WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

SJIF Impact Factor: 5.464

ISSN: 2457-0400
Volume: 5.
Issue: 3.
Page N. 443-450
Year: 2021

Original Article | w.wjahr.com

# INTERNAL FIXATION OF DISPLACED, NON-COMMINUTED, STABLE, CLOSED FRACTURE OF OLECRANON, TENSION BAND, WIRING VERSUS LAG SCREW.

**Dr. Rabah Abdulla Al-Ebadi, F.I.C.M.S. (Ortho)[1]*, Dr. Mohammed Idrees Altahan, C.A.B.M.S.[2], Dr. Omar Abed Kassem C.A.B.M.S.[3] and Dr. Mamoon Abdulmunem Al-Dabbagh, F.I.C.M.S.[4]**

[1,3]Al Jumhoori Teaching Hospital, Orthopedic Department, Al Jumhoori Teaching Hospital, Mosul, Iraq.
[2]Al Mosul General Hospital, Orthopedic Department, Al Mosul General Hospital, Mosul, Iraq.
[4]Al Al Salam General Hospital, Orthopedic Department Al Salam General Hospital, Mosul, Iraq.

**Received date:** 05 April 2021 **Revised date:** 26 April 2021 **Accepted date:** 16 May 2021

***Corresponding author: Dr. Rabah Abdulla Al-Ebadi**
Al Jumhoori Teaching Hospital, Orthopedic Department, Al Jumhoori Teaching Hospital, Mosul, Iraq.

## ABSTRACT

**Background:** Olecranon fractures in adult are a common upper extremity injury. Open reduction and rigid internal fixation have become the generally accepted method of treatment for displaced fractures of the olecranon to allow early mobilization and to prevent contracture of the elbow. **Objective:** The aim of the study to compare between two methods of internal fixation of displaced closed fractures of olecranon by tension- band wiring versus lag screw in terms of union rate and range of motion. **Patient and Methods:** A comparative prospective study of 30 patient diagnosed with displaced closed fracture of the olecranon with impairment of extensor mechanism of the elbow Colton classification (type BII) in emergency department of Al-Jumhoori Teaching Hospital from Jun. 2019 to Jan.2020. patients are randomized into 2 group, group one of 20 patients treated with K-wire and tension band wiring, while group two of 10 patients were treated with cancellous or by 6.5mm partially threaded AO cancellous screw. **Results:** Excellent and good results were achieved in 80% in group 1 patients and in 50% in group 2 patients (level of significance was p= 0.017, which is significant). **Conclusion:** The preliminary results of the current study suggest that tension- band wiring may be more valid option for internal fixation of olecranon fracture than lag screw fixation.

**KEYWORDS:** Olecranon Fracture, Tension Band Wiring.

## 1. INTRODUCTION

The exceptional mobility of our upper extremity reflects the sum of a chain of very mobile joints. In this chain, a loss of function of the elbow joint is the most difficulty compensated. Moderate flexion, extension, pronation or supination deficits affect activities of daily life. in case of a complete elbow stiffness there is a thorough change in quality of life. With a ratio of 10% of all upper extremity lesions, the olecranon fracture is one of its most frequent entities.[1] Early mobilization of the injured elbow has been advocated repeatedly since as early as 1789(David I789; Lucas-Championni fracture1889). The recent work of Salter and his co-workers has highlighted the possible benefits to be gained by early movement of injured joints (Salteral a1. 1982).[2,3] Obviously, to achieve early active movement of the fractured elbow, internal fixation must be rigid enough to resist the disturbing influence of the flexor and extensor muscles if joint congruity is to be preserved.[4] The Mechanism of injury is Indirect trauma (Tension/ Bending force); it is due to triceps pull with bending movement over the distal humerus, as falling on a partially flexed elbow with indirect forces generated by the triceps pull avulsing the olecranon.[5,6] Direct trauma, due to low energy trauma, as in fall on the tip of the elbow, high energy trauma, as in road traffic accident, and it is associated with other injures as radial head fracture, coronoid fracture, distal humerus fracture, and ligamentous instability which is the most common.[7], Chronic overload, as in Osteoporotic patients. Paediatric age group patients. After a history of trauma, there will be severe pain over the elbow with swelling and inability to move the elbow. On examination, there may be graze or bruise over the elbow suggesting a comminuted fracture, and here the triceps aponeurosis is intact, and the elbow can be extended against the gravity. With transverse fracture; there may be a palpable gap and the patient is unable to extend the elbow against resistance.[8] Radiologically; a properly oriented lateral and anteroposterior views are essential to show details of the fracture, as well as the associated injuries, also the position of the radial head should be checked.[9] Treatment methods non-operative as in undisplaced transverse fracture, when the displacement is less than 2mm when the elbow is x-rayed in 90°flexion,the elbow in immobilized by a cast in about 60°flexion for 2-3 weeks and then active exercises are begun.[10] While in severely comminuted olecranon fracture with intact elbow extension by the triceps muscle, and the patients are usually old and osteoporotic, so the arm is rested in a sling for a week, then x-ray taken, if no displacement occurs, then active elbow exercises are encouraged.[11] Operative as in displaced fractures (separation more than 2 mm) disruption of extensor mechanism of the elbow. The choice of operative management of fracture olecranon allows anatomical reduction of the fracture, rigid fixation needed for early motion, and preservation of extensor mechanism and elbow stability.[12] The operative methods include open reduction and fixation with figure – eight wire loops.[13] This method is applicable for olecranon fracture that are not comminuted and proximal to the coronoid process, it is usually used for avulsion and transverse fractures. Intramedullary fixation It is used for transverse or oblique fractures and for avulsed fracture. It is done by applying 2 parallel kirschner wires or by intramedullary pin or by 6.5mm AO cancellous screw.[14,15]

