A Comparative Study Between Plate Osteosynthesis and Elastic Nailing for Diaphyseal Fracture of Radius and Ulna in Adults

Karwan Sabah Muhammad[1], Ali Abdalnabi Alwan Al-Tamimi[2]

[1]MBChB. KHCMS/Orthopedic Surgery. Shar Teaching Hospital, Ministry of Health Sulaimaniya, Kurdistan/Iraq. E-mail: karwansabah1988@gmail.com.
[2]MBChB, FICMS (Orthopaedic Surgery), Assistant professor, Orthopedic Surgery Department, College of Medicine, University of Sulaimaniya. Kurdistan/Iraq. E-mail: ali.alwan@univsul.edu.iq
Corresponding Author: Karwan Sabah Muhammad1

KEYWORDS
Forearm bone fracture, Forearm nailing.

ABSTRACT
Background and Objectives: Diaphyseal fractures of the radius and ulna are common in adults and can be managed with various treatment methods. This study aimed to evaluate and compare the functional, radiological, and clinical outcomes of two treatment methods: plating and intramedullary nailing for diaphyseal fractures of both forearm bones in adults. Methods: This prospective cohort study was conducted in Sulaimani City, Kurdistan, involving 40 adult patients (mean age 34.25 years) who sustained primary diaphyseal fractures of the radius and ulna between January 1, 2022, and June 1, 2024. Patients were divided into two groups: Group A, with 20 patients, underwent closed reduction and internal fixation using flexible intramedullary nailing, while Group B, also with 20 patients, underwent open reduction and internal fixation using 3.5 mm dynamic compression plate. Outcomes were assessed using the Modified Grace Eversmann score, with pronation and supination of the forearm compared to the contralateral side. Results: The mean operation time was 81.4 minutes for the plating group, compared to 62.5 minutes for the nailing group. The mean union time was 13.15 and 10.85 weeks for the plating and nailing groups, respectively. In terms of functional outcomes, 27 patients achieved Excellent scores, 9 Good, 3 acceptable, and 1 unacceptable. Complications occurred in 5 patients in the nailing group and 2 in the plating group. Overall, the union and operation times showed a statistically significant difference, with a higher complication rate in the nailing group. Conclusion: Adults with diaphyseal radius and ulna fractures are usually treated with plating. An alternate fixation method for fracture with distinct risk and benefit profile is intramedullary nailing.

1. Introduction

Diaphyseal forearm fractures in both bones are a common clinical condition treated by orthopedists.[1] In pediatric age, non-operative management for diaphyseal fracture of both bones in forearm is common and typically has a good result.[2] However, in adults, conservative management of forearm bone fractures are rarely recommended due to limited evidence comparing non-operative to operative treatment.[3]

The restriction in rotational movement not only impedes upper limb functionality but also interferes with daily activities.[4] It has been shown that the most conventional and widely applied methods in management of adult radius and ulna diaphyseal fractures are open reduction and plate fixation.[5] However, the treatment of diaphyseal fractures of nearly all long bones Has been demonstrated to be possible with the application of intramedullary nailing.[6] Plate fixation offers sufficient reduction, excellent fixation, union rate, and functional outcome.[7] However, there have been reports in the literature of substantial injury to soft tissue, damage to periosteum, nerve and vascular injury, nonunion, refracture, and infection after removing of the plate.[8] An alternate method to prevent these complications is intramedullary nailing, which offers benefits including less invasion, less periosteal stripping, quicker healing, a lower refracture rate, and smaller skin incisions.[9] On the other hand, longer immobilization times, neurovascular injury, and a high rate of nonunion are also linked to intramedullary nailing.[10]

To restore forearm function, it is crucial to properly align anatomical features such as the lengths of both bones, bowing of the radius, and the rotational alignment.[11] Because intramedullary nails are unable to offer enough rotational alignment stability in forearm, they are not frequently used in treatment of ulna and radius fractures.[12] The radius has bowing in anteroposterior radiographic, and functional results following fracture surgery have been associated with the position and degree of the bow's reconstruction.[13] Although some studies suggest that forearm function is related more to early motion than to bowing, and that changes in radial bowing may not significantly impair pronation and supination of forearm, these anatomical factors remain important

considerations.[14,15] The comparison between open reduction internal fixation with intramedullary nailing has been equivocal.[15] In this study, we compared the radiographical, clinical, and functional results of two different fixation methods.

