ORIGINAL ARTICLE

Nepal Orthopedic Association Journal
NOAJ

Functional outcome of Olecranon fracture fixation with Anatomical Olecranon plate

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https://doi.org/10.59173/noaj.20261202g

Abstract

Background: Open reduction and internal fixation (ORIF) for olecranon fractures remains a challenge. Due to intra-articular extension of fractures, anatomical reduction and stable rigid fixation is essential to obtain good functional outcome. We evaluated the functional outcomes of olecranon fracture fixation using pre-contoured anatomical locking olecranon plate.

Methods: A prospective study was conducted on 14 patients (Mayo types 1B, 2A, and 2B) between age of 18 to 73 years who went surgical treatment through open reduction and internal fixation with anatomical olecranon plate between September 2021 to September 2023. These patients were followed up for 12 months (minimum 6 months) and evaluated based on union time, range of motion and functionally by Mayo elbow performance score.

Results: The mean age was 47 ± 17.9 years. The mean bone union time was 12.86 ± 1.23 weeks. At 6 months, the mean MEPS was 95.71 ± 1.54. No significant differences were found between different Mayo groups for union time (p=0.554) or MEPS (p =0.663). Complications occurred in 21.4% (3/14) due to hardware prominence. Radiological osteoarthritis (Broberg & Morrey) was noted in 35.7% (5/14) of cases (Grade 1: n=4; Grade 2: n=1), despite 100% anatomical reduction with step off and gap of ≤ 2 mm).

Conclusion: Anatomical locking plates appear to be an effective surgical option for Mayo type 1 and 2 fractures in this small series. However, larger comparative studies are required to establish long-term superiority over traditional methods.

Keyword: Anatomical olecranon plate, MEPS score, Olecranon fracture

Introduction

Olecranon fractures constitute approximately 5% of all fractures,10 % of elbow fractures and range from simple non-displaced fractures to complete fracture - dislocations of the elbow.[1] The incidence is higher in middle age adults typically around fifth decade of life with no gender predisposition.[2] Fractures occurs due to direct trauma such as fall on the tip of elbow or by indirect trauma such as fall on a partially flexed elbow with indirect forces generated by triceps muscle avulsing the olecranon.[3] Majority of cases are intra-articular and if appropriate reduction is not achieved, permanent limitation of joint motion and early osteoarthritis may occur.

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Various fixation techniques like tension band wiring(TBW), intramedullary screw fixation, rush pinning, small specially designed olecranon nails and fragment excision with re-attachment of the triceps tendon have been described.[4] Majority of fractures are simple transverse type with no or limited comminution which can be treated with the classic tension band wire fixation.[5] However, recent increase in incidence of complex fractures of the proximal ulna with severe comminution and its management has been challenging.

The aim of surgical treatment is to provide a normal anatomical contour that remains stable over time, protection of extensor mechanism and early restoration of elbow motion. Fixation with plate and screws has merged as gold standard treatment for comminuted proximal ulna fractures, fractures involving the coronoid process and monteggia fracture.[6] Pre-contoured anatomical locking plate allows them to serve as reduction template, improve the fixation strength in fragile bone and compensates for the fracture instability related to presence of comminution, although there posterior position may result in skin related complication.[7,8] In addition use of dorsal plate acts as a buttress to prevent fracture flexion in cases of deficient anterior anterior cortex.[9] In this study, we aim to evaluate the functional and radiological outcome of patients who underwent open reduction and internal fixation with pre-contoured olecranon LCP plate for closed olecranon fractures.

Methods

This was a prospective study in 18 patients who were treated with pre-contoured olecranon plate from 1st September 2021 to 1st September 2023 in Manipal Teaching Hospital. All patients with olecranon fracture who underwent fixation with pre-contoured anatomical olecranon LCP plate within the study period were included in the study.

Four patients were lost to follow-up and excluded from the study. So, the total numbers of patients were fourteen by the last follow-up. The study protocol was formally reviewed and approved by the institutional Review Board of Manipal College of Medical Sciences and Manipal Teaching Hospital. All eligible patients were informed about the nature of the study, the surgical procedure and the follow-up protocol. Written informed consent was obtained from each participant prior to their inclusion in the study. Patient were followed up clinically and radiologically for a period of 12th months (minimum 6 months) at regular interval of 2nd weeks, 6th weeks, 3rd months and 6th months and 12th months. Clinical outcome was assessed using Mayo Elbow Performance Score (MEPS) at 3rd months and 6th months. Radiological outcome was assessed based on progression of union on Anterior-Posterior and lateral view.

