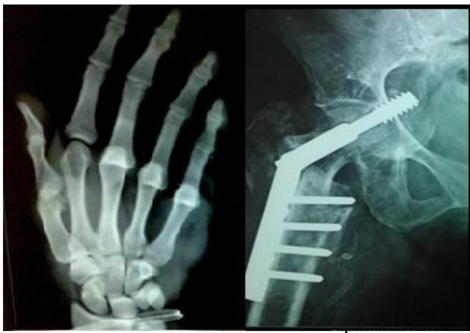

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Evaluation of functional outcomes in surgical management of both-bone forearm fractures using locking compression plates: A prospective study

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Abstract
Aim: The objective of this study was to evaluate the functional outcome of both bone forearm fractures treated with locking compression plates (LCP).
Methods: This prospective study was conducted in the Department of Orthopaedics, Pt. B.D Sharma PGIMS, Rohtak over two years after obtaining ethical approval. A total of 100 patients were included, with written informed consent obtained from all participants. Patients meeting the inclusion and exclusion criteria were studied.
Results: The study population ranged in age from 18 to 60 years, with a mean age of 32.4 years. The majority of patients were males (64%), and 55% had fractures on the left side. The most common fracture site was the lower one-third of the radius and ulna (60%), with transverse fractures being the most frequent (60%). Road traffic accidents were the leading cause of injury (40%). Complications were observed in 7% of patients.
Conclusion: Both bone forearm fractures are increasingly common and require stable fixation for optimal outcomes. Open reduction and internal fixation (ORIF) with LCP is a safe and effective treatment option.

Keywords: Both bone forearm, locking compression plate, open reduction, internal fixation

Introduction
Forearm fractures are common in trauma settings, with a bimodal age distribution affecting children and the elderly [1]. The forearm is crucial for daily activities, and restoring its function is a primary goal in fracture management [2]. Achieving rotational stability and maintaining forearm length are critical for optimal outcomes [3]. Radius and ulna shaft fractures are considered intra-articular, necessitating anatomical reduction to preserve hand function [4].
Surgical fixation using open reduction and internal fixation (ORIF) is the standard treatment. While dynamic compression plates (DCP) offer high union rates, they require long incisions and can disrupt fracture hematoma [3]. Intramedullary devices are more common in pediatric cases but often fail to provide adequate rotational stability in adults [6]. Locking compression plates (LCP) have emerged as a reliable option, offering stability and reducing complications [7].
This study aimed to evaluate the functional outcomes of both bone forearm fractures treated with LCP.

Materials and Methods
Prospective Study on Fracture Management
This prospective study was conducted in the Department of Orthopaedics, Pt. B.D Sharma PGIMS, Rohtak over a period of two years after obtaining approval from the institutional ethical committee. A total of 100 patients were included in the study. Written informed consent was obtained from all patients and their attendants before inclusion, and only those meeting the inclusion and exclusion criteria were studied.

Inclusion Criteria
1. Age above 18 years
2. Closed fractures
3. Transverse/short oblique and comminuted fractures

Exclusion Criteria
1. Open fractures
2. Segmental fractures and grossly comminuted fractures
3. Intra-articular extension
4. Surgically unfit patients
5. Polytrauma cases
6. Multiple comorbidities affecting outcomes

Clinical and Radiological Evaluation
Patients were clinically examined to assess the mechanism of injury, severity of trauma, and any associated injuries. A thorough local examination was conducted to evaluate swelling, deformity, abnormal mobility, crepitus, limb length discrepancy, and distal neurovascular status.
Radiological assessment included X-rays of the radius and ulna (shaft) in anteroposterior and lateral views, along with separate X-rays of the elbow and wrist joints in both views. The affected limb was immobilized using an above-elbow plaster slab with an arm sling. Routine preoperative investigations were conducted, and pre-anesthetic fitness was obtained.

Operative Procedure
After patient positioning, the surgical site was prepared with antiseptic painting and draping, and a tourniquet was inflated. The radius was exposed using Henry's approach, and the fracture ends were identified and freshened. Reduction was performed, and a 3.5 mm locking compression plate (LCP) was applied, ensuring engagement of at least six cortices with screws.
The ulna was approached directly along its subcutaneous border. After exposure, the fracture ends were identified and freshened using a periosteal elevator. Reduction was achieved using a bone-holding clamp, and a 3.5 mm LCP plate was applied. Plates were selected based on fracture characteristics:
- **Radius:** Plate fixation was done on the dorsal side in the upper third, dorsolateral side in the middle third, and volar aspect in the distal third.
- **Ulna:** Plates were applied over the posterior surface.