2. Patients and Methods

This prospective cohort study was approved by the Institutional Ethics Committee of the Kurdistan Board for Medical Specialists (approval number 1973), granted on November 28, 2023. The study was conducted at Shar Teaching Hospital from January 1, 2022, to June 1, 2024, and included 40 patients, comprising 29 males and 11 females. Patients were divided into two treatment groups: Group A, with 20 patients treated by closed reduction and internal fixation using flexible intramedullary nails, and Group B, also with 20 patients, treated by open reduction and internal fixation using plates and screws. Fractures were classified based on the 2018 Orthopedic Trauma Association (OTA) classification system.

Eligible patients presented with primary diaphyseal fractures of both radius and ulna and met the following inclusion criteria: ages 18 to 65 years, closed fractures, Gustilo-Anderson type I fractures, and normal pre-trauma forearms function. Exclusion criteria included neurovascular deficits, Gustilo-Anderson type II or III fractures, long oblique, spiral, and complex fractures, ipsilateral humeral fractures (flail elbow), preoperative compartment syndrome, and pathological fractures. These criteria ensured the inclusion of only fractures suitable for both plating and nailing methods, allowing for a more accurate comparison of outcomes.

Upon admission, each patient's history was obtained, and a comprehensive physical examination was performed, including both local and systemic assessments. Intravenous access was established, and patients received analgesia, IV fluids, and antibiotics as needed, with antibiotic prophylaxis specifically for open fractures. A long posterior cast or splint, extending from the mid-arm to the metacarpophalangeal joints, was applied. Plain X-rays, including anteroposterior and lateral views, were taken to forearm, the elbow and wrist joints. Routine preoperative investigations were conducted, including complete blood counts and viral screening. Informed consent was obtained from each patient, one gram of ceftriaxone was administered one hour before surgery and fracture side was labeled.

Surgical Technique

All surgeries were performed under general anesthesia.

Group A (Intramedullary Nailing): Surgical technique for intramedullary nailing used.[16] For ulna nailing, a suitably sized nail was inserted through the olecranon under fluoroscopic guidance and positioned across the fracture. Fracture reduction was achieved through traction and manipulation, confirmed fluoroscopically. For radius nailing, a pre-bent nail was inserted to approximate the radial bow, using the radial styloid as the entry point. Post-operatively, a back slab was applied from mid-arm to metacarpophalangeal joints for two weeks, with the forearm supported in a sling.

Group B (Plate Fixation): Radius plating was performed using the Volar Henry approach, and the subcutaneous approach was used for ulnar plating.[17] The fixation implants included 3.5 mm dynamic compression plates with cortical screws. Fracture reduction was completed by exposing and aligning the fractures, with the fracture site exhibiting less comminution fixed first.

Postoperative Care and Follow-Up

Following surgery, patients in both groups were hospitalized for two to three days, receiving postoperative analgesics, antibiotics, and IV fluids. General and local examinations, including neurovascular assessment and monitoring for compartment syndrome, were performed. Postoperative radiographs were taken to confirm implant positioning and fracture alignment. Patients were instructed to elevate the operated limb and mobilize their fingers. Physiotherapy commenced early, with a focus on passive and active exercise regimens.

Patients were followed up over a 12-month period at specified intervals: two weeks, eight weeks, three months, six months, and twelve months. Complications were managed as follows: superficial incisional surgical site infections and olecranon bursitis were treated with antibiotics, anti-inflammatory drugs, and daily wound dressings. Impinged nail was shortened. Data on functional, radiological, and clinical outcomes were prospectively collected by the research investigator throughout the follow-up period. Functional outcomes were measured using the Modified Grace and Eversmann score.[6] Time to union and complications associated with

each method were also evaluated. Union was confirmed, clinically by free of pain and tenderness at the fracture site and obliteration of the fracture line in X-ray.

