

# Surgical outcomes of closed forearm diaphyseal fracture treatment using locking compression plates at Haiphong University of Medicine and Pharmacy Hospital

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## ABSTRACT

**Background:** Forearm diaphyseal fractures are common injuries requiring precise anatomical restoration. This study aims to describe the clinical and radiographic characteristics and evaluate the outcomes of surgical treatment for closed forearm diaphyseal fractures in adults using locking compression plates (LCP) at Haiphong University of Medicine and Pharmacy Hospital. **Materials and Methods:** A retrospective and prospective cross-sectional descriptive study was conducted on 31 patients who underwent internal fixation with LCP at the Department of General Surgery, Haiphong University of Medicine and Pharmacy Hospital from January 2021 to June 2025. **Results:** The mean age was  $44.5 \pm 17.6$  years, with a male-to-female ratio of 0.94. Traffic accidents were the primary cause (61.3%). The most common fracture site was the middle third (83.8%). The Thompson approach was predominantly used for the radius (83.9%), while the postero-medial approach was used for 100% of ulnar fractures. The mean operative time was  $52.5 \pm 6.5$  minutes. Most cases utilized 6-hole locking plates (83.9% for the radius and 71.0% for the ulna). Primary wound healing was achieved in 96.7% of cases. Postoperative X-rays showed complete anatomical reduction in 90.3% of patients. At the end of the study, 96.8% of patients achieved good to excellent forearm rotation. Long-term outcomes according to Anderson's criteria were: Excellent 90.3%, Good 6.5%, Fair 3.2%, with no poor results. No cases of pseudarthrosis or refracture after plate removal were recorded. **Conclusion:** Internal fixation with locking compression plates is an effective treatment for forearm diaphyseal fractures, providing excellent anatomical restoration and stable fixation that allows for early mobilization with a low complication rate.

**Keywords:** Forearm diaphyseal fracture, locking compression plate (LCP), internal fixation.

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## INTRODUCTION

Fractures of the shaft of the radius and ulna are common injuries in orthopedic trauma, accounting for approximately 12-30% of all fractures generally [1, 2]. Due to the complex anatomical characteristics and the pronation-supination function of the forearm, the treatment of this fracture type requires perfect anatomical restoration,

particularly regarding the physiological bowing of the radius and the interosseous relationship. Conservative treatment often presents significant challenges in reduction, frequently leading to secondary displacement, muscle atrophy, joint stiffness due to prolonged immobilization, and high rates of malunion which limit pronation-supination function [3, 4].

Currently, open reduction and internal fixation (ORIF) with plates and screws is considered as the gold standard for treating adult forearm diaphyseal fractures. Among these, osteosynthesis using Locking Compression Plates (LCP), with a mechanism where screws lock into the plate to form a stable fixed-angle construct, does not require the plate to be compressed against the periosteum. This helps preserve the blood supply and is suitable even for cases of osteoporosis or complex fractures [5]. At Haiphong University of Medicine and Pharmacy Hospital, this technique has been widely implemented. This study was conducted with two objectives: (1) To describe the clinical and radiographic characteristics of patients with closed forearm diaphyseal fractures; (2) To evaluate the treatment outcomes of locking compression plates at Haiphong University of Medicine and Pharmacy Hospital from 2021 to 2025.

## MATERIALS AND METHODS

### Study Subjects

31 patients (10 retrospective and 21 prospective cases) diagnosed with closed forearm diaphyseal fractures, who underwent internal fixation using LCP at the Department of General Surgery, Haiphong University of Medicine and Pharmacy Hospital from January 2021 to June 2025.

#### *Inclusion criteria*

Patients  $\geq 16$  years old; closed fractures of the forearm diaphysis caused by trauma, consented to participate in the study.

#### *Exclusion criteria*

Pathological fractures, polytrauma, open fractures, pre-existing deformities in the fractured limb.

### Methods

Cross-sectional descriptive study (retrospective and prospective).

#### **Location**

Department of General Surgery, Haiphong University of Medicine and Pharmacy Hospital.

#### **Surgical protocol**

- *Method of anesthesia:* Brachial plexus block.

- *Surgical approach:* The Thompson approach was used for middle/distal third radial fractures of the radius, or the Henry approach for proximal third fractures of the radius; the ulna was accessed via the direct postero-medial approach.



