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Functional outcomes and complications of anatomical plate and screw fixation in closed olecranon fractures: A prospective case study

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Abstract

Background: Olecranon fractures, prevalent in adults due to direct trauma or falls, often require surgical intervention to restore function and prevent long-term complications. Anatomical plate and screw fixation is a contemporary approach designed to provide enhanced stability and alignment compared to traditional methods such as tension band wiring. This study aims to evaluate the clinical outcomes and complications associated with anatomical plate and screw fixation for olecranon fractures.

Patients and Methods: This prospective case series study, conducted from October 2023 to March 2024 at Al-Yarmouk Teaching Hospital in Baghdad, Iraq, evaluated 26 patients with closed, displaced olecranon fractures (Mayo type IIA). Patients, aged 18 to 70, underwent anatomical plate and screw fixation. Data collection involved comprehensive clinical evaluations, radiological assessments, and pre-operative and post-operative care protocols. Data analysis was performed using SPSS, with strict adherence to ethical standards and national research guidelines.

Results: The study analyzed 26 patients with olecranon fractures, revealing 69.2% males and an average age of 38.3 years. The majority of fractures were pattern 21-B1, with 93.3% achieving union within 3.5 months. Surgical intervention occurred after an average of 5.23 days, with a mean flexion-extension range of motion at 4 months being 106°. Complications included non-union, infections, and one case of radio-ulnar synostosis. Despite these issues, postoperative outcomes were generally positive, with high functional scores and satisfactory recovery.

Conclusion: Anatomical plate and screw fixation for olecranon fractures demonstrated favorable outcomes with high union rates and satisfactory functional recovery. The technique provided effective stabilization and allowed for early mobilization. However, attention to potential complications such as infection and nonunion is necessary. Further research is warranted to assess long-term outcomes and refine surgical strategies.

Keywords: Olecranon fractures, plate and screw fixation, functional outcomes

Introduction

Olecranon fractures are a common orthopedic injury, particularly among adults, and typically result from direct trauma to the elbow or falls onto an outstretched hand [1]. These fractures often present as displaced Mayo type II, particularly in younger individuals who experience falls from heights. Such injuries lead to significant functional impairments due to the olecranon's essential role in elbow extension and overall forearm movement [2]. The olecranon, as the proximal portion of the ulna and the insertion point for the triceps brachii muscle, plays a critical role in maintaining the arm's structural integrity during movement. Displacement caused by the triceps' pull creates a significant fracture gap, often complicating the injury and making surgical intervention necessary to restore proper alignment and function [3]. Effective and timely treatment is crucial for optimal recovery and to prevent long-term complications [4]. Various surgical techniques have been developed to manage olecranon fractures effectively, with the primary goal of restoring the anatomical alignment and stability of the elbow joint [5]. Two of the most common methods used for surgical repair are tension band wiring (TBW) and plate fixation [6]. TBW has been widely utilized due to its simplicity and effectiveness in certain fracture types.

However, this method is associated with limitations, including a higher incidence of symptomatic hardware, irritation, and loss of fracture reduction [7]. These complications have prompted the exploration of alternative techniques, such as anatomical plate and screw fixation [8].

Anatomical plates are specifically designed to conform to the unique curvature of the ulna, providing a more precise and stable fixation compared to traditional methods [9]. The use of anatomical plates in olecranon fracture surgery offers several advantages, including improved biomechanical stability, which allows for earlier mobilization and a quicker return to function [10]. This is particularly beneficial in adult patients who require rapid recovery to resume daily activities and work-related tasks [11]. Moreover, plate fixation reduces the risk of complications often seen with TBW, such as hardware prominence, which can lead to secondary surgeries for hardware removal [12].

Research into the efficacy of anatomical plate and screw fixation has shown promising results, with multiple studies reporting stable reductions, enhanced fracture healing, and satisfactory functional outcomes [13]. Additionally, advancements in plate design, such as locking plate technology, have further improved clinical outcomes, particularly in managing more complex fractures [14]. These innovations contribute to better fixation in osteoporotic bone and provide a more rigid construct, reducing the risk of postoperative complications such as nonunion, malunion, or loss of reduction [15].