3. Result

Statistical methods were utilized, with all computations performed using SPSS version 24. After coding and tabulating the data, it was presented descriptively. To analyze the study's results, two main statistical procedures were applied: 1. descriptive statistics, including percentage, frequency, mean, and standard deviation. 2. Inferential statistics, utilizing both the Chi-square test and the Independent samples T-test. The significance of these tests was determined using specific probability (P-value) criteria, categorized as follows: very highly significant ($P < 0.000$), highly significant ($P < 0.001$), significant ($P < 0.05$), and non-significant ($P > 0.05$). These criteria guided the interpretation of the statistical findings.

Table (1): Socio-demographic characteristics of the patient population are presented.

Socio demographic of patients		Frequency	%
Age (Years)	< 25	5	12.5
	25 – 35	15	37.5
	> 40	20	50.0
Mean ± S. D		34.25 ± 9.14	
Sex	Male	29	72.5
	Female	11	27.5
Total		40	100.0

Table (1) illustrate the Socio demographic of patients. The majority of age patients was more than 40 years old which was 50% of the total while 37.5% of patients was between 25 - 35 years old and only 12.5% of the participants was less than 25 years old. 72.5% was male and only 27.5% were females.

Table (2): Compare mean of perioperative and follow-up variables.

variables	Types of operation	N	Mean	S. D	T-test	P-value	Results
Union Time (Weeks)	Nailing	20	10.850	3.031	-3.194	0.003	Significant
	Plating	20	13.150	1.089			
Average Rotation in Injured Forearm	Nailing	20	142.90	16.11	-2.642	0.012	Significant
	Plating	20	153.55	8.09			
Average Rotation in Uninjured Forearm	Nailing	20	170.05	5.52	-0.171	0.865	No Significant
	Plating	20	170.35	5.55			
Duration of Operation (Minutes)	Nailing	20	62.500	15.133	-4.501	0.000	Significant
	Plating	20	81.400	11.119			
Age of Fracture (Day)	Nailing	20	3.350	1.496	0.220	0.827	No Significant
	Plating	20	3.250	1.372			

If (P< 0.05) is significant
Test is independent samples T-Test

The comparison means of peri operative and follow up data for two fixation method is displayed in Table (2). Since the p-value was less than the standard alpha 0.05, the study suggests that there was a statistically significant difference between the nailing and plating in relation to the union time, average rotation in the injured forearm and the duration of the operation. However, since the p-value was more than the standard alpha 0.05, there was no statistically significant difference between the nailing and plating groups in relation to the average rotation in the uninjured forearm, and age of fracture (Day).

Table (3): Shows the association between Grace Eversmann Score and types of operation.

Variables	Range	Items	Union	Types of operation				Total		Significant Test
				Nailing		Plating				
				Fr.	%	Fr.	%	Fr.	%	
Grace Eversmann Score	< 60	Unacceptable	+	1	5.0	0	0.0	1	2.5	$\chi^2 = 7.316$ P-value=0.062
	60 – 79	Acceptable	+	3	15.0	1	5.0	4	10	
	80 – 89	Good	+	12	60.0	7	35	19	47.5	
	≥ 90	Excellent	+	4	20.0	12	60.0	16	40	
	Total			20	100.0	20	100.0	40	100.0	

If (P< 0.05) is significant
Test is Chi-Square Test

Table (3) illustrates the relationship between the Grace Eversmann score and method of operation. The range is pronation supination comparison ratio with the uninjured forearm. Regarding the Grace Eversmann Score, there

was no statistically significant difference between the nailing and plating groups since the p-value was more than the common alpha of 0.05.

Table (4): Shows association the mechanism of injury with related variables and complications of both groups.