**Figure 1.** Thompson approach  
(Patient Duong Thi M, Female, 73 years old, SLT: 1178.2023)



**Figure 2.** Henry approach  
(Patient Vu Thi T, Female, 53 years old, SLT: 1154.2024)

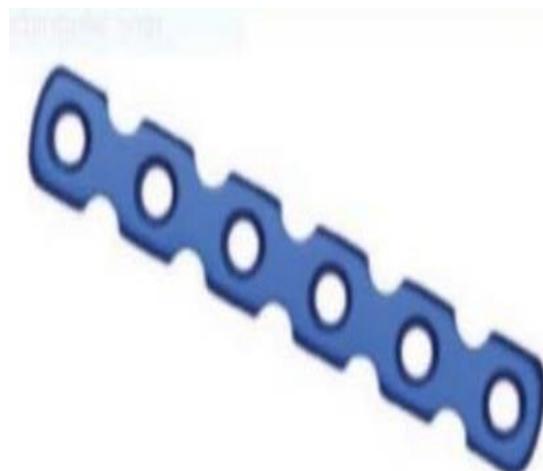


**Figure 3.** *The direct postero-medial approach*  
 (Patient Vu Thi T, Female, 53 years old, SLT: 1154.2024)

- *Implants:* Locking compression plates with 6 or 8 holes, utilizing 3.5mm locking screws.

**Locking compression plate (LCP)**

Number of holes	Length (mm)	Plate thickness	2.5mm
5	58	<b>Plate width</b>	10.0mm
6	70	Hole spacing	12.0mm
7	82	Type of screws	3.5mm
8	94		
9	106		
10	118		
12	142		
14	166		
16	190		



**Figure 4.** *Specifications of INTERCUS GmbH locking compression plate*  
 (Source: Compiled and translated by HANOI.IEC Company, 2015)

- *Postoperative rehabilitation:* Early mobilization exercises were initiated on postoperative day 1-2.

**Study Indices**

General characteristics (age, gender, etiology), clinical and radiographic features,

operative time, complications, bone union results, and functional recovery (evaluated according to Anderson and Brunelli criteria).

**Data Analysis**

Data were processed using SPSS 20.0 software.

**RESULTS**

**General Characteristics of Materials**

*Table 1. Age (n= 31)*

Age group	Number of Patients (n = 31)	Percentage (%)
16 – 30 years old	8	25,8%
31 – 59 years old	15	48,4%
≥ 60 years old	8	25,8%
<b>Mean age</b>	<b>44,5 ± 17,6 years old (16 – 73 years old)</b>	

- The reasearch on 31 patients showed that The mean age was 44.5 ± 17.6 years (16 – 73 years), The working-age group (31-59 years) accounted for the highest percentage (48.4%). The male/female ratio was approximately 1:1 (0.94).

- Traffic accidents were the leading cause (61.3%), followed by domestic accidents (25.8%).

- The mean time from injury to surgery was 16.34 hours, with 71% of patients operated on within the first 24 hours.

**Injury Characteristics and Surgical Details**

*Table 2. Radiographic characteristics of fractures*

Fractured bone	Fracture location	Proximal third	Middle third	Distal third	Total
		Rate %	Rate %	Rate %	Rate (%)
<b>Radius</b>		1	26	4	31
		3,2%	83,8%	13%	100%
<b>Ulna</b>		1	26	4	31
		3,2%	83,8%	13%	100%

Fracture location: Fractures of the middle third were predominant in both the radius and ulna (83.8%).

*Table 3. Radius Fracture Morphology (n=31)*

<b>Radius Fracture Morphology</b>	<b>Number of Patients (n=31)</b>	<b>Rate %</b>
<b>Transverse fracture with a butterfly fragment</b>	2	6,5
<b>Simple transverse fracture</b>	2	6,5
<b>Simple oblique fracture</b>	24	77,4
<b>Segmental fracture (two-level, three-segment fracture)</b>	2	6,5
<b>Comminuted fracture</b>	1	3,3
<b>Total</b>	<b>31</b>	<b>100%</b>

*Table 4. Ulna Fracture Morphology (n=31)*

<b>Ulna Fracture Morphology</b>	<b>Number of Patients (n=31)</b>	<b>Rate %</b>
<b>Transverse fracture with a butterfly fragment</b>	8	25,8
<b>Simple transverse fracture</b>	16	51,6
<b>Simple oblique fracture</b>	6	19,4
<b>Oblique fracture with a butterfly fragment</b>	1	3,2
<b>Total</b>	<b>31</b>	<b>100%</b>

Radial fractures were primarily oblique (77.4%), whereas ulnar fractures were predominantly transverse (77.4% combined).

