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PLATE FIXATION FOR OLECRANON FRACTURES (PROXIMAL ULNA)

By

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ABSTRACT

Background: Complex fractures of olecranon with severe comminution have become more frequent in the recent years. However, these fractures still remain a treatment challenge for trauma surgeons. To allow early functional mobilization and to prevent stiffness of the elbow joint, the fracture fixation has to provide secure stability. Especially for severely comminuted olecranon fractures, fractures including the coronoid process and Monteggia fracture dislocations, plate fixation have evolved as gold a standard treatment.

Objective: To investigate the efficacy of plate fixation of comminuted olecranon fractures in achieving good functional result measured by Mayo Elbow Performance score (MEPS) , union and range of motion.

Patients and methods: A prospective case series was conducted at Beni Suef Generalized Hospital on patients with comminuted olecranon fractures presenting to the emergency department. The study included fifteen patients, all of whom were treated by open reduction and internal fixation (ORIF) using anatomical locked plate, during the period from February 2020 to March 2021. All patients followed the same postoperative and rehabilitation program allowing early range of motion. The mean follow up period was 4 months. Patients were evaluated for functional outcome using MEPS, range of motion, union and secondary procedure rate.

Results: After 4 months, the average range of motion was 106° ±19.57° with a mean extension loss of 16.67° ± 12.91° and mean flexion range of 122.67° ± 7.99° .The mean functional score was 87.67 ± 13.61 with 86% of cases achieving good or excellent outcomes. 93.3% of patients united, and 6.6% required secondary grafting with no cases of hardware breakage, or fracture displacement. The secondary procedure rate was 12.5%.

Conclusion: Anatomically preshaped locking compression plate (LCP) was an effective fixation method for comminuted fractures of the olecranon allowing reliable stability for early elbow motion.

Keywords: Plate fixation, Olecranon fractures, proximal ulna, locking compression plate.

INTRODUCTION

Olecranon fractures are common injuries of the proximal ulna which constitute about 10% of all upper extremity lesions *(Siebenlist et al., 2011)*. Most olecranon fractures follow low-energy trauma such as a fall from a height of less than 2 meters, a direct blow to the elbow, or from forced hyperextension. A fall on a partially flexed elbow may generate an avulsion fracture of the olecranon from the pull of the triceps. The fractures are usually isolated but associated lesions can occur in complex injuries and polytrauma cases *(Bailey et al., 2010)*.

The aim of fracture treatment is to restore early, active, elbow motion in order to prevent joint stiffness *(Nowinski et al., 2010)*. Open reduction and stable fixation with the anatomical reduction of the articular surface is the gold standard for olecranon fracture treatment. Various fixation techniques have been used for proximal ulna fracture treatment, including tension band wiring, intramedullary screws, plate and screw fixation, rush pins, small specially designed olecranon nails and simple fragment excision with re-attachment of the triceps tendon *(Hutchinson et al., 2013)*.

Tension band wiring (TBW) is the gold standard fixation for treating displaced transverse intraarticular olecranon fractures a principle first advocated by Weber and Vasly in 1963. However, a number of complications such as infection, non-union, malunion and ulnar nerve palsy could compromise the effect of operative treatment in up to 10% of cases *(Romero et al., 2010)*.

Plate fixation was reported to give adequate stability and achieve fracture union in simple and comminuted olecranon fractures. Despite the excellent union rates, 20% of plates needed to be removed because of prominence under the skin. Due to dissatisfaction with reoperation rates for plate fixation, a prototype locked intramedullary nail (IMN) was developed to provide internal fixation for such fractures. It was hypothesized that this IMN would result in a stiffer and stronger fixation than TBW fixations and that the interlocks would prevent hardware migration. In case of fracture comminution, stable and long-term reliable fixation is required. The reasons for these requirements are the necessity for immediate postoperative elbow motion for adequate rehabilitation and the risk of fatigue failure, which can be caused by extreme bending stresses *(Bailey et al., 2010)*.

Because of biomechanical advantages, plate fixation of comminuted olecranon fractures is preferable than tension band wiring and therefore considered as the golden standard for treatment of comminuted fractures *(Hak and Golladay, 2010)*.

As an application of an intramedullary screw may interfere with the placement of bicortical screws in the ulnar shaft, a locking compression plate (LCP) allowing for placement of unicortical screws can be used instead. If unicortical locking screws is used, interference with a long intramedullary screw can be prevented *(Buijze et al., 2010)*. Placement of an intramedullary screw in a metaphyseal plate with bicortical screws has been reported to provide more support to the construct as it acts as an internal splint, analogous to an intramedullary nail *(Gordon et al., 2012)*.

The aim of the present study was to investigate the efficacy of plate fixation of comminuted olecranon fractures in achieving good functional result measured by Mayo Elbow Performance score (MEPS), union and range of motion.