Patients included in our study were age >16 years, closed olecranon fracture without associated radial head or coronoid process fracture, fracture less than 1st week old, Mayo type 1, type 2 and type 3 olecranon fractures and patient who comply with regular follow up for a period of at least 6 months and exclusion criteria of the study were as follows. While the inclusion criteria initially covered mayo type 1, type 2 and type 3 fractures, the final study only represented type land type 2 as no type 3 fractures presented during the study period Exclusion criteria included open / compound fracture, patient with history of previous fracture around the elbow joint, multiple traumas with or without neurovascular injuries, pathological fracture, patient unfit for surgery and uncooperative for physiotherapy.

Pre-operative protocol

On admission, demographic data was recorded with detailed history and clinical examination of all patients was done. Patients were temporarily immobilized with above elbow posterior slab, underwent routine investigation including radiological assessment of the fractured limb. Patients were further investigated depending on the general condition and co-morbidity of the patient and routine pre-operative protocol was followed as per our hospital guidelines.

Operative technique

The procedure was performed under a brachial plexus block with the patient in the lateral decubitus position and a tourniquet applied to the upper arm. After standard skin preparation and draping, a curved dorsal incision (about 6–7.5 cm) was made over the olecranon, and the ulna was exposed between the flexor and extensor muscle groups. The fracture hematoma was evacuated, and the fragments were irrigated, reduced with clamps, and temporarily stabilized using Kirschner wires. Definitive fixation was achieved by applying a precontoured anatomical locking plate to the dorsal surface of the olecranon, positioned deep to the triceps tendon. Finally, the wound was closed in layers, and a well-padded plaster slab was applied.

Post-operative protocol

Post-operatively, patients received I.V cefuroxime (1.5gm 12 hourly). While modern guidelines often suggest a 24 hour's window, a 5-day extended prophylactic regime was utilized in this series according to institutional protocol which was aimed for proper wound monitoring. Analgesics and other supportive management were given according to patient need. Sterile dressing was done on third post-operative day and changed every third day. The above elbow posterior slab was continued for two weeks to ensure pain relief and to improve patient comfort. Patient was discharged once wound confirmed healthy and patient fit for discharge preferably on 5 post-operative days. Suture removal was done on 14th

post-operative day. Rehabilitation was started as soon as posterior slab was removed and consisted of active -passive self-rehabilitation elbow Rom exercises. Elbow loading was prevented for 6th-8th weeks. Patients were permitted to return to normal daily activities, as tolerated, at 3rd months. Patients were followed up at 2nd weeks,6th weeks,3rd months ,6th months and at 12th months of surgery. During the follow-up period, radiological assessment (Anterior-posterior and lateral views) was done seeing the course of fracture healing on X-ray. Articular reduction was categorized as anatomical if the residual step-off or gap was ≤ 2 mm and inadequate if it exceeded 2 mm. Functional assessment was done using Mayo Elbow performance score at 3rd months and at 6th months. Fracture union was defined as union of three out of four cortices on two orthogonal radiographs. Any complications in terms of loss of reduction, infections, skin related problems, hardware prominence, problems related to union and implant failure were noted.

Post-traumatic osteoarthritis was graded at 12 months follow-up using the Broberg and Morrey classification system. Grade 1 was defined as slight joint space narrowing with minimal osteophyte formation; Grade 2 as moderate joint space narrowing with moderate Osteophyte formation; Grade 3 as severe joint space narrowing with significant osteophyte formation and subchondral sclerosis.

Statistical analysis was performed with SPSS version 20. Continuous variables including age, Mean union time, range of motion and MEPS were expressed as mean and range. The Kruskal Wallis test was used to compare the union time and MEPS across the three mayo fracture types. For comparison between two points (3 months and 6 months), Wilcoxon signed rank test was used. A p-value ≤ 0.05 was considered statistically significant.

Results

A total of 14 patients were included in the study. Majority of the patients were female 11(78.5%), most of the patients were in the age group of (50-60) years with the mean age of 47 ± 17.9 years (18-73 years). Eight (57%) cases were caused by fall from height and six (42%) were due to road traffic accident. According to Mayo classification system, most common type of fracture was type 2B (8 cases, 57%) cases followed by type 2A (4 cases, 28.5%) and type 1B fracture (2 cases, 14.2%). No mayo type 3 fractures were encountered in the 14 patient [Table 1]. Radiological union was seen at 10th weeks in 2 (14%) cases, 12th weeks in 7 (50%) cases, 14th weeks in 2(14%) cases and 16th weeks in 3 (21%) cases.