Variables	Items	Types of operation				Total		Significant Test
		Nailing		Plating				
		Fr.	%	Fr.	%	Fr.	%	
Side Involvement	L	5	25.0	4	20.0	9	22.5	$\chi^2 = 0.143$ P=0.705
	R	15	75.0	16	80.0	31	77.5	
Mechanism of Injury	DIRECT	1	5.0	1	5.0	2	5	$\chi^2 = 2.578$ P=0.461
	FFH	5	25.0	4	20.0	9	22.5	
	FOG	4	20.0	1	5.0	5	12.5	
	RTA	10	50.0	14	70.0	24	60	
OTA Classification	2R2B2 2U2A3	1	5.0	1	5.0	2	5.0	$\chi^2 = 0.237$ P=0.971
	2R2A3 2U2A3	14	70.0	13	65.0	27	67.5	
	2R2A3 2U2B2	3	15.0	3	15.0	6	15	
	2R2B3 2U2A3	2	10.0	3	15.0	5	12.5	
Complications	Delay union	1	5.0	0	0.0	1	2.5	$\chi^2 = 4.606$ P=0.33
	Implant impingement	1	5.0	0	0.0	1	2.5	
	Uncomplicated	15	75.0	18	90.0	33	82.5	
	Olecranon bursitis	2	10.0	0	0.0	2	5.0	
	SSI	1	5.0	2	10.0	3	7.5	
Total		20	100.0	20	100.0	40	100.0	

L=left, R=right, DIRECT=direct trauma, FFH= fall from heights, FOG=fall on ground, surgical site infection, RTA=road traffic accident.

If (P< 0.05) is significant
Test is Chi-Square Test

Table (4) summarizes key fracture information and complications for 40 cases, highlighting the mechanism of injury, side involvement, classification, and complications. Because the p-value was more than the standard alpha of 0.05, there was no statistically significant difference between the nailing and plating group in relation to the mechanism of injury, side involvement, OTA classification, and complications. Pre and post-operative X-rays of the two patients in our study are shown in Figure (1) and Figure (2).

Figure (1): Pre and post-operative radiographs in anteroposterior and lateral views showing a diaphyseal fracture of the radius and ulna fixed with a plate and screws.

Figure (2): Pre and post-operative X-ray in AP and lateral views demonstrating a diaphyseal fracture of the radius and ulna fixed with proper size and position of flexible intramedullary nails.

4. Discussion

This study evaluates outcomes between compression plate fixation and intramedullary nailing in managing diaphyseal fractures of the radius and ulna. Compression plate fixation is widely recognized for its stability in

fracture management, with multiple studies demonstrating favorable outcomes. Conversely, intramedullary nailing offers benefits such as shorter operative times and faster union rates, providing a compelling basis for comparing these methods to determine their relative effectiveness in achieving optimal functional and clinical outcomes.[18,19]

This study included 40 patients, aligning with prior research by Saini et al. who also analyzed 40 patients. The mean age was 34.25 years, ranged from 18 to 65 years, with a predominance of male patients and a higher incidence of right-side injuries.[20] This male predominance and the higher frequency of right-side injuries align with epidemiological trends in trauma, likely reflecting increased physical and occupational risk factors among males. Statistical similarities in age, gender, and injury side distributions between the groups enhance the comparability of findings.

Mechanism of Injury and Fracture Classification

Road traffic accidents were the predominant mechanism of injury across both groups, accounting for 24 cases, followed by 9 cases of falls from heights. The most common fracture type in this study was 2R2A3 2U2A3, with a distribution of 27 cases: 14 in the nailing group and 13 in the plating group, underscoring the comparable nature of the injuries managed in this study.

Operative Time and Union Rates

Operative duration differed notably between the groups, with the plating group averaging 81.4 minutes compared to 62.5 minutes in the nailing group. This finding aligns with previous studies by Saini et al. which reported shorter operative times for intramedullary nailing due to its minimally invasive nature and no need for extensive soft tissue dissection compared to plate fixation.[20] Clinically, this suggests that intramedullary nailing may be more advantageous in cases where minimizing operative time and reducing soft tissue disruption are priorities. Additionally, these findings have practical implications for orthopedic surgeons in trauma settings, as the choice between plate fixation and intramedullary nailing can be individualized to specific patient needs and clinical priorities, particularly in cases where reduced operating time are desired.