PATIENTS AND METHODS

A prospective case series was conducted at Beni Suef Generalized Hospital on patients with comminuted proximal ulnar fractures presenting to the emergency department. The study

included fifteen patients, all of whom were treated by open reduction and internal fixation (ORIF) using anatomical locked plate, during the period from February 2020 to March 2021.

Inclusion criteria: Comminuted proximal ulnar fractures, age group 18-70 years, closed fractures, open fractures (Gustillo I, II, IIIA), and associated upper limb injuries.

Exclusion criteria: Pathological fractures, and skeletally immature patients.

Patients' evaluation:

Clinical evaluation:

i. History:

- Personal Data: Name, age, sex, occupation, address, telephone number, hand dominance, Special habits of medical importance
- Mode of trauma, time of trauma, any first aid medications given or procedures done.
- Co-morbidities: Diabetes, hypertension, cardiac, renal, any allergies.
- Pre fracture level of activity and ROM of affected elbow is asked for documentation.

ii. Examination:

- In cases involved in high energy trauma, management according to Advanced Trauma Life Support (ATLS) protocol ABCDE with attention to possible life threatening conditions, and other systems injury and associated fractures.
- Local examination to injured limb involves assessment of vascular and neurological status with meticulous attention to radial and ulnar nerves, any wounds, abrasions and local soft tissue edema.

iii. Investigations:

A. Radiological:

- Plain X-ray anteroposterior (AP) and lateral (Lat) views of the affected elbow, ipsilateral shoulder and wrist, In cases with high energy trauma other routine X-rays are done according to mode of trauma (chest, pelvis, cervical and lumbosacral spine).
- CT Scan: to determine the fracture pattern, planes and extension to the articular surface.

B. Laboratory:

- Routine pre-operative labs: CBC, PT, PC, INR, AST, ALT, RBS, urea and creatinine. Other labs were ordered according to associated co-morbidities.

Preoperative management:

- Immoblization: In an above elbow slab to decrease pain, and soft tissue injury.
- In case of open fractures : Antibiotics as early as possible, in this series ceftriaxone 1.5gm/8hrs was used, saline soaked dressing for initial coverage of wounds after taking photos to avoid need for any more exposure in case further assessment of the wound is warranted by multidisciplinary trauma team.
- Anti-edematous measures: Limb elevation and anti-edematous drugs.

- Proper control of blood sugar in diabetic patients.
- Anesthesia consultation to check for surgical fitness. Other consultations were performed according to associated co-morbidities.
- All patients were orally consented for the study.

Postoperative management:

- Immediately after wound closure, the elbow was placed in a bulky noncompressive Jones dressing with a plaster slab in flexion, and the upper extremity was kept elevated and immobilized for three to seven days postoperatively.
- Immediate post-operative X-rays were performed: elbow AP and Lat views.
- Neurovascular status was examined after the patient regains his awareness.
- Patients were prescribed intravenous antibiotics (ceftriaxone 1 gm every 12 hours), analgesics and anti-oedematous injections.
- The slab was removed before discharge, all patients were permitted active use of the hand and were instructed not to lift (or push or pull) anything heavier than a glass of water or a telephone receiver for the first six weeks. No form of external protection such as casts or braces was used. Patients were taught on discharge active and active assisted exercises for flexion and extension, supination and pronation. Patients were discharged on oral antibiotics, anti-oedematous and analgesic medications.

Follow up program:

- At 2 weeks: Removal of stitches, discontinue oral antibiotics and encourage the use of hand and elbow according to previously mentioned precautions.
- At 6 weeks: X-ray AP and LAT views of elbow.
- At 16 weeks (4 months): X-ray Ap and LAT views to check for signs of union or hardware failure, record ROM and functional score and start instructed physiotherapy program according to X-rays.

Statistical methods:

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 25. Data were summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data.

RESULTS

Mean age in years was 39.73 ± 14.45 SD, with youngest being 19 years old and oldest 65 years old. There were 10 males and 5 females, 8 patients (53.3%) were smokers and 7(46.7%) were nonsmokers **(Figures 1& 2)**.