The locking screw slot near the fracture site was prepared using a drill sleeve, and both cortices were drilled using a 2.7 mm drill bit. Screw length was determined using a depth gauge, and 3.5 mm locking screws were inserted. The radius was fixed first, followed by the ulna. A drain was placed, and the wound was closed. A compression bandage was applied with a crepe bandage, and an arm pouch was provided. The patient was advised to keep the limb elevated and perform active finger movements.

Postoperative Care and Rehabilitation
- **Day 3:** Suction drain removal
- **Day 5:** Postoperative check X-ray (anteroposterior and lateral views)
- **Day 5:** Patient discharged with a short arm slab for two weeks
- **Day 14:** Suture removal
- **Monthly follow-ups:** Patients were evaluated using Anderson *et al.* [9] scoring system, assessing elbow and wrist joint movements until fracture union.

Fracture Union Criteria
- **Union:** Obliteration of the fracture gap with periosteal bridging callus visible on radiographs
- **Delayed union:** Healing occurs without operative intervention but takes more than six months
- **Non-union:** Fracture fails to unite without any intervention

Functional Outcome Assessment
The functional outcome was graded using Anderson *et al.*[9] criteria.

Statistical analysis
Data was analysed using Microsoft Excel (2010). Results were expressed as mean, frequency and range. Tables and figures were used as required. Subjective assessment was done using the Quick DASH score. Statistical analysis was made using the software SPSS 20. Difference was considered significant when the p value was < 0.05.

Results

Table 1: Patient details

Age	N (%)
18-20	15 (15)
21-30	25 (25)
31-40	20 (20)
41-50	15 (15)
51-60	25 (25)
Gender	
Male	64 (64)
Female	36 (36)
Side of Injury	
Right	45 (45)
Left	55 (55)

The age of our study population ranged from 18 to 60 years, with the youngest participant being 18 and the oldest 60. The mean age was 32.4 years. The majority of participants fell within the 21-30 and 51-60 age groups, each comprising 25% of the total. Males accounted for 64% of the study population, while females made up 36%. Regarding fracture location, 55% of participants (n = 55) had a fracture on the left side, while 45% (n = 45) had a fracture on the right side.

Table 2: Fracture site, fracture pattern and mechanism of injury in the study participants

Fracture site	Frequency
Proximal one-third region, *n* (%)	12 (12)
Middle one-third region, *n* (%)	28 (28)
Distal one-third region, *n* (%)	60 (60)
Fracture pattern	
Transverse fracture, n (%)	60 (60)
Short oblique fracture, n (%)	25 (25)
Comminuted fracture, n (%)	10 (10)
Segmental fracture, *n* (%) 5 (5)	
Mechanism	**Frequency**
Self-fall, *n* (%)	23 (23)
Fall from height, *n* (%)	12 (12)
Fall while playing, *n* (%)	25 (25)
Road traffic accident, *n* (%) 40 (40)	

Among the participants, 28 (28%) had a mid-diaphysis fracture, 12 (12%) had a fracture in the upper one-third, and the remaining 60 (60%) had a lower one-third fracture of the radius and ulna. The majority of fractures were transverse (60 cases, 60%), followed by short oblique fractures (25 cases, 25%), comminuted fractures (10 cases, 10%), and segmental fractures (5 cases, 5%). The most common cause of injury was road traffic accidents, accounting for 40 cases (40%), followed by falls while playing (25 cases, 25%), self-falls (23 cases, 23%), and falls from height (12 cases, 12%).

Table 3: Description of the mean range of motion at elbow and radioulnar joints in the study participants

	4 weeks (mean ± SD)	8 weeks (mean ± SD)	12 weeks (mean ± SD)	24 weeks (mean ± SD)
In degrees				
Flexion at elbow (Active)	114 ± 36	125 ± 30	130 ± 32	142 ± 36
Extension at elbow (Active)	23 ± 6	18 ± 5	10 ± 5	1 ± 2
Flexion at elbow (Passive)	116 ± 34	127 ± 30	139 ± 32	148 ± 32
Extension at elbow (Passive)	18 ± 5	14 ± 4	7 ± 3	0 ± 1
Supination	68 ± 22	76 ± 24	77 ± 16	88 ± 12
Pronation	58 ± 22	65 ± 20	75 ± 20	87 ± 18
Palmar flexion	45 ± 17	56 ± 18	64 ± 16	69 ± 18
Wrist dorsiflexion	47 ± 20	66 ± 18	78 ±20	87 ± 18