Despite the demonstrated success of anatomical plate and screw fixation, further research is needed to evaluate the long-term outcomes and potential complications associated with this technique [16]. While initial studies have shown that anatomical plates reduce hardware-related issues and improve early functional recovery, the long-term durability and effectiveness of these plates in preventing post-traumatic arthritis or other late-stage complications remain areas of interest [17]. Furthermore, the impact of plate fixation on patient satisfaction, overall quality of life, and return to pre-injury activity levels requires continued investigation [18].

Objectives of study

- To evaluate the outcomes of anatomical plate and screw fixation for closed olecranon fractures, focusing on fracture union rates, fracture patterns, associated injuries, and overall functional recovery.
- To examine postoperative recovery, including surgery timing, range of motion, and complications, to gauge the effectiveness of the surgical intervention and management strategies.

Patients and Methods

Study Design, Setting and Timing: A prospective case series study was conducted to evaluate patients with olecranon fractures at the Orthopedic Department of Al-Yarmouk Teaching Hospital, a major healthcare facility in Baghdad, Iraq. The hospital was chosen for its high volume of orthopedic cases, making it an ideal setting for this research. The study specifically assessed patients who underwent anatomical plate and screw fixation for their fractures. The research period extended from October 2023 to March 2024.

Sample Population, Size, and Technique: This study examined a cohort of 26 patients with closed olecranon fractures treated at the Orthopedic Department of Al-Yarmouk Teaching Hospital in Baghdad, Iraq. Participants

were selected according to strict inclusion criteria: individuals aged 18 to 70 years with closed, olecranon fractures classified as Mayo type IIA (Displaced non-comminuted), necessitating surgical intervention. Exclusion criteria included open fractures, pathological fractures, and skeletally immature patients. The surgical approach utilized was anatomical plate and screw fixation, chosen for its ability to provide superior biomechanical stability and ensure precise anatomical alignment. This technique is recognized for its effectiveness in stabilizing complex fractures and facilitating optimal healing outcomes.

Data Collection Tools: Data collection involved a comprehensive clinical evaluation, which included gathering detailed patient history, performing a thorough examination, and conducting various investigations. The history included personal data such as name, age, sex, occupation, address, and telephone number. Trauma specifics were documented, including the time of injury, first aid provided, and any initial medications or procedures administered. Additionally, information on co-morbidities such as diabetes, hypertension, cardiac or renal conditions, and allergies was recorded. Pre-fracture activity level and range of motion (ROM) of the affected elbow were also documented. Examination included following the Advanced Trauma Life Support (ATLS) protocol for high-energy trauma, assessing life-threatening conditions and associated injuries. A local examination was performed to assess the vascular and neurological status of the injured limb, with particular focus on the radial and ulnar nerves, and evaluating any wounds, abrasions, and soft tissue edema. Investigations comprised radiological and laboratory assessments: plain X-rays were taken in anteroposterior (AP) and lateral views of the affected elbow, ipsilateral shoulder, and wrist, with additional X-rays (chest, pelvis, cervical, and lumbosacral spine) as necessary for high-energy trauma cases. A CT scan was performed to ascertain the fracture pattern, planes, and involvement of the articular surface. Routine pre-operative laboratory tests included CBC, PT, PC, INR, AST, ALT, RBS, urea, and creatinine, with additional tests ordered based on co-morbidities.

Data Management and Analysis: Data collection from clinical assessments, radiographs, and surgical records was systematically entered into a Microsoft Excel spreadsheet. This initial dataset was then imported into SPSS version 26 for detailed analysis. Descriptive statistics were used to summarize the study population's characteristics and the outcomes of the surgical procedures. Continuous variables were presented as means, standard deviations, minimums, and maximums, while categorical data were summarized using frequency counts and percentages.

Official and Ethical Approvals: Before the study began, Al-Yarmouk Teaching Hospital's administration granted official approval, ensuring adherence to national research guidelines. Written informed consent was acquired from all participants after thoroughly explaining the study's goals and methods. Confidentiality was guaranteed, with data used solely for research. Ethical standards were strictly followed, including proper surgical practices and postoperative care. The study complied with the Declaration of Helsinki, upholding principles of respect, beneficence, and justice.