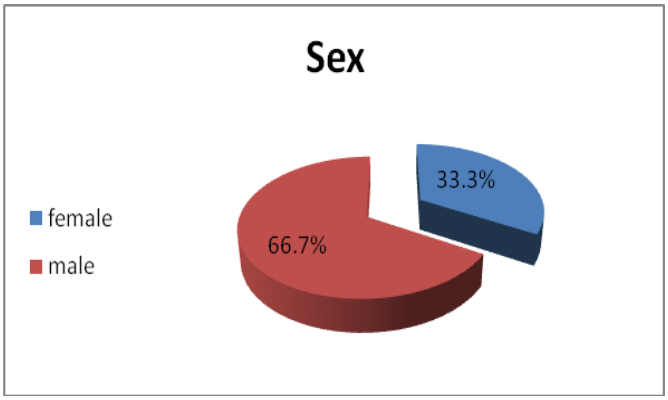

Figure (1): Percent age of male: female distribution

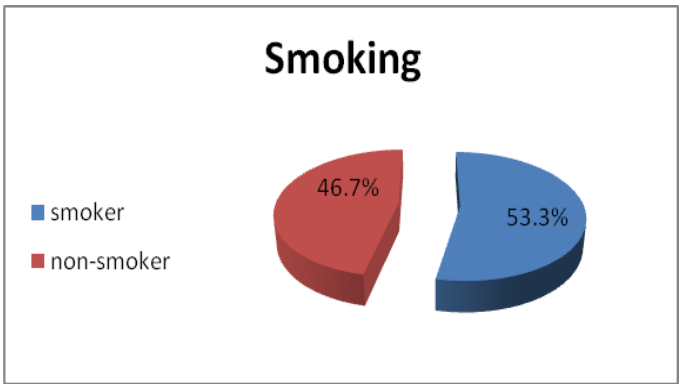

Figure (2): Percent age of smokers: non-smokers

Fifteen patients were Rt handed, the RT upper limb was affected in 8 patients (53.3%) and 7 patients (46.7%) had the left side affected **(Figure 3)**.

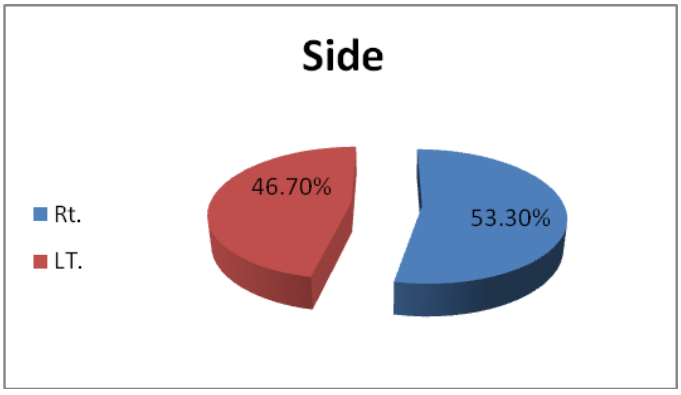

Figure (3): Percent age of patients with right elbow affected to left elbow affected

Four patients had a significant co-morbidity. Two patients were known to have diabetes and hypertension, one patient was known to have hypertension and one patient was known to have diabetes.

Preoperative data:

Mode of trauma (MOT) was direct trauma in 4 patients, falling down stairs in 4 patients, road traffic accidents in 4 patients, fall to the ground in 2 patients, and fall from height in 1 patient **(Figure 4)**.

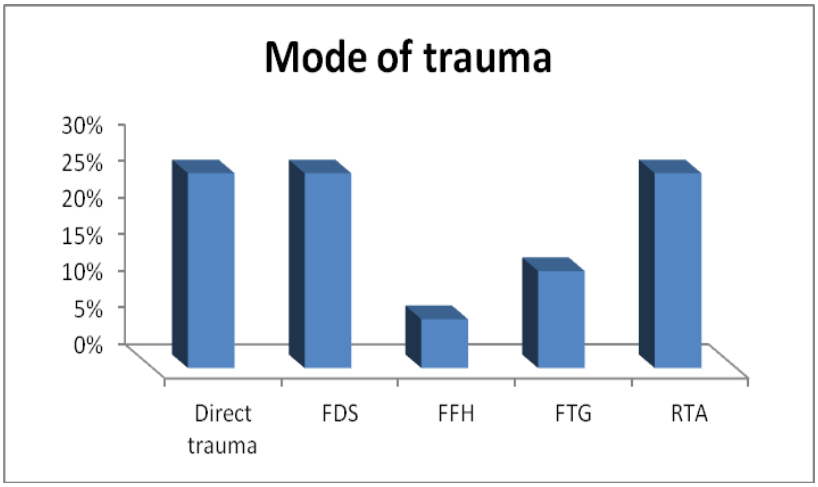

Figure (4): Percent of different modes of trauma.

The mean time from trauma till operation was 4.47 days with earliest done on day 1 and the latest done on day 15 **(Table 1)**.

Table (1): Time till operation in days

	Mean	SD	Minimum	Maximum
Time till operation (days)	4.47	3.8	1	15

Eight fractures (53.3%) closed, and 7 (46.7%) open **(Figure 5)**.