There was a significant restriction in movement at the elbow and radioulnar joints following injury and fixation. The mean active flexion at the elbow improved from 112° at four weeks to 142° at 24 weeks. An initial restriction of approximately 22° in elbow extension at four weeks gradually normalized to 0° by 24 weeks. Pronation was more affected than supination; however, both showed significant improvement over the 24-week postoperative period. The range of palmar flexion increased from 45° at four weeks to 68° at 24 weeks, while wrist dorsiflexion improved considerably from 47° to 87° over the same period.

Table 4: Complications

Complications	Frequency, n (%)
Delayed union	3 (3)
Skin irritation	4 (4)

Complications were found among 7 (7%) patients.

Discussion

The forearm has a complex anatomical architecture consisting of two parallel, mobile bones providing a stable link between the wrist and elbow. Diaphyseal fractures of the radius and ulna, commonly referred to as both bone forearm fractures, are among the most common fractures in children, accounting for approximately 32% of all fractures [10, 11]. As it serves as the origin of several muscles of the hand, restoration of forearm rotation, elbow and wrist movements, and grip strength following the fracture is facilitated by anatomic reduction and internal fixation. Historically, the majority of these fractures have been treated with nonoperative management relying on closed reduction and casting [12-15].

Our study population age ranged from 18 to 60 years, with 18 years being the youngest patient and 60 years the oldest. The mean age of our study population was 32.4 years. The majority of the patients belonged to the 21-30- and 51-60-years age groups (25%). There were 64% males and 36% females. About 55% of the participants (n = 55) had a fracture on the left side, while 45% (n = 45) had a fracture on the right side. Among them, 28 participants (28%) had a mid-diaphysis fracture, 12 participants (12%) had a fracture at the upper one-third, and the remaining 60 patients (60%) had a lower one-third fracture of the radius and ulna. The majority of the fractures were transverse (60%), 25% were short oblique type, 10% were comminuted type, and 5% were segmental fractures. Road traffic accidents were the most common cause of injury in the study population, constituting 40%, followed by falls while playing (25%), self-falls (23%), and falls from height (12%). However, Kc *et al.*, in a study conducted in 2013, reported that the incidence of fractures is higher on the left side because it is usually non-dominant and used as a protective function when patients fall to the ground [16].

There was a significant restriction in the movements at the elbow and radioulnar joints following the injury and fixation. The mean active flexion at the elbow improved from 112° at four weeks to 142° at 24 weeks. A restriction of about 22° in elbow extension at four weeks normalized to 0° at 24 weeks. The degree of pronation was more compromised than supination. However, both significantly improved over the 24-week postoperative period. The range of palmar flexion improved from 45° at four weeks to 68° at 24 weeks. The range of wrist dorsiflexion significantly improved over time from 47° at four weeks to 87° at 24 weeks. This finding is similar to the systematic review by Westacott *et al.*, which compared the functional outcomes following intramedullary nailing or plate and screw fixation of pediatric diaphyseal forearm fractures [17]. The improvement in the range of motion was significant over time in patients who underwent intramedullary nailing. The overall complication rate in our study was 7%, which aligns with the rates described by Kc *et al.* [16] According to the criteria by Price *et al.*, 90% of cases showed excellent outcomes, 7% showed good outcomes, and 3% showed fair outcomes [18].

This procedure is not without drawbacks; the surgeon has no tactile feedback regarding the quality of screw purchase into the bone as the screw is tightened. As the screw locks into the plate, all screws abruptly stop advancing when the threads are completely seated in the plate, regardless of bone quality. Current locking plate designs can maintain fracture reduction but not obtain it. The fracture must be reduced and limb alignment, length, and rotation must be set properly before placing any locked screws. The inability of the surgeon to alter the angle of the screw within the hole and still achieve a locked screw is a problem that needs to be addressed. Any attempt to contour locked plates could potentially distort the screw holes and adversely affect screw purchase.

Conclusion

The incidence of both bone forearm fractures is increasing in this modern era, and conservative treatment often yields poor results. Stable fixation is required to achieve fracture union with a good functional outcome. Hence, ORIF with LCP is a safe and effective option for the fixation of both bone forearm fractures.

Conflict of Interest

Not available

Financial Support

Not available

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