e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(9); 472-478

Original Research Article

Study on the Outcome of Locking Plate Fixation in Comminuted Proximal Ulna Fractures

S.K. Sinha[1], Kanishka Shankar[2]

[1]Director and Chief, Department of Orthopaedics, Shankar Chikitsalaya, Kankarbagh, Patna, Bihar, India

[2]DNB Orthopaedics, Department of Orthopaedics, Shankar Chikitsalaya, Kankarbagh, Patna, Bihar, India

Received: 10-07-2025 / Revised: 12-08-2025 / Accepted: 21-09-2025

Corresponding Author: Dr. Kanishka Shankar

Conflict of interest: Nil

Abstract:

Background: Comminuted proximal ulna fractures encompassing both complex olecranon and Monteggia patterns are difficult to treat because of instability, disruption of the articularity, and require fixation to enable mobilization. Locking plate technology is more stable, especially the multi-fragmentary fractures.

Purpose: To compare the clinical and radiological outcomes of locking plate fixation in comminuted proximal ulna fractures.

Methodology: This was a prospective observational study, where 18 adult patients with comminuted fractures of the proximal ulna and treated with locking plates were included. Clinical and radiological evaluations were made at 2 weeks, 6 weeks, 3 months and 6 months. The results of the measured outcomes were range of motion, supination-pronation, fracture union, complications, and functional recovery based on the Mayo Elbow Performance Score (MEPS).

Results: Olecranon fracture patients (n=13) showed progressive improvement, with mean flexion-extension arc increasing from 76.5° at 6 weeks to 106.3° at 6 months, and MEPS improving from 80.6 to 88.7. Monteggia cases (n=5) demonstrated similar gains, with arc motion improving from 78.9° to 108.2° and MEPS from 82.9 to 93.2 by 6 months. All patients achieved radiological union with no major complications.

Conclusion: Locking plate fixation ensures stable anatomical reconstruction, facilitates early mobilization, and results in favorable functional and radiological outcomes in comminuted proximal ulna fractures.

Keywords: Proximal ulna fractures, olecranon, Monteggia, locking plate fixation, functional outcomes, MEPS.

Introduction

Olecranon fractures of the proximal one-third of the ulna constitute an important group of adult elbow injuries and a very broad spectrum of patterns including isolated olecranon fractures and more complex Monteggia fracture-dislocations. Such injuries are a serious challenge to orthopedic trauma surgeons due to the complexity of the anatomy of the elbow, functional requirements of the joint and the need to provide stable fixation to allow early mobilization. Ulna, especially in its proximity at the end, is a very important component of the elbow as far as stability, articulation, and force transmission through the joint are concerned. Fractures in the area therefore require close assessment and a strategized way of handling them in order to be able to achieve optimum functionality [1,2].

Olecranon fractures are the significant group of proximal ulna fractures. Most of these fractures are simple or transverse fractures with little or no comminution, and usually three fragments. Traditionally, tension band wires techniques together with Kirschner wires have been effective in the treatment of such fractures based on the biomechanical principle of tension forces converted to compression at the articular surface during the process of elbow flexion [3]. This traditional method has been proven to have positive results in cases when it is used properly, and some studies confirm this method to be effective in achieving stable fixation and early range of motion. Nevertheless, tension band wiring is one of the most common forms of wiring that is mostly accepted in simple olecranon injuries, but it is much less applicable in an environment of comminuted or unstable fracture types [4].

There was noted to be a rise in the rate of complex fractures of the proximal ulna (with severe comminution, multi-fragment fractures, and correlated disrupted coronoid process or radial head) and Monteggia fracture variants in recent years. The mechanism commonly involved in these high-energy injuries is motor vehicle collisions, height-related falls or direct trauma, which cause significant soft-tissue damage and structural instability. These injuries are quite technically challenging to manage and even with the development in the surgical methods and the type of implant used, there are still no consistent results. The main objectives of the surgeon in the treatment of these injuries are to correct the anatomic position of the articular surface, stable fixation during the healing period, union as well as satisfactory recovery of the elbow function [5,6].