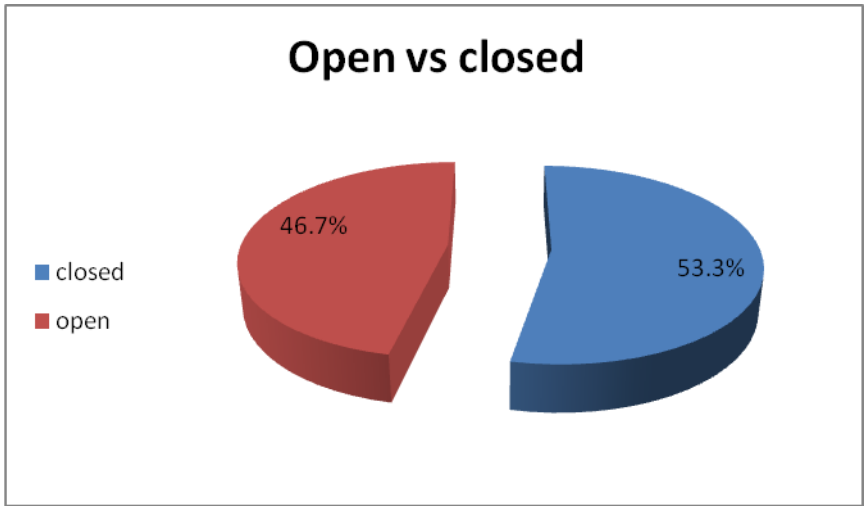

Figure (5): Percent of open and closed fractures

Eight patients (53.3%) were classified as 21-B1 pattern, 4 patients (26.7%) as 21-B1 (monteggia Bado type 1) pattern, 2 patients (13.3%) as 21-A1, and 1 patient (6.7%) as 21-B3 **(Figure 6)**.

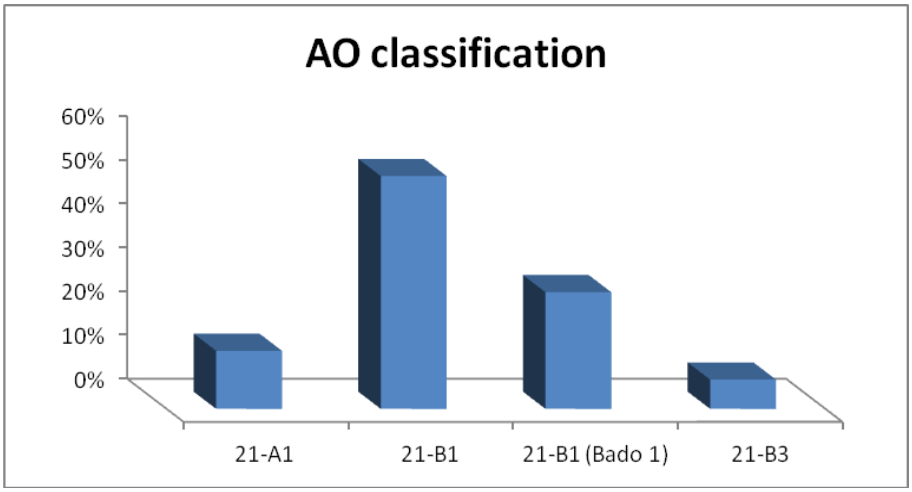

Figure (6): Distribution according to the fracture pattern

Out of fifteen patients, 9 (60%) had isolated proximal ulnar fractures and six (40%) had associated injuries. Out of those six, 2 (13.4%) had lower limb injuries, and 4 (26.8%) had ipsilateral upper limb injuries **(Figure 7)**.

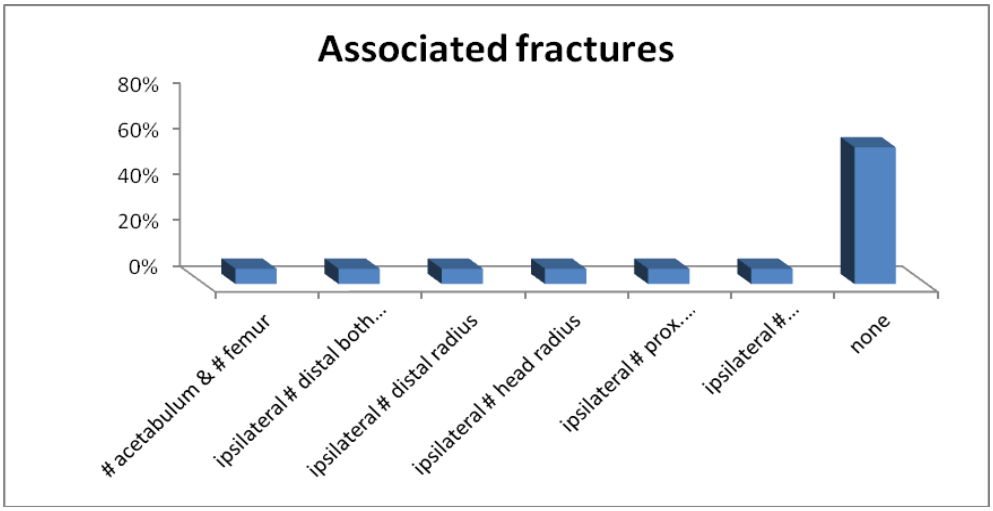

Figure (7): Distribution of cases according to presence and type of associated injuries

