 9 **Paternostro-Sluga T**, Grim-Stieger M, Posch M, Schuhfried O, Vacariu G, Mittermaier C, Bittner C, Fialka-Moser V. Reliability and validity of the Medical Research Council (MRC) scale and a modified scale for testing muscle strength in patients with radial palsy. *J Rehabil Med* 2008; **40**: 665-671 [PMID: [19020701](https://pubmed.ncbi.nlm.nih.gov/19020701/) DOI: [10.2340/16501977-0235](https://doi.org/10.2340/16501977-0235)]
- 10 **Nakamichi K**, Tachibana S. Radial nerve entrapment by the lateral head of the triceps. *J Hand Surg Am* 1991; **16**: 748-750 [PMID: [1880378](https://pubmed.ncbi.nlm.nih.gov/1880378/) DOI: [10.1016/0363-5023\(91\)90206-q](https://doi.org/10.1016/0363-5023(91)90206-q)]
- 11 **Lin J**. Locked nailing of spiral humeral fractures with or without radial nerve entrapment. *Clin Orthop Relat Res* 2002; **(403)**: 213-220 [PMID: [12360029](https://pubmed.ncbi.nlm.nih.gov/12360029/) DOI: [10.1097/00003086-200210000-00031](https://doi.org/10.1097/00003086-200210000-00031)]
- 12 **Latef TJ**, Bilal M, Vetter M, Iwanaga J, Oskouian RJ, Tubbs RS. Injury of the Radial Nerve in the Arm: A Review. *Cureus* 2018; **10**: e2199 [PMID: [29666777](https://pubmed.ncbi.nlm.nih.gov/29666777/) DOI: [10.7759/cureus.2199](https://doi.org/10.7759/cureus.2199)]
- 13 **Shao YC**, Harwood P, Grotz MR, Limb D, Giannoudis PV. Radial nerve palsy associated with fractures of the shaft of the humerus: a systematic review. *J Bone Joint Surg Br* 2005; **87**: 1647-1652 [PMID: [16326879](https://pubmed.ncbi.nlm.nih.gov/16326879/) DOI: [10.1302/0301-620X.87B12.16132](https://doi.org/10.1302/0301-620X.87B12.16132)]
- 14 **Wang JP**, Shen WJ, Chen WM, Huang CK, Shen YS, Chen TH. Iatrogenic radial nerve palsy after operative management of humeral shaft fractures. *J Trauma* 2009; **66**: 800-803 [PMID: [19276756](https://pubmed.ncbi.nlm.nih.gov/19276756/) DOI: [10.1097/TA.0b013e31816142cf](https://doi.org/10.1097/TA.0b013e31816142cf)]
- 15 **Seigerman DA**, Choung EW, Yoon RS, Lu M, Frank MA, Gaines LC, Liporace FA. Identification of the radial nerve during the posterior approach to the humerus: a cadaveric study. *J Orthop Trauma* 2012; **26**: 226-228 [PMID: [21918485](https://pubmed.ncbi.nlm.nih.gov/21918485/) DOI: [10.1097/BOT.0b013e31821d0200](https://doi.org/10.1097/BOT.0b013e31821d0200)]
- 16 **Rocchi M**, Tarallo L, Mugnai R, Adani R. Humerus shaft fracture complicated by radial nerve palsy: Is surgical exploration necessary? *Musculoskelet Surg* 2016; **100**: 53-60 [PMID: [27900704](https://pubmed.ncbi.nlm.nih.gov/27900704/) DOI: [10.1007/s12306-016-0414-3](https://doi.org/10.1007/s12306-016-0414-3)]
- 17 **Moattari M**, Kouchesfehiani HM, Kaka G, Sadraie SH, Naghdi M. Evaluation of nerve growth factor (NGF) treated mesenchymal stem cells for recovery in neurotmesis model of peripheral nerve injury. *J Craniomaxillofac Surg* 2018; **46**: 898-904 [PMID: [29716818](https://pubmed.ncbi.nlm.nih.gov/29716818/) DOI: [10.1016/j.jcms.2018.03.015](https://doi.org/10.1016/j.jcms.2018.03.015)]
- 18 **Eckholm R**, Ponzer S, Törnkvist H, Adami J, Tidermark J. The Holstein-Lewis humeral shaft fracture: aspects of radial nerve injury, primary treatment, and outcome. *J Orthop Trauma* 2008; **22**: 693-697 [PMID: [18978544](https://pubmed.ncbi.nlm.nih.gov/18978544/) DOI: [10.1097/BOT.0b013e31818915bf](https://doi.org/10.1097/BOT.0b013e31818915bf)]
- 19 **Rupp RE**, Chrissos MG, Ebraheim NA. The risk of neurovascular injury with distal locking screws of humeral intramedullary nails. *Orthopedics* 1996; **19**: 593-595 [PMID: [8823817](https://pubmed.ncbi.nlm.nih.gov/8823817/)]
- 20 **Vural M**, Arslantaş A. Delayed radial nerve palsy due to entrapment of the nerve in the callus of a distal third humerus fracture. *Turk Neurosurg* 2008; **18**: 194-196 [PMID: [18597237](https://pubmed.ncbi.nlm.nih.gov/18597237/)]
- 21 **White WJ**, Hawken RM, Giles NC. Posterior to anterior distal locking of humeral intramedullary nails. *Ann R Coll Surg Engl* 2012; **94**: 603 [PMID: [23131238](https://pubmed.ncbi.nlm.nih.gov/23131238/) DOI: [10.1308/003588412x13373405387096d](https://doi.org/10.1308/003588412x13373405387096d)]



Published by **Baishideng Publishing Group Inc**  
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

**Telephone:** +1-925-3991568

**E-mail:** [bpgoffice@wjgnet.com](mailto:bpgoffice@wjgnet.com)

**Help Desk:** <https://www.f6publishing.com/helpdesk>

<https://www.wjgnet.com>