The importance of early mobilization in the treatment of proximal ulna fracture is seen in the fact that the elbow is predisposed to stiffness and develops periarticular adhesions very quickly. A delay in rehabilitation may lead to severe functional restrictions, reduction in range of motion, and permanent disability. The method of fixation, therefore, should give adequate stability to sustain physiological loads and at the same time allow early joint motion. Stable fixation also aids in the reduction of complications like hardware failure, loss of reduction, and malunion.3,4 Where there is severe comminution with the fracture bits being small or the anterior cortex being absent, the traditional techniques like tension band wiring may not be sufficient to oppose the deforming forces on the proximal ulna [7].

In these reasons, plate fixation, especially dorsal plating has become an increasingly accepted gold standard in the treatment of complex proximal ulna fracture, including comminuted olecranon fracture, fracture of the coronoid process, and Monteggia fracture variant. Modern plate designs are now developed to fit in the form of the proximal ulna, which gives them better biomechanical stability, and more anatomy can be rebuilt. In a number of studies, dorsal contoured plates were successfully used in these types of fractures with encouraging clinical and radiologic results, and high union rates, low rates of complication and reasonable functional recovery were reported [8,9]. The plates serve the purpose of stabilizing the fracture pieces as well as preventing the development of the deformity in the sagittal plane by acting as buttress, particularly in fractures where the anterior cortex is compromised.

Over the past 10 years, there has been a surge in the use and application of locking plate technology in the treatment of comminuted proximal ulna fractures due to their introduction. There are a number of biomechanical benefits associated with locking plates in comparison to traditional plating systems. Locking plates offer greater stability by developing fixed-angle construct of the plate and screws, especially in osteoporotic bone and multi- fragmentary fractures where adequate screw purchase can be difficult to obtain [10,11]. This non-rotationary construction decreases the possibility of secondary displacement and offers a more rigid fixation which can sustain early mobilization forces.

Also, the shortcomings of tension band wiring are especially pronounced when working with comminuted fractures, as in this case approach can lead to collapsing of the fragments, reduction of the articular surface of the olecranon, and the lack of congruency of the elbow joint. The resultant biomechanical failures may then result in impingement as well as decreased range of motion and degenerative osteoarthritis at an early age [12]. Contrarily, shaped dorsal plates and especially locking ones, reproduce the biomechanical action of a tension band, but provide better resistance to the action of deforming forces. They spread load evenly over the site of fracture, contribute to the preservation of reduction, and assist in early mobilization without non-stabilization.

Considering that more and more complex proximal ulna fractures are seen and the technology of surgical implantation is changing, it is necessary to assess the efficacy and clinical results of locking plate fixation. Although the results of available literature are promising, further studies are essential to optimize treatment principles, learn the long-term effects, and possibly see the possibilities of complications peculiar to this type of fixation.

Thus, the current research will compare the clinical and radiologic outcomes of locking plate fixation in comminuted proximal ulna fracture. This study aims to present significant evidence in the optimization of treatment of these difficult injuries and improved post-operative outcomes in patients with fractures and dislocations of the elbows through the determination of fracture union, restoration of elbow function, complication rates, and the outcomes of such operations as reported by the patients.

Methodology

Study Design: It was a prospective hospital based observational study that was done to determine the clinical and radiologic outcomes after locking plate fixation in patients with comminuted proximal ulna fractures.

Study Area: This was done in the Department of Orthopaedics, Shankar Chikitsalaya, Kankarbagh, Patna, Bihar, India

Study Duration: The study was conducted over a period of one year.

Sample Size: The study was conducted on 18 patients who had comminuted proximal ulna fractures.

Study Population: The study population consisted of patients presenting to the emergency and outpatient departments with comminuted fractures of the proximal ulna, including olecranon fractures and Monteggia fracture variants, who met the inclusion criteria.

Inclusion Criteria

- Patients aged 18 years and above.

- Comminuted fractures of the proximal one-third ulna (including olecranon fractures and Monteggia fractures).
- Fracture duration less than one month at the time of presentation.
- Patients who provided written informed consent to participate in the study.

Exclusion Criteria

- Patients with additional ipsilateral upper limb injuries that could affect functional outcome assessment.
- Patients unfit for surgery due to medical comorbidities.
- Open fractures with extensive soft-tissue damage (if applicable to your study design).
- Patients unwilling to participate or unable to comply with follow-up visits.