*Table 5. Surgical approach to the Radius*

<b>Surgical approach to the Radius</b>	<b>Number of Patients (n=31)</b>	<b>Rate %</b>
Henry approach	05	16,1%
Thompson approach	26	83,9%
<b>Total</b>	<b>31</b>	<b>100%</b>

- The radius was predominantly approached via the Thompson approach in 83.9% of cases. For the ulna, 100% of cases utilized the postero-medial approach.

- Operative Time: The mean operative time was  $52.5 \pm 6.5$  minutes. 80.6% of surgeries were completed within 50-60 minutes.

*Table 6. Operative time following surgical approach (n=31)*

<b>Surgical approach</b>	<b>Number of patients</b>	<b>Average operative time</b>	$p > 0,05.$
Henry approach	05	$56,04 \pm 5,43$ minutes	

Thompson approach	26	53,32 ± 4,72 minutes
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- There was no statistically significant difference in operative time between the Henry and Thompson approaches ( $p > 0.05$ ).
- Plates and screws: The majority of cases were treated using 6-hole locking plates (83.9% for the radius and 71.0% for the ulna).

### Treatment Outcomes

*Early outcomes:* The mean length of hospital stay was  $11.4 \pm 3.1$  days. Primary wound healing was achieved in 96.7% of patients; one case of surgical site infection healed by secondary intention. Most patients (58.1%) began mobilization exercises on the first postoperative day.

*Radiographic results:* 90.3% of patients achieved perfect anatomical reduction (no displacement in either bone).

*Long-term outcomes (at the end of the research):*

- Scar condition: Soft, pliable scars were observed in 96.7% of cases; one patient developed a hypertrophic scar.
- Plate removal: All patients (100%) who reached 12 months postoperatively underwent plate removal, with no cases of refracture recorded.
- Forearm pronation–supination function (according to Brunelli’s criteria): Good in 87.1% of patients, Fair in 9.7%, and Moderate in 3.2%.

**Table 7.** Long-term outcome evaluation according to Anderson’s criteria ( $n = 31$ )

Short-term outcome evaluation	Number of Patients (n=31)	Rate %
Good	30	96.8%
Moderate	1	3,2%
Bad	0	0,0%
Total	31	100%

## DISCUSSION

The mean age in our study was  $44.58 \pm 17.63$  years, which is consistent with findings by Tran Nam Trung ( $37.02 \pm 21.46$ ), Vo Minh Luan ( $38.86 \pm 17.58$ ), Factor S. (32 years), and Heo Y.M. & Kim S.B. (31 years) [6-8]. This confirms that forearm diaphyseal fractures are common injuries at the working-age group, having a significant impact on socio-economic aspects. In the research, men predominated in the younger age group (due to traffic accidents, manual heavy work), while women accounted for the majority in

the age group over 60. This is consistent with the global literature, which explains that postmenopausal osteoporosis makes women more susceptible to fractures even from minor trauma, such as household accidents [1, 2].

In our study, the mean time from injury to surgery was  $16.34 \pm 26.87$  hours (range: 3 – 124 hours). The earliest internal fixation surgery was performed on the first day (3 hours post-injury), and the latest on day 6 (124 hours). Early surgery allows fixation when the fracture site has not yet developed callus and the surrounding tissues are less

edematous, making anatomical reduction and fixation easier, achieving closer fracture apposition, and enabling earlier postoperative mobilization. This, in turn, facilitates functional recovery of the forearm.