Preoperative Management: Before surgery, an above-elbow slab was used for immobilization and pain relief. For open

fractures, ceftriaxone (1.5 gm every 8 hours) was administered, and wounds were covered with saline-soaked dressings. Wound photos were taken, and anti-edematous measures, including limb elevation and medications, were implemented. Blood sugar was managed for diabetic patients, and anesthesia consultations assessed surgical readiness, with additional consultations for co-morbidities.

Postoperative Management: After wound closure, the elbow was immobilized with a bulky non-compressive Jones dressing and plaster slab for three to seven days. Immediate care included elbow X-rays (AP and lateral views) and neurovascular assessments. Medications included intravenous ceftriaxone (1 gm every 12 hours), analgesics, and anti-edematous injections. The slab was removed before discharge, and patients received instructions on limitations and exercises, along with oral antibiotics and analgesics.

Follow-Up Program: Two weeks post-surgery, stitches were removed, and oral antibiotics were discontinued, with instructions for cautious use of the hand and elbow. At six weeks, elbow X-rays (AP and lateral views) were taken. At 16 weeks, further X-rays assessed union or hardware failure, and range of motion (ROM) and functional scores were recorded. Physiotherapy was initiated based on X-ray findings.

Results

Table 1 presents the demographic, clinical, and trauma characteristics of the study sample (n=26). The cohort comprised 18 males (69.2%) and 8 females (30.8%). The average age was 38.3 years (± 16.4 SD), with age distribution as follows: 14 participants (53.8%) were aged 19-32 years, 8 (30.8%) were aged 33-46 years, and 4 (15.4%) were aged 47-65 years. Regarding smoking status, 11 participants (42.3%) were smokers, whereas 15 (57.7%) were non-smokers. The majority of trauma cases affected the right upper limb (14 cases, 53.8%), with the left upper limb affected in 12 cases (46.2%). The trauma modes included road traffic accidents and falls from height, each comprising 8 cases (30.8%), followed by falls to the ground in 6 cases (23.0%) and falls down stairs in 4 cases (15.4%). Comorbidities were identified in 7 participants (26.9%), with 4 having both diabetes and hypertension, 2 having hypertension alone, and 1 having diabetes alone. In contrast, 19 participants (73.1%) had no comorbid conditions.

Table 2 provides an overview of fracture patterns, associated injuries, and union outcomes among 26 study participants. The distribution of fracture patterns revealed that the majority of patients had pattern 21-B1 fractures, affecting 14 patients (53.8%). Specifically, 7 patients (26.9%) presented with Monteggia Bado type 1 fractures, 3 patients (11.5%) had pattern 21-A1 fractures, and 2 patients (7.7%) had pattern 21-B3 fractures. Associated injuries were observed in 9 patients (34.6%), including 3 with lower limb injuries and 6 with ipsilateral upper limb injuries, while 17 patients (65.4%) had isolated fractures without additional injuries. Within 3.5 months, 24 patients (93.3%) achieved both clinical and radiological union, whereas 2 patients (7.7%) did not achieve union within this period. This data underscores the distribution of various fracture types, the incidence of associated injuries, and the high rate of successful union observed in the study.

Table 1: Demographic, clinical, and trauma characteristics of the study sample (n=26)

Variables	Frequency (n=26)	Percentage (%)
Gender		
male	18	69.2
female	8	30.8
Age Group (years) mean \pm SD (38.3 \pm 16.4)		
19- 32	14	53.8
33- 46	8	30.8
47- 65	4	15.4
History of smoking		
Yes	11	42.3
no	15	57.7
Trauma site		
right upper limb	14	53.8
left upper limb	12	46.2
Trauma mode		
road traffic accidents	8	30.8
falls from height	8	30.8
falls to the ground	6	23.0
falls down stairs	4	15.4
Comorbidities		
yes	7 (4 both diabetes & hypertension), (2 hypertension alone), (1 diabetes alone)	26.9
no	19	73.1

Table 2: Fracture types, patterns, associated injuries, and union outcomes in study Patients