Fourteen of the 15 patients (93.3%) achieved union clinically and radiologically within 3.5 months, 1 patient failed to achieve union as evidenced by minor hardware failure as persistence of fracture lines and underwent grafting. This Patient is still under follow up. No major hardware failure was recorded **(Figure 8)**.

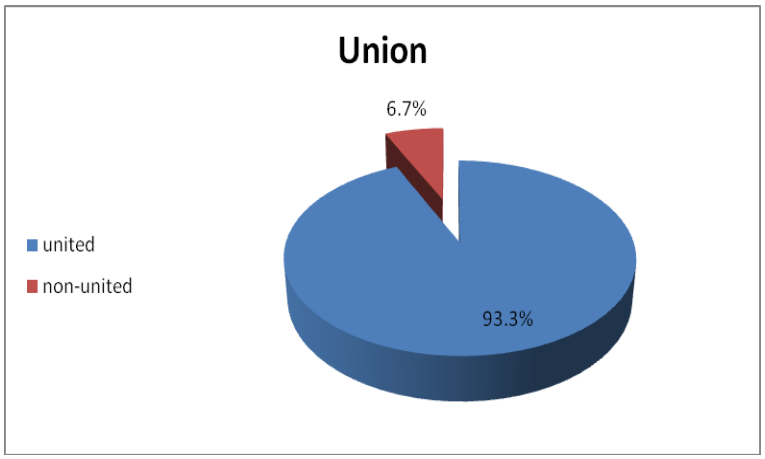

Figure (8): Percent of united cases vs nonunion cases

ROM at 4 months:

Mean flexion extension ROM at 4 months was 106° ± 19.57° SD with minimum 70° maximum 130°. Patients were distributed into 3 groups according to flexion extension ROM with patients with ROM less than 50° in a group, patients with range between 50-100° in a group and a third group containing patients with range of 100° or more. Five patients (25%) had a ROM between 50-100° and 10 patients (75%) had more than 100°.

Mean extension loss (flexion deformity) 16.67° ± 12.91° SD degrees and mean elbow flexion 122.67° ± 7.99° SD **(Table 2)**.

Table (2): Showing mean extension loss and mean flexion range in degrees

	Mean	**Standard deviation**	**Minimum**	**Maximum**
Extension loss/ °	16.67	12.91	0	40
Flexion Range/ °	122.67	7.99	110	130

Complications and secondary procedures:

Four patients had complications.

One patient showed failure of union for which iliac crest grafting was done and the patient is still under follow-up.

One case was diagnosed as having a deep infection and underwent plate removal after union of the fracture, another one had superficial infection for which antibiotics according to culture & sensitivity were given and the infection eventually treated.

One case was diagnosed as having radio-ulnar synostosis radiologically and clinically in which the patient suffered from limited supination-pronation range.

Case presentations:
Preoperative data:
- Male patient 19 years old non-smoker RT handed.
- Mode of trauma: FFH.
- Fracture type& side: open RT proximal ulnar fracture.
- Associated fractures: none.
- Time till surgery: 1 day.

Figure (9): Preoperative X-rays for case 1

Anesthesia: General.
Operation:
- Approach: Midline dorsal approach.
- Operative time: 90 mins.
- Intra operative blood loss: 250 ml.

Post-operative:
- Post-operative blood transfusion: nil.
- Drain removal: after 2 days.
- Mobilization after 5 days.