The middle third was the most common fracture site for both radius and ulna bones (51.6%). Fractures of both forearm bones at the same level were the most common, occurring in 28 patients (90.3%). Transverse fractures, with or without a butterfly fragment, were most frequently observed in the ulna, accounting for 77.4%. Oblique fractures were most common in the radius, occurring in 26 patients (77.4%). Our results are consistent with previous studies: Tran Nam Trung (2019) reported middle-third fractures in 84% of cases, Vo Minh Luan (2025) reported distal-third fractures in 71.7%, and Nguyen Lam Minh Tan (2022) found segmental fractures in 32 of 42 patients (76.19%) [6][7][9]. In fractures of both forearm bones, the integrity of the interosseous membrane plays a critical role. According to Hotchkiss, if the interosseous membrane is torn, fracture stability can be compromised in up to 71.5% of cases. Therefore, internal fixation with plates and screws is mandatory to restore the bony framework and the tension of the interosseous membrane.

We prioritized the Thompson approach (83.9%) for middle and distal third radial fractures. With the elbow in full extension and the forearm supinated, the skin incision is made along a line from the bicipital groove to the radial styloid, passing between the brachioradialis and pronator teres muscles. The fracture site is located at the midpoint of the incision, and the incision length is generally about 2 cm longer than the plate to be used. This approach allows easy exposure of the fracture site while minimizing the risk

of injury to the interosseous nerve branches (motor branch of the radial nerve). For proximal-third fractures, we usually employ the posterior (Henry) approach. With the forearm pronated, this incision is nearly straight and carries a lower risk of injury to the radial nerve at the proximal radius compared to the anterior approach. According to Saikia KC [10], the Henry approach allows for a shorter operative time; however, in our study, the difference in operative time between the two approaches was not significant (53 minutes vs. 56 minutes). In our study, 100% of patients underwent ulna exposure via the direct postero-medial approach, separating along the interval between the flexor carpi ulnaris and the extensor carpi ulnaris. The length of the incision depends on the fracture type and the length of the plate to be used. Typically, the center of the incision is at the fracture site, and the incision is extended proximally and distally as needed.

In this study, we used locking compression plates (LCP), which differ from traditional dynamic compression plates (DCP) that rely on friction between the plate and bone, potentially causing periosteal damage. Locking plates function as an internal fixator, with screws locking into the plate to form a stable construct. This eliminates the need to compress the plate directly against the bone, thereby preserving the periosteum and blood supply. This is particularly advantageous in cases of comminuted fractures or osteoporosis in elderly patients, reducing the risk of bone resorption under the plate and plate breakage. In our study, 6-hole plates were used in the majority of cases, ensuring that each fracture segment was stabilized with at least three screws, achieving optimal biomechanical stability [5,11]. Plate material is also an important consideration. Although

titanium is not inherently bioactive, it is well tolerated by the body. Its main advantage is the avoidance of accumulation of toxic metallic ions. Titanium also has fewer mechanical limitations, and with advances in medical technology, titanium plates are approximately 90% as strong as stainless steel plates. Due to its excellent biocompatibility, titanium reduces the risk of immune-mediated complications [12].

The mean length of hospital stay in our study was  $11.4 \pm 3.1$  days. Primary wound healing was achieved in 96.7% of cases. Anatomical fracture union was observed in 90.3% of patients, and good to fair functional outcomes were achieved in 96.8%, comparable to the results reported by Pham Ngoc Thang (97.3%) and Tran Nam Trung (97.3%) [6]. A key factor contributing to these results was an early mobilization protocol. Owing to the stable fixation provided by locking plates, patients were allowed to begin passive motion exercises as early as the first postoperative day (58.1% of patients). Early mobilization promotes circulation, reduces edema, and prevents tendon adhesions and joint stiffness—complications commonly associated with prolonged immobilization in casts. The only patient with moderate functional outcome had a complex soft tissue injury around the elbow and did not adhere to the early mobilization regimen, resulting in limited forearm pronation–supination. Regarding complications, the incidence of surgical site infection was 3.3% (1 case), lower than classical reports (2–10%). This case was successfully managed with debridement and secondary closure. No cases of refracture were observed after plate removal; plates were removed at 12–18 months postoperatively, when radiographs confirmed solid bone union.

## CONCLUSION

Internal fixation using locking compression plates is an effective method for treating forearm diaphyseal fractures. It facilitates excellent anatomical restoration and rigid fixation, enabling early mobilization with a low rate of complications.

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