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Treatment of Supracondylar Humerus Fracture in Adults by Parallel Plates

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ABSTRACT

Objective: The aim of this study was to evaluate the outcome of parallel plates for the treatment of supracondylar humerus fractures in adults.

Patients and Methods: This study included 20 adult patients with supracondylar humerus fractures. They were treated by open reduction and internal fixation by parallel plates through olecranon osteotomy technique. They were followed up clinically and radiologically for 6 months. On admission, all were assessed by careful history taking and detailed clinical examination. The preoperative radiological workup was performed by antero-posterior and lateral radiographs of the elbow with traction and computed tomography was performed with three-dimensional reconstruction. Postoperative, patients were assessed after 2, 4, 8, 12 weeks and 6 months of surgery, with clinical and radiological evaluations and assessed for pain, swelling, range of joint motion and radiological union. The functional assessment of the patient was done according to Mayo elbow performance index and the outcome was graded into excellent, good, poor and fair.

Results: The excellent outcome was achieved among 55.0%, while 30.0% had good, 10% had fair and 5.0% had poor outcome. The overall complication rate was 30.0% and the commonest were pain and stiffness (15.0% for each). The mean±SD times to clinical and radiological union were 12.75 ± 6.44 and 14.70 ± 7.84 weeks, respectively. The excellent outcome was significantly associated with lower rate of complications and shorter time to clinical and radiological union.

Conclusion: Parallel plates for the treatment of adult supracondylar humerus fractures could be considered safe and effective technique, leading to good functional outcome and a complication rate comparable to published literature.

Keywords: Fracture fixation; Humeral Fractures; Elbow; Olecranon; Parallel Plates.

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INTRODUCTION

Fracture distal humerus accounts for 2 -6 % of all the fractures and its incidence in the adults around 5.7 per 100,00 per year [1,2]. In young patients, distal humeral fractures are commonly caused by high velocity injuries, such as sports injuries or road traffic accidents. In contrast, distal humeral fractures in elderly people are predominantly low velocity injuries complicated by poor bone quality [3]. Distal humerus fracture can be classified based on the Orthopedic Trauma Association / *Arbeitsgemeinschaft für Osteosynthesefragen* (OTA/AO) classification system as extra-articular fractures (type A), partial articular fractures (type B), and complete articular fractures (type C). Intra-articular fractures incorporate trochlea and capitulum fractures [4]. The examining surgeon must play out an exhaustive neurovascular assessment with all speculated elbow fractures; perceive subtle fracture; give sufficient immobilization and survey whether fractures require admission, quick orthopedic assessment or less urgent referral [5,6]. Dealing with such fractures can be very challenging due to the intricate anatomy of the elbow and small fracture fragments. In adults, the gold standard treatment for the distal humerus fractures is considered to be the open reduction internal fixation (ORIF) with plate fixation of both columns [7,8].

Open reduction and internal fixation with plates with good articular reconstruction have demonstrated satisfactory clinical outcomes. Firm stabilization can be achieved through various methods of fixation of plates [9-11]. Among them, several mechanical studies have proved that double plate fixation provides more stable fixation than other methods [12-14].

Various plate designs have been developed for the fixation of these fractures, some are like Y-plates, recon plates, precontoured anatomical plates. However, controversy still exists concerning the plate positions in terms of providing optimal stability for distal humerus fractures. The most widely used plate fixation method is placing plates perpendicular to each other one over medial supracondylar ridge and other one over the flat posterior surface of lateral column called as orthogonal plating. Stoffel *et al* demonstrated on mechanical studies two plates placed parallel to each other, one over each supracondylar ridge, providing better stability in compression and external rotation than to perpendicular plating system in cadaveric models [15-17].

THE AIM OF THE STUDY

The aim of this study was to evaluate the outcome of parallel plates for the treatment of supracondylar humerus fractures in adults.

PATIENTS AND METHODS

This clinical trial had been conducted for supracondylar humerus fractures in adult patients admitted to the department of Orthopedic Surgery, Al-Azhar University Hospital (New Damietta). Patients were treated by open reduction and internal fixation by parallel plates during the period from March to September 2022. They were followed up clinically and radiologically for 6 months.