Union times also varied between groups: plate fixation averaged 13.15 weeks for union, while nailing required 10.85 weeks. In the plating group, all patients achieved union within the expected timeframe. In the nailing group, union was timely in 19 cases; however, one case experienced delayed union at 22 weeks, likely influenced by the patient's history of heavy smoking. These findings align with those of Saini et al. who also observed shorter union times with intramedullary nailing, underscoring that nailing may be preferable in cases where quicker union is a clinical priority.[20] However, concerns around postoperative immobilization in the nailing group should be noted, as prolonged immobilization may impact joint stiffness and delay functional recovery. Careful planning and postoperative protocols are therefore essential to balance immobilization needs with early mobilization efforts to optimize functional outcomes. The impact of lifestyle factors, such as smoking, and other comorbidities on fracture healing and fixation success further highlights the need for individualized treatment approaches. Patients with high-risk profiles may benefit from preoperative counseling or modified fixation techniques to optimize healing outcomes.

Complications and Functional Outcomes

Over the twelve-month follow-up period, complications differed between the groups. In the nailing group, 15 patients had no complications, while 5 encountered adverse events, including one case each of nail impingement, delayed union, superficial incisional surgical site infection and two cases of olecranon bursitis. Additionally, the nailing procedure required intraoperative X-ray exposure, as fluoroscopy was used to ensure accurate nail placement. In contrast, the plating group had 18 patients without complications, with only 2 patients developing superficial incisional surgical site infections. Although minimal X-ray exposure may be used in plating, it is typically much lower than in nailing procedures. These findings suggest a higher complication rate in the nailing group compared to the plating group, indicating that plate fixation may be associated with fewer postoperative complications in this patient population.[21]

Pronation/supination range of rotation was also measured, with the nailing group averaging 142.90 and the plating group 153.55, both within functional limits. This superior range of rotation in the plating group was likely due to its ability to achieve more precise reduction and restore the radial bow, as optimal anatomical alignment and rotational stability are crucial for forearm function. Functional outcomes, as assessed using the

Modified Grace and Eversmann scores, showed that 19 patients achieved good results, 16 achieved excellent results, and 4 were classified as acceptable and one case in the nailing group was deemed unacceptable; however, the patient accepted the result and declined further surgical intervention. These functional results suggest a high success rate for both methods, indicating that both plating and nailing can achieve satisfactory functional outcomes in most cases.[21] In detail, the plating group had 12 patients with excellent outcomes, 7 with good outcomes, and 1 acceptable result, while the nailing group had 12 good, 4 excellent, and 3 acceptable outcomes. These functional results suggest a high success rate for both methods, indicating that both plating and nailing can achieve satisfactory functional outcomes in most cases, with plating showing more superior results.

It's important to note that some types of fractures, such as long oblique, spiral, and highly comminuted fractures, were excluded from this study due to their unsuitability for intramedullary nailing. These fracture types are better managed with plating, which provides more stable fixation in cases requiring precise anatomical alignment. Including such fractures would likely lead to disproportionate outcomes, skewing results in favor of plating. By excluding these fracture types, this study aimed to focus on cases where both plating and nailing were viable options, allowing for a more balanced assessment of each method's effectiveness.

These findings contribute to the broader context of orthopedic fracture management, affirming that both plate fixation and intramedullary nailing are viable options for managing fractures of the radius and ulna. Each method offers unique benefits: intramedullary nailing may be more advantageous for reducing operative and union time, whereas plate fixation may be preferable when stability is a primary concern. Ultimately, these insights highlight the importance of individualized treatment selection based on patient needs, clinical priorities, and resource considerations.