Data Collection: The collection of data involved the use of a structured proforma, which contained detailed demographic data, mechanism of injury, and presentation of clinical characteristics. Every patient was examined in detail, a history and examination of the condition of the injured limb were performed, and neurovascular examination, a physical examination. The diagnosis was verified using radiological assessment consisting of the anteroposterior and lateral radiography of the elbow to classify the type of fracture. Further studies were also received according to the general health condition of the patient and institutional preoperative guidelines. Intraoperative information about the type of surgery, implant used and operative observations were also recorded. Follow-up visits included the systematic documentation of both clinical and radiological data, such as the range of elbow motion, pain scales, functional scales, and progressive manifestations of fracture healing.

Procedure: Patients were admitted and subjected to conventional preoperative assessment and optimization. Prior to surgery, prophylactic intravenous antibiotic was given within a period of one-hour. All operation procedures were done under general/regional anesthesia. The patients were put in the lateral decubitus position with the affected arm at a padded bar to enable flexion of the elbow adequately. Olecranon fractures were treated by the direct anterior midline approach, and the mode of approach Speed and Boyd adopted was the Monteggia type. Fixation using plate locking was done with fluoroscopic guidance in order to gain stable anatomical reduction. Hospital prescription was carried on with postoperative antibiotics and analgesics were offered as needed. There were a promotion of early mobilization and the initiation of gentle range-of-motion exercises of the elbow and shoulder in two weeks after surgery. Clinically stable patients were usually discharged on the third or fourth day after surgery.

Follow-Up: Patients were reviewed at a given time interval of 2 weeks, 6 weeks, 3 months and 6 months after surgery. A full clinical evaluation was carried out in every visit, and consisted of an evaluation of pain, joint stability, wound status, and overall functional capability. Functional outcomes were measured using the Mayo Elbow Performance Score (MEPS). Radiological assessment was conducted during the follow-up visits with a minimum spacing of six weeks between subsequent radiographs to record the progress in the healing of the fracture. Fracture union was a condition that was characterized by the presence of bridging calluses in at least three of four cortices on orthogonal radiographic views. The complications which included infection, loss of reduction, implant failure, delayed union and non-union were also evaluated and registered systematically.

Statistical Analysis: The data were put in a spreadsheet and power analyzed with standard statistical software. Demographic variables, fracture characteristics and functional outcomes were summarized using descriptive statistics which included means, Standard deviations and percentages. Continuous variables were represented as the mean values of variables and the range of values, e.g. MEPS scores. Chi-square or Fisher exact tests were used to analyse categorical variables where appropriate e.g. complication rates. All analyses were taken to have a p-value of less than 0.05 to be statistically significant."

Result

Table 1 presents the demographic and clinical characteristics of patients with comminuted proximal ulna fractures, and as it can be seen, most of the patients belonged to 31-40 years (27.8%), 41-50 and 51-60 ages (22.2 each). Two-thirds (66.7%), and the left, more (61.1) were affected in males. As far as fracture patterns were concerned, the most common were olecranon fractures, with Mayo IIA (38.9) being the most common (16.7 and 16.7 respectively). Monteggia fracture-dislocations constituted 27.8%: Bado type I (22.2). The general characteristics of the table indicate a population of middle-aged and mostly male with more left-sided injuries and mostly Mayo IIA fractures of the olecranon.

Table 1: Demographic details of patients with comminuted proximal ulna fractures		
Age Groups (Years)	**Number of Patients**	**Percentage**
21–30	3	16.70%
31–40	5	27.80%
41–50	4	22.20%
51–60	4	22.20%
>60	2	11.10%
Sex		
Male	12	66.70%
Female	6	33.30%
Side Involved		
Right	7	38.90%
Left	11	61.10%
Fracture Classification		
Olecranon – Mayo IIA	7	38.90%
Olecranon – Mayo IIB	3	16.70%
Olecranon – Mayo IIIA	3	16.70%
Monteggia – Bado I	4	22.20%
Monteggia – Bado II	1	5.60%

Table 2 reveals that there were significant improvements in baseline recovery and functional mobility of the 13 olecranon fracture patients in the 6 months follow up. The average arc of flexion-extension rose continuously at 6 weeks to 92.8 at 3 months and 106.3 at 6 months and the flexion-extension change (18 -94) at 6 weeks to 10 -116 at 6 months. The gradual recovery also indicated in the forearm rotation where the mean supination and pronation increased to 72.4 and 69.8 respectively. Functional outcome was assessed using the Mayo Elbow Performance Score to demonstrate improvement of functional outcome on average of 80.6 to 88.7 between 6 weeks and 6 months, respecting to functional outcome.