The inclusion criteria: 1) Recent supracondylar humerus fractures, 2) Age between 18 and 60 years, and 3) Isolated closed supracondylar traumatic humerus fractures. On the other side, the exclusion criteria were the presence of open injuries, polytrauma patients, pathological fractures (except osteoporosis), and fractures with distal neurovascular injury.

Sampling technique: A non-probability (convenient) sample technique was used to recruit cases. All patients admitted in the Orthopedic Department during the study period and who's matching the inclusion criteria were recruited to participate in this study after taking the informed consent. They were (20) patients.

Ethical considerations:

The details of the operation technique & complications were explained to the patients and informed written consent was obtained. The right to withdraw was granted and the collected data were obtained for research purposes only without divulging of any data talk about the personality of the patient (Confidentiality will be ascertained). In addition, the study protocol approved by the local research and Ethics Committee of Al-Azhar Faculty of Medicine (New Damietta) (IRB# DFM-IRB00012367-22-03-008).

All patients were treated with open reduction and internal fixation with parallel plates through olecranon osteotomy technique, and they were followed up clinically and radiologically for 6 months. On admission, all were assessed by careful history taking and detailed clinical examination. This included inquiry about personal data, comorbid disease conditions (e.g., diabetes mellitus (DM), Cardiac disease, hypertension, etc..), the mechanism of injury, pain or swelling, deformity, wounds, ecchymosis, neurovascular integrity, or associated injuries. The neurological examination was performed to assess the ulnar, radial and median nerve function. The preoperative radiological assessment was performed by antero-posterior and lateral radiographs of the elbow with traction. Computerized tomography of the elbow was performed especially in partial or very distal fractures because the various fragments usually superimposed, which hinders precise analysis of the fracture on standard views. Three-dimensional reconstruction showed the shape and position

of the bone fragments and was helpful in determining the appropriate surgical approach. To complete preoperative evaluation, laboratory tests were performed. This included complete blood count and bleeding profile, kidney and liver function tests, fasting blood sugar and postprandial blood sugar tests.

The preoperative preparation achieved by the application of the above elbow slab with good padding to all the bony prominences, proper analgesia, control of any comorbid condition, and intravenous antibiotic administration, one hour before surgery. An informed consent for surgery was signed by the patient and his first close relative. This was signed after full explanation of the surgery and possible complications.

All surgeries were performed under general anesthesia in lateral decubitus position with arm supported and forearm hanging. The elbow was then exposed through standard midline posterior approach with incision beginning 5cm distal to the tip of the olecranon and extending proximally in the arm up to 10 cm above the tip of the olecranon **(Figure 1).** The ulnar nerve was exposed and secured **(Figure 2).** Ulnar nerve was identified proximally along the medial border of triceps, then released through the cubital tunnel down until the first motor branch by incision of the flexor pronator aponeurosis as the nerve passes between the two heads of flexor carpi ulnaris (FCU). The site of the osteotomy was determined by subperiosteal reflection of the anconeus laterally and the ulna head of FCU medially to expose the olecranon. The bone was cleared with a small elevator at the site of the planned osteotomy. About 1.5 cm from the tip of olecranon the apex distal chevron osteotomy was performed with an oscillating saw and completed with an osteotome to facilitate interdigitation. A 'V' shaped Olecranon osteotomy was done to get better exposure of the articular surface in all cases as proximal mobilization of the osteotomized fragment and triceps allows ample exposure of the articular surface and columns **(Figure 3).** The articular fragments of inter-condylar humerus were reduced and held with 'K' wires and then fixed with intercondylar screw. The reconstituted articular (condylar) block was reduced to the more stable column and one or more K-wires were used for preliminary fixation. The comminuted fragments of the other column were reduced into correct alignment and one or more K-wires were used for preliminary fixation. The accurate alignment of the articular block to the shaft was assured. One third tubular plates were placed parallel to each other on medial and lateral columns **(Figure 4).**