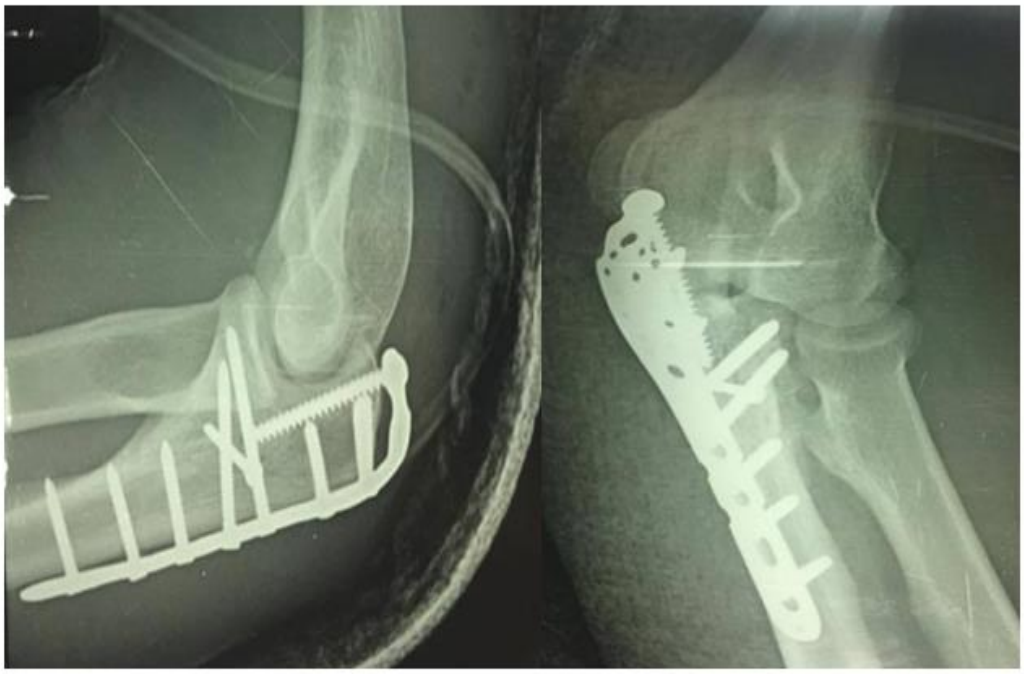

Figure (10): Immediate post-operative X-ray

Follow up: 5 months.
At 2 weeks: removal of stitches.
At 6 weeks: wound clean.
At 12 weeks:

- Follow up X-ray Good union.
- ROM 130° in flexion extension, 80°-90° pronation supination.
- MEPS 100.

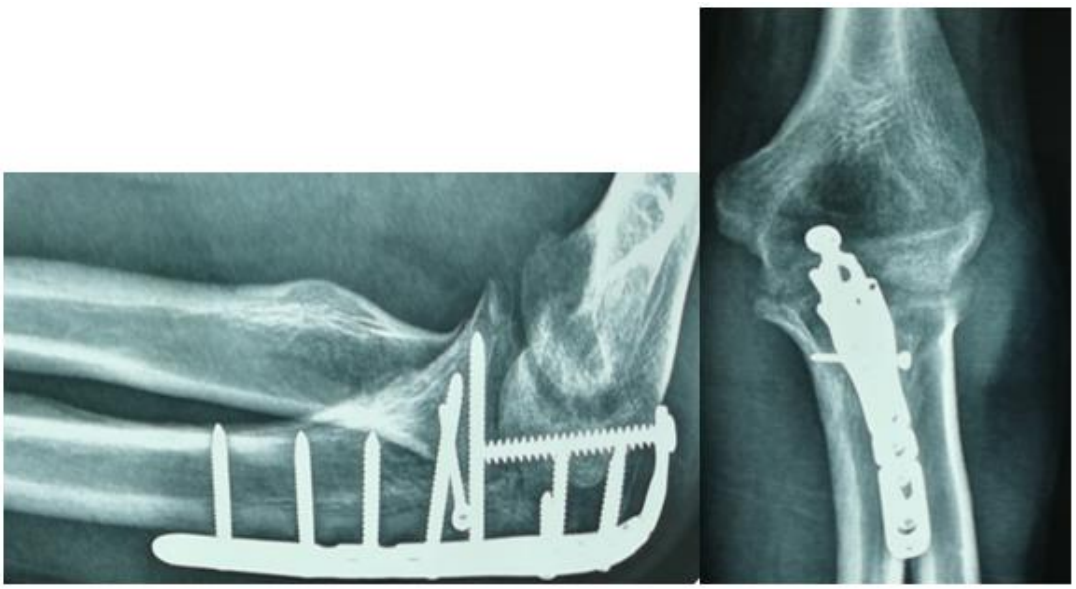

Figure (11): Follow-up X-ray at 12 weeks

Figure (12): ROM at 12 weeks.

Figure (13): Pronation Supination ROM at 12 weeks.

DISCUSSION

In this study a prospective case series in which fifteen patients with comminuted proximal ulnar fractures were included. Their mean age was 39.73 yrs. Four different fracture patterns were included as 21-B1 pattern, 21-B1 (monteggia Bado type 1) pattern, 21-A1, and 21-B3 according to the AO/ OTA classification, both open and closed fractures were included and patients with associated injuries were included. All patients underwent open reduction and internal fixation using a posterior plate. The average follow up period was 4 months and patients were assessed for union,

functional outcome, ROM and need for secondary surgeries. The results of the present study were taken before any secondary intervention and revealed a mean functional score using MEPS of 87.67 and a mean ROM of 106°, a secondary procedure rate of 13% and the percentage of cases requiring secondary grafting 6% with no cases of failure.