Range of motion (Flexion, Extension, Supination and Pronation) was evaluated at 3 months and 6 months post-operatively [Figure 1 and 2]. The mean forearm pronation demonstrated a significant improvement during the follow-up period, increasing from 67.2 ± 1.54 degree at 3months to 70.3 ± 2.0 degree at 6 months. This gain in pronative mobility was found to be highly statistically significant (Wilcoxon Signed-Rank test, P ≤0.001). Similarly, mean forearm supination increased from 75 ± 2.0 degree at 3 months to 81.43 ± 1.87 degree at 6 months which was found to be statistically significant (Wilcoxon Signed-Rank test, P ≤ 0.001). Combined with the pronation data, these results confirm that the anatomical locking plate maintains the delicate rotational axis of the forearm, allowing for a return to near-physiological rotational dynamics. The mean pronation-supination arc increased from142.4 ± 1.46 degree at 3months to 151.7 ± 2.08 degree at 6 months. This mean improvement of 9.3 degree was found to be statistically significant. The mean flexion-extension arc showed significant improvement throughout the follow-up period, progressing from 90.2 ± 1.75 degree at 3 months to 112.8 ± 2.14 degree at 6 months with improvement of 22.6 degree. This represents a statistically significant gain in joint mobility (p ≤ 0.001) and reflects the stability provided by the anatomical locking plate.

Mayo elbow performance scoring system at 3 months and 6 months post-operative follow-up,12 patients (85%) had excellent result and 2 patients (14%) had good result. The mean Mayo Elbow Performance Score (MEPS) for the entire cohort at the final functional assessment at 6 months was 95.71 ± 1.54 compared to 85.5 ± 2.14 at 3 months. (Table:2). Comparative analysis revealed no statistically significant difference in functional outcomes between the Mayo subgroups (Mayo 1B :96.25 ± 2.5; Mayo 2A:95.0 ± 3.16; Mayo 2B: 96.25 ± 2.50; Kruskal-Wallis p= 0.663 (Table 3). The mean time to radiological bone union for the entire cohort was 12.86 ± 1.23 weeks [Figure 3 and 4].

Table 1. Demographic and Clinical Details of Olecranon fractures

Variable	Category	Number of Patient (n=14)	Per-centage
Age (years)	Mean ± SD	47 ± 17.9 years	—
	<30	4	28.5%
	31-40	1	7.1%
	42-50	1	7.1%
	51-60	5	35.7%
	>60	3	21.4%
Sex	Male	3	21.4%
	Female	11	78.5%
Side	Right	8	57.1%
	Left	6	42.8%
Mayo Classification	1B	2	14.2%
	2A	4	28.5%
	2B	8	57.1%
	3 (instability)	0	0%

Figure 1 Range of Motion (Flexion of elbow) at final follow-up.

Figure 2 Range of Motion (Extension of elbow) at final follow-up.

Figure 3 Preoperative X-Ray Anterior-posterior and Lateral view of Elbow

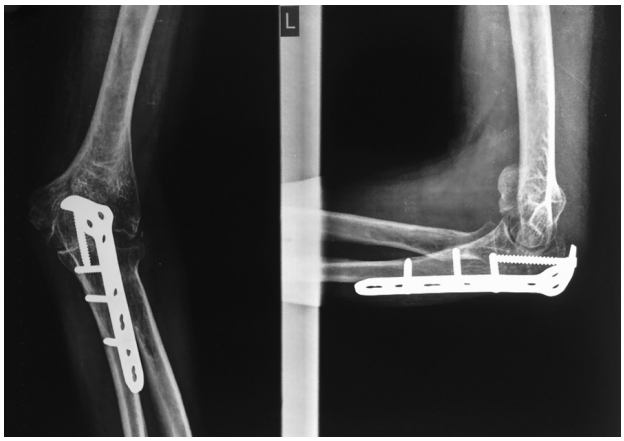

Figure 4 Final follow-up x ray AP and lateral view of elbow.

Sub-group analysis showed no statistically significant difference in union time between Mayo groups 1B(12.50 ± 0.87 weeks), 2A(13.17 ± 1.47weeks), and 2B(12.75 ± 0.83 weeks) (Kruskal-Wallis, p=0.554). These finding suggest that the anatomical locking plate provides consistent stability regardless of the specific fracture pattern within Mayo type 1 and type 2 classification.(Table 3).This clinical and radiological outcome with non-significant p value (both >0.05) demonstrate that the pre-contoured anatomical plate is a versatile and reliable tool that produces high-quality outcomes regardless of the specific fracture anatomy in these patients.