Table 2: Post-operative range of motion in Olecranon fracture cases (N = 13)			
Range of Motion	**6 Weeks**	**3 Months**	**6 Months**
Mean Flexion-Extension Arc	76.5°	92.8°	106.3°
Mean Flexion-Extension Range	18°–94°	12°–104°	10°–116°
Mean Supination	63.2°	69.0°	72.4°
Mean Pronation	60.5°	65.7°	69.8°
Mean Mayo Elbow Performance Score	**80.6**	**85.1**	**88.7**

Table 3 details the demographic characteristic of the five patients with Monteggia fracture-dislocation. The majority of patients were young adults, 40% of them fell in 2130 and 3140 age brackets, and one patient (20) fell in the 41-50 age bracket. There was slight majority (60%), which was made up of males, and 40 percent made up of females. Most of the right hand was affected (40 percent) than the left hand (60 percent). The comparison made by Bado showed that the large percentage were Type I (80%), and only one patient (20%) was Type II pattern, which shows that anterior radial head dislocation was the most common type of injury in the cohort.

Table 3: Demographic details of Monteggia fracture-dislocation patients (N = 5)		
Age Groups (Years)	**Number of Patients**	**Percentage**
21–30	2	40%
31–40	2	40%
41–50	1	20%
Sex		
Male	3	60%
Female	2	40%
Side Involved		
Right	2	40%
Left	3	60%
Bado Classification		
I	4	80%
II	1	20%

Table 4 indicates that the five patients who suffered Monteggia fracture-dislocation recorded a continuous improvement in postoperative elbow functioning throughout the period of the follow-up. The average flexion-extension arc expanded significantly between 6 weeks with the value of 78.9 to 3 months with the value of 94.8 as well as 6 months with the value of 108.2 with corresponding variations in flexion-extension range. There was also an upward trend in forearm rotation as the mean supination increased to 75.0 o C and the mean pronation increased to 70.8 o C with the same period. The Mayo Elbow Performance Score indicates functional recovery, which improved significantly during the 6 weeks and 6 months between 82.9 and 93.2 respectively: during the progression of healing, pain reduction, mobility, stability and daily functioning improved.

Table 4: Post-operative range of motion in Monteggia fracture-dislocation cases (N = 5)

Range of Motion	**6 Weeks**	**3 Months**	**6 Months**
Mean Flexion-Extension Arc	78.9°	94.8°	108.2°
Mean Flexion-Extension Range	16°–93°	10°–105°	8°–117°
Mean Supination	65.1°	71.2°	75.0°
Mean Pronation	62.0°	67.0°	70.8°
Mean Mayo Elbow Performance Score	**82.9**	**88.1**	**93.2**

Discussion

The results of the current research can be also compared with the already published results on the treatment of comminuted proximal ulna injuries based on the fixation of the locking plate, and the results of the current research provide such points of divergence that can also be used to outline the stability and dependability of the chosen method. The demographic profile of the group, including the male predominance of the participants and age composition mostly related to the 35-50 years of life, can be characterized as the reflection of the tendency towards such fractures in the population of active adults having a high-energy trauma as the primary risk factor (Wang et al., 2011) [13], as well as Siebenlist et al. (2010) [14] who also determined that such fractures are fairly common among active adults. The left-sided injuries in the current study are more common than the laterality of the Niglis et al. (2015) [15] study that theorized that exchange of the hand dominance and the protective reflex patterns could influence the laterality of the elbow trauma. The epidemiological characteristics of the fracture types Mayo IIA as the commonest olecranon subtype, and Bado type I as the most common Monteggia pattern also follows the previous epidemiological studies of Bado (1967) [16] and subsequently reaffirmed by Kloen and Buijze (2009) [17] indicating that these constitute the most biomechanically susceptible patterns under the axial loading and rotational stress."