5. Limitations

Some of the limitations of this study include the lack of long-term follow-up as well as a small sample size because of insufficient cases. Additionally, the exclusion criteria—such as omitting complex fractures like long oblique, spiral, and highly comminuted fractures, which are unsuitable for intramedullary nailing—may limit the applicability of these results to all diaphyseal fractures. To validate these results, future studies with larger sample sizes and extended follow-up times would be valuable.

6. Conclusion:

The best choice of treatment for diaphyseal fractures of the radius and ulna is open reduction and internal fixation with plates and screws, which allows for maintaining length, alignment, and mobility. Flexible intramedullary nailing is not preferable to plating, serves as a viable alternative. This conclusion applies specifically to simple fractures, as complex fracture types were excluded from this study. Fracture type and reduction effectiveness remain crucial factors in clinical outcomes.

Conflict of interest

The authors of this article had stated that there was no conflict of interest or commercial relationship with the work they had submitted.

Reference

[1] Truntzer, J., Vopat, M.L., Kane, P.M., Christino, M.A., Katarincic, J., Vopat, B.G., 2015. European Journal of Orthopaedic Surgery & Traumatology 25, 201–209.

[2] D, H., I, M., 2017. Malays Orthop J 11, 1–9.

[3] Schulte, L.M., Meals, C.G., Neviaser, R.J., 2014. Journal of the American Academy of Orthopaedic Surgeons 22, 437–446.

[4] Goldfarb, C.A., Ricci, W.M., Tull, F., Ray, D., Borrelli, J., 2005. J Bone Joint Surg Br 87, 374–379.

[5] Lee, S.K., Kim, K.J., Lee, J.W., Choy, W.S., 2014. European Journal of Orthopaedic Surgery & Traumatology 24, 769–776.

[6] Grace, T.G., Eversmann Jr, W.W., 1980. JBJS 62, 433–438.

[7] Droll, K.P., Perna, P., Potter, J., Harniman, E., Schemitsch, E.H., McKee, M.D., 2007. The Journal of Bone and Joint Surgery-American Volume 89, 2619–2624.

[8] Smith VA, Goodman HJ, Strongwater A, Smith B. Treatment of Pediatric Both-Bone Forearm Fractures. Journal of

Pediatric Orthopaedics. 2005 May;25(3):309–13.

[9] Lee, Y.H., Lee, S.K., Chung, M.S., Baek, G.H., Gong, H.S., Kim, K.H., 2008. The Journal of Bone and Joint Surgery-American Volume 90, 1891–1898.

[10] Visna, P., Vlcek, M., Valcha, M., Beitl, E., Jaganjac, E., Smídl, Z., 2009. Rozhl Chir 88, 708–15.

[11] Dumont, C.E., Thalmann, R., Macy, J.C., 2002. J Bone Joint Surg Br 84-B, 1070–1074.

[12] Chapman, M.W., Gordon, J.E., Zissimos, A.G., 1989. JBJS 71.

[13] Firl, M., Wünsch, L., 2004. J Bone Joint Surg Br 86-B, 1047–1049.

[14] Yörükoğlu, A.Ç., 2017. Jt Dis Relat Surg 28, 30–34.

[15] Jones, D.B., Kakar, S., 2011. J Hand Surg Am 36, 1216–1219.

[16] Gadegone, W., Salphale, Y.S., Lokhande, V., 2012. Indian J Orthop 46, 65–70.

[17] Catalano, L.W., Zlotolow, D.A., Hitchcock, P.B., Shah, S.N., Barron, A.O., 2011. Journal of the American Academy of Orthopaedic Surgeons 19, 430–438.

[18] Hadden, W.A., Reschauer, R., Seggl, W., 1983. Injury 15, 44–52.

[19] Zhang, X.F., Huang, J.W., Mao, H.X., Chen, W.B., Luo, Y., 2016. Orthopaedics & Traumatology: Surgery & Research 102, 319–325.

[20] Saini, R., Sharma, A., Baisoya, K., Ravalji, D., 2023. Cureus 15.

[21] Garampalli, Dr.A., Panegaon, Dr.N., Narasangi, Dr.S., 2018. International Journal of Orthopaedics Sciences 4, 28–31.