Immediate post-operative radiographs were evaluated for the quality of articular reduction. Anatomical reduction was defined as an articular step-off or gap of ≤ 2mm, which was achieved in all 14 patient (100%). Despite achieving anatomical congruity in all cases, radiological signs of early osteoarthritis were noted in 5 patients (35.7%) at the 12th months follow up. Peri-articular ossification developed in 1 patient (7.14%) with no clinical consequences.

The overall complications rate was 35.7% (5/14). Keloid scar was seen in 7.14% (1/14) patient which responded to local steroid injection. Hardware prominence was seen in 21.42% (3/14) patients, with exposed screw head in 1 patient. Though screw head was exposed, no features of infection was there, so patient was followed up till fracture got united and later exposed screw and olecranon plate was removed. Superficial infection was seen in 7.14% (1/14) patient which responded to daily dressing and oral antibiotics. Transient ulnar neuropraxia, implant impingement, non-union or malunion were not reported in any case (0%, 0/14).

At the final 12- month follow-up, radiological evidence of early post-traumatic osteoarthritis was observed in 35.7% (5/14). Using the Brobery and Morrey classification system, 28.6% (4/14) of cases were identified as Grade1 and 7.1% (1/14) of cases were identified as Grade 2. No cases of Grade 3

Table 2. Post-operative Functional outcome

Range of Motion/Score	3 months (Mean ± SD)	6months (Mean ± SD)	P-value
Pronation	67.2 ±1.54	70.3 ± 2.0	0.002
Supination	75.2 ± 2.0	81.43 ± 1.87	0.001
Pronation-supination arc	142.4 ± 1.46	151.7 ± 2.08	0.001
Flexion-extension arc	90.2 ± 1.75	112.8 ± 2.14	0.001
Mayo Elbow performance Score	85.5 ± 2.14	95.71 ± 1.54	0.001

Table 3. Post-operative Functional outcome

Variable	Overall (mean ± SD)	Mayo 1B (mean ± SD)	Mayo 2A (mean ± SD)	Mayo 2B (mean ± SD)	p-value
Union time (weeks)	12.86 ± 1.23	12.50 ± 0.87	13.17 ± 1.47	12.75 ± 0.83	0.554
MEPS (6 months)	95.71 ± 2.84	96.25 ± 2.5	95.0 ± 3.16	96.25 ± 2.50	0.663

or 4(advanced) degeneration were observed (0/14). All 5 patients with radiological osteoarthritis maintained excellent functional outcome, with a mean MEPS of 95.71 ± 2.84.

Discussion

The treatment of olecranon fractures seeks to achieve several objectives: realignment of the longitudinal axis, restoration of joint stability, maintaining the articular congruity, restoration of the extensor mechanism and a pain free functional arc of motion of the elbow. Olecranon has wide margin of tolerance, as 50% of the joint surface can be removed without altering elbow stability provided humeral trochea and coronoid process are intact.[10] This makes the management of complex, comminated feature of the olecranon challenging when it is combined with the radial head fracture and/ or coronoid process of the ulna or injury to the collateral ligaments of the elbow.[3] Pre-contoured anatomical locking compression plate acts as an internally placed external fixator which provides better rigidity because of its close proximity to the bone fracture site.[11] Such plates have advantages of providing both angular and axial stability eliminating the need for exact plate contouring ,are not subject to the toggling of unlocked screw seen with conventional plate, which improves fixation in osteoporotic and comminution. Additionally pre-contoured LCP has a central proximal intra-medullary screw that considerably increases the mechanical strength of the fixation, producing greater stiffness in flexion compared to a double proximal plate or a posterior construct with no central intra-medullary screw.[12] Plates are applied to the dorsal surface of the proximal ulna which is the tensile side and use of such type of plate offer the option of bone grafting to support depressed articular fragment.[13]

Age of the patient in the present study ranged from 18 to 73 years with the mean age of 47 years which is comparable to studies done by Kumar TS et al.[14] In the present study the most susceptible sex was female differed form studies done by Kumar TS et al.[14] and Singh NK et al.[15] It may be explained by the commonest mode of injury in our study which is fall from standing height. Female patient are mostly affected by low energy trauma as a fall from a standing height. In the present study, the predominant mode of trauma was fall from standing height 8(57%) which is comparable to the studies done by Buijze et al.[16]

Our observed 100% radiological union rate at the mean of 12.86 ± 1.23 weeks aligns with the findings of Wang YH et al.[17] who reported similar outcomes using anatomical locking plate. The high union rate in our study can be attributed to the biological preservation of the soft tissue envelope during the plating process and the rigid stability provided by the pre-contoured anatomical plate, which acts as a tension band on the dorsal cortex of the olecranon.