Congruent anatomic plating is a safe effective option for the treatment of olecranon fractures with a low rate of hardware removal and stability with early motion *(Andreson et al., 2013)*. In the current study anatomical Shaping of the plate before fixation helped in intraoperative stabilization of the fracture especially comminuted fracture.

The biomechanical advantages of posterior plating made it the gold standard for fixation of comminuted fracture olecranon *(Munoz-Mahamud et al., 2010)*. This finding is congruent with the current study as all comminuted fractures were stabilized with plating techniques and provided satisfactory results in terms of biomechanical stability.

Tension band has been recommended for comminuted fractures in the company of iliac graft which made it an alternative to plating technique *(Sultan and Khan, 2011)*. Although this method was not used by the current study, previous studies showed satisfactory results.

Anatomically preshaped locking compression plate to treat comminuted olecroanon fractures can attain stable fixation, perform early motion, and get satisfied results. LCP (locked compression plate) had the advantage of preserving the periosteal blood supply over 3.5mm reconstruction plate, as no compression of the plate onto the bone is required, and generates better endosteal blood supply, as part of the cortex is spared in unicortical screw fixation. Necrosis-induced bone loss as a consequence of decreased periosteal perfusion has been described as potential factor for implant loosening *(Erturer et al., 2011* and *Yang et al., 2011)*.

Buijze et al. (2010) reported the biomechanical strength of different plating techniques in comminuted olecranon fractures. Some studies simulated a comminuted fracture on cadavers. Most studies were based on the creation of a gap (or segmental defect) at the osteotomy site. It was unclear how well this correlates to a comminuted fracture without a large defect. In these simulations with segmental defects, there is no option for compression at the fracture site. Plates could only act as a buttress to prevent flexion bending at the fracture site. In other words, these studies merely tested the plate itself rather than the reconstruction. In our opinion this may raise doubts in the results of the plating techniques. In the current study posterior plating technique with recon. plate was used in comminuted fractures and we have gained satisfactory results towards stability and postoperative outcomes.

Buijze et al. (2010) had shown that by creating a reproducible osteotomy model would better simulate a comminuted fracture although this osteotomy model has not been previously evaluated in their study. Compression at the fracture site was achieved either by the coronoid lag screw in the one-third tubular plated specimens or by the intramedullary screw in the LCP specimens. Their results

revealed that there is no difference in stiffness or load to failure criterion of 2 mm gapping between locking compression plating and one-third tubular plating in comminuted olecranon fractures in the current study one third tubular plates and recon plates were used, non with intramedullary screw or coronoid lag screw, both providing satisfactory intraoperative and radiological results. The plates were anatomically contoured around the olecranon providing anatomical fixation, none of these cases have reported failure of instrumentation and full flexion and extension that were fairly accomplished, but the delay of full extension and flexion was mostly due to uncooperation of the patient with the instructions provided and associated injuries.

Arnander et al. (2011) concluded from his cadaveric study that Contoured LCP and intramedullary screw fixation can be used as an alternative treatment method for comminuted olecranon fractures as its stiffness and strength were not significantly different from a conventional plating technique. This finding is congruent with the current study as all the comminuted fractures fixed by LCP with intramedullary screw fixation provided satisfactory results in terms of biomechanical stability.

Siebenlist et al. (2010) showed that anatomically preshaped LCP olecranon plating is an effective fixation method for comminuted fractures of proximal ulna allowing reliable stability for early elbow motion with an average extension deficit 12o to an average flexion of 141o. Also, the arc of forearm rotation was from an average supination of 87o to an average pronation of 84o. None of the patients had any varus-valgus or posterolateral rotatory instability. The functional results are comparable with formerly described plating system. This finding is congruent with the current study and its results with average extension deficit 16o to an average flexion of 122o. Also, the arc of forearm rotation was from an average supination of 86o to an average pronation of 73o.

Gordon et al. (2012) conducted a cadaveric study and showed that posterior plating with an intramedullary screw was significantly stronger than dual medial and lateral plating and may, therefore, be the preferred method of fixation for comminuted olecranon fractures, especially when early motion is desired. Although this method (dual plating) was not used by the current study, previous studies showed satisfactory results.

Melamed et al. (2015) showed that a stable, functional elbow can be restored in most patients with proximal ulna fractures treated with open reduction and internal fixation. Loss of full flexion is likely with high-energy trauma, complex fracture patterns, and concomitant injuries. Fracture patterns involving the coronoid and/or the radial head are associated with restricted forearm rotation. This finding is congruent with the current study as most of comminuted proximal ulnar fractures resulted from high energy trauma as road traffic accidents showed a limited range of motion especially elbow flexion. Also in the current study a case of proximal ulnar fracture associated with radial head fracture ended up in radio-ulnar synostosis with limited pronation-supination range.