The plates were secured with 3.5 mm cortical screws in diaphyseal area and with 4 mm cancellous screws in metaphyseal area. Proximal end of both plates was not at the same level to avoid stress riser fracture. The stability of the internal fixation was tested by moving the elbow through full range of motion. The Olecranon osteotomy was reduced and held with pointed reduction forceps to apply compression. Then distal to the fracture line, a hole was drilled through the ulna. Then a tension band was inserted through a drilled hole. then 2 k-wires were inserted through the proximal end of olecranon towards the anterior cortex under direct vision. The tension band was passed under triceps tendon in a figure of '8" around 2-pointed k-wires **(Figure 5).** After fixation of the osteotomy the elbow was again put through the range of motion to test the stability of fixation. Suction drain was inserted and incision was closed in layers by sutures or surgical staples. The arm was bandaged to support and protect the surgical wound.

In the postoperative period, the limb was kept elevated. Active movement of fingers and elbow joint were encouraged from second postoperative day. Suction drain was removed after 24 hours. Antibiotic prophylaxis was given as intravenous administration for 3 days and continued with oral antibiotic for 4 days. Analgesics were given until the pain was subsided. Suture/staples were removed on the 14th postoperative day. Post-operative radiographs were obtained as soon as patient was comfortable **(Figure 6).**

Elbow was mobilized through full range of movement at least twice daily and patient was discharged with instruction to carry out physiotherapy outside the hospital in the form of active flexion-extension and pronation-supination exercises without loading. Patient was assessed after 2 ,4, 8, 12 weeks and 6 months of surgery. At every follow up a detailed clinical examination was done and patient was assessed subjectively for the pain, swelling, range of joint motion and radiological union. The functional assessment of the patient was done according to Mayo elbow performance index.

The Mayo Elbow Performance score (MEPS) is an instrument used to test the limitations of the elbow during activities of daily living (ADL) [18]**.** It included 4 domains (pain, range of motion, stability and daily function). The total score reached 100 and value below 60 was considered poor. Values between 60 and 74 are fair, while values between 75 and 89 are good, and values between 90 and 100 are excellent.

Statistical analysis: Data was coded and entered to a Microsoft Excel Sheet. Data were then imported into Statistical Package for Social Sciences (SPSS) version 16.0) (SPSS Inc., Chicago, USA) for analysis. The relative frequencies and percentages were calculated for qualitative (categorical variables), while mean, standard deviation, sometimes minimum and maximum values were computed for quantitative continues variables.