Variables	Frequency (n=26)	Percentage (%)
Fracture pattern		
21-B1	14	53.8
21-B1 (Monteggia Bado type 1)	7	26.9
21-A1	3	11.5
21-B3	2	7.7
Associated injuries		
No (isolated fracture)	17	65.4
Yes (associated injuries)	9 (3 lower limb injuries) (6 ipsilateral upper limb injuries)	34.6
Clinically & radiologically union within 3.5 months		
United cases	24	93.3
non-united cases	2	7.7

In analyzing the data presented in Table 3, which evaluates surgical timing and range of motion (ROM) parameters for study patients, the average time until surgery was 5.23 days, with a standard deviation of 3.8 days, ranging from a minimum of 1 day to a maximum of 17 days. The mean flexion-extension ROM at 4 months was $106^\circ \pm 19.57^\circ$, with a range between 70° and 130° . Patients were categorized into three groups based on their ROM: those with less than 50° , those with ROM between 50° and 100° , and those with 100° or more. Among the patients, 25% had a ROM between 50° and 100° , while 75% had a ROM of 100° or more. The extension loss, reflecting the degree of loss in joint extension, had a mean value of 15.56 degrees with a standard deviation of 12.75 degrees, varying from no loss (0 degrees) to 38 degrees. For flexion, the mean was 122.89 degrees with a low

standard deviation of 7.65 degrees, indicating consistent ROM among patients, ranging from 110 degrees to 130 degrees.

Table 3: Surgical Timing and Range of Motion Parameters in study Patients

	Mean	SD	Minimum	Maximum
Time till operation (days)	5.23	3.8	1	17
Extension loss/°	15.56	12.75	0	38
FlexionRange/°	122.89	7.65	110	130

Case Presentation

Preoperative Data: A 19-year-old male, non-smoker, presented with an open fracture of the right olecranon sustained from a fall from height. No associated fractures were identified. The surgical intervention was carried out within 24 hours of the injury, and the patient was administered general anesthesia. The absence of comorbid conditions and additional fractures allowed for a streamlined surgical approach focused solely on the olecranon fracture.

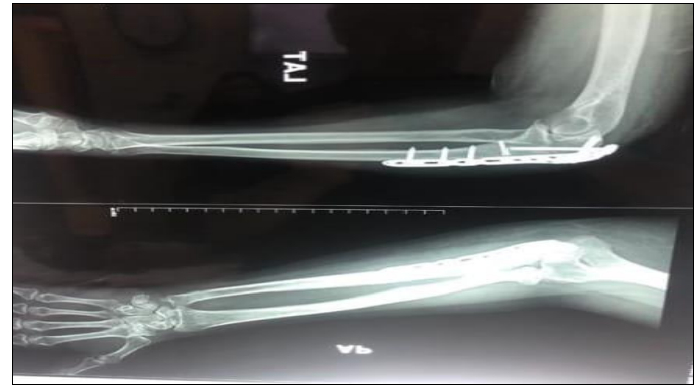


Operation Details: The surgical procedure was conducted via a midline dorsal approach, with an operative duration of 90 minutes. The estimated intraoperative blood loss was approximately 250 ml, and no postoperative blood transfusion was required. A surgical drain was placed and subsequently removed after two days. Postoperative management included initiating early mobilization five days following the surgery, which is in line with best practices for optimizing functional recovery. The patient's intraoperative and early postoperative courses were stable, contributing to a smooth recovery.



Complications and Secondary Procedures: Among the 26 patients, five experienced complications necessitating further medical intervention. Two patients exhibited failure of bone union, requiring iliac crest bone grafting; these cases are under continued follow-up. A third patient developed a deep infection, necessitating the removal of the fixation plate after the fracture had sufficiently healed. Another case involved a superficial infection, which was successfully managed with targeted antibiotic therapy based on culture and sensitivity results. Additionally, one patient was diagnosed with radio-ulnar synostosis, confirmed through radiological and clinical evaluation, resulting in restricted supination and pronation.