CONCLUSION

Anatomically preshaped LCP olecranon plating is an effective fixation method for comminuted fractures of the proximal ulna allowing reliable stability for early elbow motion. A low rate of symptomatic hardware removal suggested better patient's compatibility.

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التثبيت بالشرائح لكسور النتوء الزجى (اعلى عظمة الزند)

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خلفيـــة البحـــث: أصـــبحت الكســـور المعقـــدة فـــي عظـــم الزنـــد القريـــب مـــع التفتـــت الشـــديد أكثـــر تكـــرارا فـــي الســـنوات الأخيـــرة. ومـــع ذلـــك، لا تـــزال هـــذه الكســـور تشـــكل تحـــديًا علاجيًـــا لجراحـــي الصـــدمات. للســـماح بالتعبئـــة الوظيفيـــة المبكـــرة ولمنـــع تصـــلب مفصـــل الكـــوع، ويجـــب أن يـــوفر تثبيـــت الكســـر ثباتًـــا آمنًـــا. ولقـــد تطـــور تثبيـــت الصـــفيحة كعـــلاج دقيـــق بالنســـبة لكســـور الزُجِـــر المفتتـــة بشـــدة، والكســـور بمـــا فـــي ذلـــك عمليـــة الإكليـــل وخلـــع كســـر مونتيجيا.

الهـــدف مـــن البحـــث: التحقيـــق فـــي فعاليـــة تثبيـــت الصـــفيحة لكســـور الزبـــر المطحـــون فـــي تحقيـــق نتيجـــة وظيفيـــة جيـــدة تقـــاس بـــدرجات أداء كـــوع مـــايو، والاتحاد ونطاق الحركة.

المرضـــى وطـــرق البحـــث: تـــم إجـــراء سلســـلة حـــالات مســـتقبلية بمستشـــفى بنـــي ســـويف العـــام علـــى المرضـــى الـــذين يعـــانون مـــن كســـور الزنـــد القريبـــة المفتتـــة والمقدمـــة لقســـم الطـــوارئ. اشـــتملت الدراســـة علـــى خمســـة عشـــر مريضًـــا تـــم علاجهـــم جميعًـــا عـــن طريـــق التخفـــيض المفتـــوح والتثبيـــت الـــداخلي بإســـتخدام لوحـــة تشـــريحية مقفلـــة ، وذلـــك خـــلال الفتـــرة مـــن فبرايـــر 2020 إلـــى مـــارس 2021. يتبـــع جميـــع المرضـــى نفـــس برنـــامج مابعـــد الجراحـــة وإعـــادة التأهيـــل الـــذى يســـمح بالحركـــة فـــى وضـــع مبكـــر و بلـــغ متوســـط فتـــرة المتابعـــة 4 أشـــهر. تـــم تقيـــيم المرضـــى عـــن طريـــق معرفـــة القـــدرة الوظيفيـــة للكـــوع باســـتخدام مقيـــاس مـــايو لأداء الكـــوع و المـــدى الحركـــى والتئـــام الكســـر و معدل الاجراءات الثانوية.

نتـــائج البحـــث: بعـــد 4 أشـــهر كـــان متوســـط الحركـــة O19,57106O± و متوســـط فقـــدان بحركـــة البســـط O12,9167,16O± و متوســـط حركـــة القـــبض O7,9967,122O± و متوســـط مقيـــاس مـــايو 13,61±67,87 درجـــة و حصـــول 86% مـــن الحـــالات علـــى تقيـــيم ممتـــاز أو جيـــد. و تبـــين وجـــود معـــدل التئـــام 3,93% و تـــم الحاجـــة إلـــى إجـــراء ترقيـــع ثـــانوى فـــى 6,6% مـــن الحـــالات و لـــم يـــتم تســـجيل أى حالـــة كســـر للشـــرائح أو حركـــة للكســـر بعـــد التثبيـــت، تـــم إجـــراء تـــدخل جراحـــى ثـــانوى فـــى 5,12% مـــن الحالات.

الاســـتنتاج: تقنيـــة الشـــرائح ذاتيـــة الغلـــق هـــى تقنيـــة تثبيـــت فعالـــة للكســـور المفتتـــة أعلـــى عظمـــة الزنـــد حيـــث أنهـــا تســـمح بالحركـــة المبكـــرة لمفصـــل الكوع عن طريق منحها إستقراراً فعالاً للكسر.

الكلمـــات الدالـــة: تثبيـــت الصـــفيحة، كســـور الزنـــد، الزنـــد القريـــب، الشـــرائح ذاتية الغلق.