Figure (1): Incision over the elbow

Figure (2): Ulnar nerve exploration

Figure (3): V-shaped olecranon osteotomy

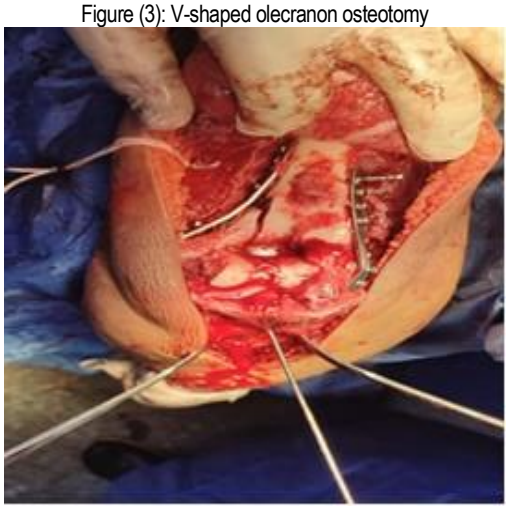

Figure (4): K-wire and parallel plates fixation

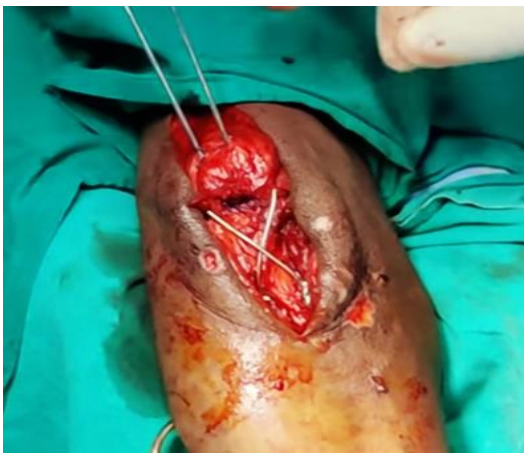

Figure (5): K- wire and tension band of olecranon

Figure (6): X ray AP and Lateral of elbow after fixation

RESULTS

The current study included 20 patients, their age ranged between 28 and 50 years, with male-sex predominance (males represented 70.0%); smoking practiced by 35%, while 20.0% had hypertension and 15% had diabetes mellitus. The road traffic accident was the major mode of injury (75.0%), with right had predominance (70.0%) and 90% of subjects were right-handed (Table 1).

According of MEPS grading system, 55.0% had an excellent outcome, 30.0% had good, 10% had fair and 5.0% had poor outcome. The complications were reported among 30.0% of subjects and commonest were pain and stiffness (15.0% for each complication). The mean±SD times to clinical and radiological union were 12.75 ± 6.44 and 14.70 ± 7.84 weeks, respectively (Table 2).

The excellent outcome when compared to other outcomes was significantly associated with significantly lower rate of complications and stiffness. In addition, it is significantly associated with shorter time to clinical and radiological union. Otherwise, no significant association was discovered (Table 3). The laboratory data was mainly in normal values and showed no significant association with excellent outcome (Data not tabulated).

Table (1): Demographic data of the studied patients.

Variables		Statistics
Age (year)	Mean ±SD	37.45±6.23
	Min. – Max.	28- 50
Sex (n, %)	Male	14 (70.0%)
	Female	6 (30.0%)
Comorbid conditions (n, %)	Smoking	7 (35.0%)
	Hypertension	4 (20.0%)
	Diabetes mellitus	3 (15.0%)
Mode of injury (n, %)	RTA	15 (75.0%)
	Fall from height/heavy object	3 (15.0%)
	Assault	2 (10.0%)
Injured side (n, %)	Right	14 (70.0%)
	Left	6 (30.0%)
Dominant hand (n,%)	Right	18 (90.0%)
	Left	2 (10.0%)

Table (2): Final outcome among the study subjects.

		Statistics
MEPS Outcome	**Excellent**	11 (55.0%)
	Good	6 (30.0%)
	Fair	2 (10.0%)
	Poor	1 (5.0%)
Postoperative complications (n, %)	**Total complications**	6 (30.0%)
	Myositis	1 (5.0%)
	Stiffness	3 (15.0%)
	Infection	2 (10.0%)
	Non-union at osteotomy	1 (5.0%)
	Pain	3 (15.0%)
	Hardware prominence	1 (5.0%)
Time to	**Clinical union (weeks)**	12.75 ± 6.44
	Radiological union (weeks)	14.70 ± 7.84
Mayo score		86.35 ± 12.67

Table (3): Factors associated with excellent outcome compared to others

		Excellent outcome (n=11)	Other outcome grades (n=9)	Test	p
Age (years)		37.90±6.65	36.89±6.03	0.35	0.72
Sex	Male	9 (81.8%)	5 (55.6%)	1.62	0.20
	Female	2 (18.2%)	4 (44.4%)		
Comorbid conditions	Smoking	4 (36.4%)	3 (33.3%)	0.02	0.89
	Hypertension	2 (18.2%)	1 (11.1%)	0.19	0.66
	Diabetes mellitus	3 (27.3%)	1 (11.1%)	0.81	0.36
Mode of injury	RTA	8 (72.7%)	7 (77.8%)	2.22	0.32
	Fall from height/heavy object	1 (9.1%)	2 (22.2%)		
	Assault	2 (18.2%)	0 (0.0%)		
Injured side	Right	8 (72.7%)	6 (66.7%)	0.09	0.76
	Left	3 (27.3%)	3 (33.3%)		
PO complications	Total complications	1 (9.1%)	5 (55.6%)	***5.08***	***0.024****
	Myositis	0 (0.0%)	1 (11.1%)	1.28	0.25
	Stiffness	0 (0.0%)	3 (33.3%)	***4.31***	***0.038****
	Infection	0 (0.0%)	2 (22.2%)	2.71	0.10
	Non-union at osteotomy	0 (0.0%)	1 (11.1%)	1.28	0.25
	Pain	1 (9.1%)	2 (22.2%)	0.67	0.41
	Hardware prominence	0 (0.0%)	1 (11.1%)	1.28	0.25
Time to	Clinical union (weeks)	9.18±1.60	17.11±7.52	***3.42***	***0.003****
	Radiological union (weeks)	10.91±1.36	19.33±9.35	***2.97***	***0.008****