Our study specifically demonstrates high functional success (mean MEPS of 95.74 ± 2.84) at six months in stable and displaced olecranon fracture (Mayo type 1 and type 2 fractures) which is comparable to studies done by Buijze et al.[16] and Duckworth et al.[18] who both found that anatomical plating yields excellent to good functional outcome and all patients returned to pre-injury state of daily activities. This suggests that the pre-contoured shape of the plate provides superior biomechanical stability allowing for early mobilization. While our study demonstrates excellent outcome for Mayo type 1 and Mayo type2 fractures, further research is needed to evaluate the efficacy of anatomical LCP specifically for type 3 fracture dislocation in our clinical setting.

In our present series, symptomatic hardware prominence was seen in 21.4%(3/14) patients which is lower compared to 40-50% typically reported for tension band wiring. This shows the low profile anatomical locking plates reduces skin irritation, less reoperation rate for symptomatic hardware

prominence with less complication rate (38% as compared to tension band wiring with 63% as stated by Duckworth et al.[18] though the subcutaneous nature of the olecranon makes some degree of hardware awareness inevitable. Superficial infection was seen in 1 (7.1 %) patient similar to study done by Bailey CS et al.[19] which was treated with daily wound dressing and oral antibiotics.

We observed Grade 1 and 2 osteoarthritis (Broberg and Morrey) in 35.7% of cases despite 100% anatomical reduction (≤ 2mm step off).This correlates with the findings of Garrigues et at.[20] who suggests that development of post- traumatic OA in olecranon fractures is not solely dependent on the quality of surgical reduction, but likely also influenced by the initial energy of the trauma and primary chondral damage sustained at the time of injury .This observation contrasts with traditional views that solely blame inadequate reduction for post-traumatic OA. Precontoured anatomical locking olecranon plate facilitates their easy positioning and allow them to serve as reduction template, thus theoretically ensuring perfect reduction and this usual suites for Mayo 2A and 2B fractures because they often involve oblique lines that tension band wiring cannot compress effectively. Study done by Puchwein et al.[21] showed that the proximal ulna has a highly variable and gender specific morphology and use of anatomically pre-shaped ulnar plates cannot exactly match the local anatomy. Forcing a mismatch plate onto bone during complex fracture fixation could lead to poor reduction and may impact the other joints of the elbow. Different studies demonstrate that both tension band wiring and plate fixation provide good to excellent functional outcome, but anatomically contoured plate provides better stability and fewer implant related complications, particularly in comminuted olecranon fracture. (Table 4)

Our study has several important limitations. First, the sample size is small (n=14), and the follow-up period of 12 months is short in accessing long term complications such as post-traumatic osteoarthritis. Second, the absence of a control group (e.g., tension band wiring) which prevents a direct comparative analysis of the anatomical plate superiority. Third there is a potential for selection bias, as the study was conducted at a single tertiary center and included patients who met specific follow-up criteria. Furthermore, while radiological reduction was assessed by two independent surgeons, a formal inter-observer reliability analysis (such as a Kappa coefficient) was not performed, which may affect the objectivity of the radiographic findings.

Conclusion

Our prospective study demonstrates that open reduction and internal fixation with pre-contoured anatomical locking compression plate is an effective and reliable surgical option for Mayo type 1 and type 2 olecranon fracture. This technique provides rigid fixation, allowing early range of motion and higher rate of radiological union with excellent functional outcome. However given the small sample size and lack of control group, our findings should be considered preliminary and further large scale randomized comparative studies are required to establish its superiority over traditional methods like tension band wiring.

Conflict of interest: None
Source of Funding: None
Acknowledgement: None

Table 4. Summary of clinical studies on the management of displaced olecranon factures

Study	Year	Study Type	Sample size	Treatment	Union Rate	Functional score	Major Findings
Bailey et al.[19]	2001	Clinical study	40	plate fixation	100%	Good MEPS	Plate provides stable fixation but some implant irritation occurred
Anderson et al.[22]	2007	Retrospective	25	Locking plate fixation	96-100%	Good-excellent MEPS	Locking plate useful in osteoporotic and comminuted fracture
Duckworth et al.[17]	2017	RCT	67	TBW versus plate	Union similar in both group	DASH similar in both group	TBW had higher hardware irritation and implant removal compared to plate fixation
Our Study	2024	Prospective cohort	14	Anatomical locking plate	100%	Good-Excellent MEPS	Plate provides stable fixation but some implant irritation occurred

MEPS: Mayo Elbow Performance Score; TBW: Tension Band Wiring; DASH: Disabilities of Arm Shoulder and Hand

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