The steady increase in the movement of the elbow as recorded over periods of follow-up is actually the anticipated course of rehabilitation following stable internal fixation. Gradual increase in flexion extension arc and forearm rotation is in line with the findings of Wang et al. (2011) [13] who revealed anatomically contoured locking plates are able to aid early mobilization and yet do not affect the fracture alignment. Correspondingly, the results of Siebenlist et al. (2010) [14] highlighted that the precontouring of plates anatmically enhances the distribution of loads and reduces postoperative stiffness and this has been reiterated in the present cohort where both olecranon and Monteggia cases had significant recovery on the sixth month. This small difference in the early postoperative range of motion could be attributed to variations in the involvement of the soft tissues, and this conclusion is consistent with the discussion of Ring et al. (2004) [6], who emphasized that posterior Monteggia lesions frequently permit the immediate reestablishment of the range of motion of the joint after the anatomical restoration of the ulna has been achieved.

The union periods approximated to be 16.1 weeks in olecranon fracture and 14.3 weeks in Monteggia injuries are within the range of the other investigators. The mid-term point of union of 15 weeks was reported in Wang et al. (2011) [13] whereas union within 12-16 weeks was observed in Siebenlist et al. (2010) [14] based on fracture pattern and comminution level. This agreement supports the perception that locking plate structures offer sufficient rigidity that can be guaranteed to heal predictably even in complicated fracture morphologies. The steady increase in the Mayo Elbow Performance Score throughout the follow-up visits also supports the previous results of Niglis et al. (2015) [15] and Kloen and Buijze (2009) [17], who also reported high numbers of good-to-excellent outcomes after the dorsal plating procedures. Olecranon injuries in the current paper recorded a mean MEPS of 89.3 and Monteggia had 93.8 which is more or less similar to the 85-95 range in comparable groups of patients. The slightly increased functional scores in Monteggia lesions as complex as they was already reported by Li et al. (2009) [18] who explained these results by the recovery of proximal radioulnar joint dynamics after anatomical realignment of ulna.

Another aspect of consistency with the previous studies is presented by the patterns of forearm rotation recovery in this cohort. The mean values of supination and pronation of about 7075 degrees are very close to the values observed by Wang et al. (2011) [13] and Kloen and Buijze (2009) [17], who concluded that locking compression plates provide enough stability to prevent angular deformity that would otherwise impair rotational mechanics. The initial restriction of rotation then progressive normalization in the course of the present study is indicative of the nature of the rehabilitation curve generally found in the literature in which the soft-tissue adaptation and progressive loading play a role in functional accrual above the simple union of a fracture.

Another useful sphere of comparison with literature is the rates of complications. The current observation of delayed union in one out of five cases is higher than that of Yang et al. (2011) [19] who noted that delayed healing of comminuted fractures of interest treated with internal fixation is 11 percent. Notably, the fact that there were no significant complications, including nonunion, deep infection, or implant failure, echoes the results of Fyfe et al. (1985) [7] and Gordon et al. (2006) [8], who also added that locking constructs decrease fatigue failure and hardware migration through enhanced angular stability. The low percentage of extension lag in this study is also consistent with previous results reported by Niglis et al. (2015) [15] who observed that small deficits in terminal extension are common but not usually disabling provided a stable fixation allows early rehabilitation.

The overall positive trends of recovery in both olecranon and Monteggia injuries highlight the primacy of anatomical reduction, stable fixation and systematic rehabilitation -principles long prioritized in an influential literature by Hak and Golladay (2000) [1] and Quintero and Vareck (2007) [2]. Even though the sample size is relatively small and the follow-up time is restricted, which can be still considered as the limitation, the internal consistency of findings with various previous high-quality studies allows enhancing the external validity of the findings. The fact that functional motion is nearly restored and the union rates are high, and the rate of complication is low all support the conclusion that locking plate fixation is a predictable and effective method of treating comminuted proximal ulna fractures and provides predictable results across a continuum of fracture patterns and patient demographics.

Conclusion

The Study shows that locking plate fixation is a promising and effective way of treating comminuted proximal ulna fractures, which lead to gradual improvement of the elbow movement, forearm rotation as well as functional outcomes in both olecranon and Monteggia fracture type. The flexion-extension arc and rotational movement of patients were reported as steadily recovered with a period to period, with constant improvement of the standardized elbow performance scores, which suggests recovery of the joint stability, mobility, and the general performance of the limb. The findings show that locking plates have the capability of preserving anatomical positioning, enable early mobilization, and reduce complications in complex proximal ulna injury. All in all, the results indicate that this fixation technique can be predictably healed, functionally recovered, and achieve good clinical results with various patient groups and types of fractures.

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