DISCUSSION

This study was conducted for supracondylar humerus fracture in adults treated by open reduction and internal fixation by parallel plates by olecranon osteotomy technique and they were followed up clinically and radiologically for 6 months. **Yadav *et al.*** [19] reported that, the olecranon osteotomy approach does not seem to have a clinical advantage over the approaches that preserve the integrity of the elbow extensor device. However, a systematic review and meta-analysis conducted by **Chen *et al.*** [20] compared various surgical approaches on elbow functional outcomes for patients with distal humerus intercondylar fractures (DHF). They concluded olecranon osteotomy was superior than triceps-sparing approach in restoring joint function**.** The meta-analysis included four studies with 276 patients, and compared olecranon osteotomy with triceps-sparing. The pooled analysis indicated that patients treated using olecranon osteotomy had a better functional outcome than patients treated with triceps-sparing. Thus, we used it on the current work.

Results of the current work are in line with **Kumar *et al.*** [21] who included 23 subjects, their mean age was 39.1±11.5 years with male sex predominance (69.6%). They reported union rate in all patients and complications rate of less than 19%. However, they followed up their patients for a longer duration (for up to one year) that the current study. **Salvador *et al.*** [22] treated 27 supracondylar humeral fractures and achieved 96.0% complete union at 6 months of follow up. They reported no infection. However, two subjects needed another surgery to treat stiff elbow. 60% of subjects were able to return to their previous usual activities. To explain their results in the light of the current one, they included older patients (the mean age was 56 ± 22.9 years) with higher females (52.0%). In addition, **Shah *et al.*** [23] reported excellent outcome in 41 (56.94%), good in 21 (29.17%), fair in 6 (8.33%) and poor outcome in 4 (5.56%) of their patients. These results are comparable to the current study. However, **Singh *et al.*** [24] reported that total of 25 patients, 8 patients (32%) got excellent results, 14 patients (56%) got good outcome and 3 (12%) got poor outcomes.

Most recently, **Jagadish U *et al.*** [25] reported on a total of 30 patients with distal humerus fracture fixed with parallel plates. The excellent outcome was reported among 47%, while 33.0% had good outcome, 13.0% had fair and 7.0% had poor outcome. The results which comparable to the current work.

Postoperative pain was reported among 15.0% in the current work. However, **Salvador *et al.*** [22] reported mild and moderate pain in 9 and 6 out of 27 patients included in their study, which is quite different and higher than the current work. This could be explained by the older age of their patients and the predominance of females, where the threshold of pain is lower among them than younger (adult) males (the predominant in the current work). Additionally, **Patel *et al.*** [26] reported a complication rate of 61%. Among all patients, 49% required a reoperation. Elbow stiffness (19%) was the commonest complication followed by nerve palsy (16%). The non-union rate was 9.0% and the deep infection, painful implants, post-traumatic arthritis and heterotopic ossification (9% for each of them). The higher rate and different distribution of complications are due to heterogeneous surgical procedures according to surgeon preferences. Furthermore, **Singh *et al.*** [24] revealed a complication rate of 44%. The commonest were painful hardware, superficial infection and transient ulnar nerve palsy.

Conclusion: Parallel plates for the treatment of adult supracondylar humerus fractures could be considered safe and effective technique, leading to good functional outcome and a complication rate comparable to published literature. However, the relatively low number of patients, shorter duration of follow up, absence of comparative groups or procedures are limiting steps of the current work. This advocate future studies including higher number of patients with longer duration of follow up. The current one represented one step on the road to determine the ideal intervention.

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