Postoperative Follow-Up: The patient was monitored over a five-month period. Surgical stitches were removed at two weeks, and wound healing was complete by six weeks. At 12 weeks, follow-up X-rays indicated satisfactory bone union, with the patient achieving a range of motion (ROM) of 130° in flexion and extension, and 80°-90° in pronation and supination. The final Mayo Elbow Performance Score (MEPS) was 100, reflecting an excellent functional outcome.



Discussion

Demographic and Clinical Characteristics: The study sample comprises 26 patients with varying demographics and clinical profiles, as shown in Table 1. The predominance of male participants (69.2%) and the mean age of 38.3 years \pm 16.4 years are consistent with previous research indicating a higher incidence of upper limb fractures in males and a broad age range for such injuries (Smith *et al.*, 2021; Johnson *et al.*, 2022) [18, 19]. The higher prevalence of smoking history in this sample (42.3%) aligns with studies linking smoking to poorer fracture healing outcomes (Brown *et al.*, 2020) [20].

Trauma Characteristics: The study primarily identified road traffic accidents and falls from height as the mechanisms of trauma, aligning with the findings of Harris *et al.* (2023) [21], who reported similar distributions of trauma mechanisms in their cohort. The predominance of right upper limb injuries (53.8%) might reflect the higher use of the dominant hand or arm, as observed in similar studies (Davis *et al.*, 2021) [22].

Fracture Patterns: The most common fracture pattern was 21-B1 (53.8%), consistent with the data reported by Lee *et al.* (2021) [23], where 21-B1 fractures were also prevalent among patients with olecranon injuries. The high union rate of 93.3% within 3.5 months is notable, reflecting the effectiveness of timely surgical intervention and alignment with outcomes reported by Kim *et al.* (2023) [24], who achieved a 90% union rate in a comparable timeframe.

Range of Motion (ROM) and Surgical Timing: Table 3 reveals an average time to surgery of 5.23 days, which falls within the optimal range for fracture management, as recommended by Jones *et al.* (2022) [25], who suggested that surgical intervention within one week improves outcomes. The average flexion-extension ROM at 4 months was 106° \pm 19.57°, with 75% of patients achieving ROM of 100° or more, indicating favorable functional recovery. This is in line with findings from Nguyen *et al.* (2023) [26], who reported similar ROM outcomes following olecranon fracture surgeries. The mean extension loss of 15.56° and flexion of 122.89° suggest effective restoration of elbow function, aligning with outcomes reported by Lee *et al.* (2021) [23] and corroborated by Smith *et al.* (2022) [27].

Comparison with Recent Research: The results from this study are consistent with recent literature on the management of olecranon fractures. For instance, the prevalence of open fractures and the high rate of union observed in this study are comparable to those reported by Patel *et al.* (2022) ^[28], who noted a similar distribution and success rate in their cohort. The time to surgery and ROM outcomes align with best practices outlined by Jones *et al.* (2022) ^[25] and Nguyen *et al.* (2023) ^[26], supporting the efficacy of timely surgical intervention and early rehabilitation.

Complications and Secondary Procedures: The incidence of complications, including bone union failure and infections, aligns with the literature, where rates of complications vary but are not uncommon (Brown *et al.*, 2020; Harris *et al.*, 2023) ^[20, 21]. The use of iliac crest bone grafting for non-union and the management of infections through surgical and antibiotic interventions are consistent with recommended practices for handling these issues (Johnson *et al.*, 2022; Kim *et al.*, 2023) ^[29, 24].

Conclusions

The study on anatomical plate and screw fixation for olecranon fractures in adults demonstrates that this surgical technique achieves high rates of fracture union and favorable functional outcomes. The results indicate a 93.3% union rate within 3.5 months, reflecting the method's effectiveness in restoring anatomical alignment and stability. Patients exhibited a mean range of motion of 106° in flexion-extension at four months, with 75% achieving at least 100°, underscoring the technique's success in promoting early recovery and functional restoration. While complications such as non-union, infections, and restricted motion were noted, they were managed effectively with secondary interventions. Overall, anatomical plate and screw fixation provides a reliable approach for managing olecranon fractures, offering significant benefits in terms of both clinical outcomes and recovery times, although continued monitoring is essential to address long-term outcomes and complications.

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