## 2. PATIENT AND METHODS

A comparative prospective study carried out in orthopedic unit in Al-Jumhoori Teaching Hospital from Jun. 2019 to Jan. 2020. This study is approved by the Mosul Ethical Research Committee, and Directorate of Health in Ninawa. we see Thirty consecutive patients with displaced closed fracture of the olecranon with impairment of extensor mechanism of the elbow that are treated by open reduction and internal fixation, the fractures were classified according to Colton classification (type BII), we exclude other types of olecranon fractures according to Colton classification system. we divided the patient into two groups, group one of 20 patients treated with K-wire and tension band wiring, while group two of 10 patients were treated with cancellous or by 6.5mm partially threaded AO cancellous screw. The patients were between 20-50 years in age (mean 29,5 years), sex ratio (male: female) is (2:1), fracture type (transverse or oblique fractures), and aetiology (fall with sudden forceful extension of the triceps, direct trauma), as in table (1).

**Table 1: Data of 30 patients presented with olecranon fracture.**

| **Mean age in years** | **Group 1 patients** | **Group 2 Patients** | **Total number** |
|---|---|---|---|
| | 34.25 years (20-50) | 32.6 years (20-50) | 33.4 years (20-50) |
| Male: Female ratio | 13:7 | 7:3 | 20:10 |
| Right elbow<br>Left elbow | 15<br>5 | 7<br>3 | 22<br>8 |
| Causes of fracture: Fall with triceps pull<br>Direct trauma | 16<br>4 | 8<br>2 | 24<br>6 |
| Fracture type: Transverse<br>Oblique | 13<br>7 | 6<br>4 | 19<br>11 |

### Pre-operative planning

Preoperative evaluation includes assessment of the general health of the patients and an assessment of the upper limb neurovascular status, or any associated fractures or/ and dislocations was done. Radiographic evaluation includes anteroposterior, and lateral views are taken for the elbow and wrist, as in figure (1). The surgery was performed as soon as we could arrange the surgery for the patients.

**Figure 1: Anteroposterior and lateral views of 23 years old male presented with olecranon Fracture after falling on his left outstretched hand.**

Surgical technique: All patients in this study were operated UGA, some patients were positioned supine, and the involved elbow was flexed and rest on the chest, as in figure (2), other patient positioned laterally on the normal limb and the injured one flexed at the elbow and rested on a sand- bag or pillow (according to surgeon preference), and an Esmarch tourniquet was applied to the upper arm. Sterilization of the skin by povidone iodine 10% starting from below the site of tourniquet application and involving the fingers, we made a longitudinal incision on the posterior aspect of the elbow extending 2.5cm proximal to the olecranon and parallel with its lateral border, carry it distally7.5 cm close to the lateral border of the ulnar shaft, this is when we applied tension-band figure –of eight loop, as in figure (2),while it extend for the distal end of olecranon (less than 5cm) during the use of the lag screw.

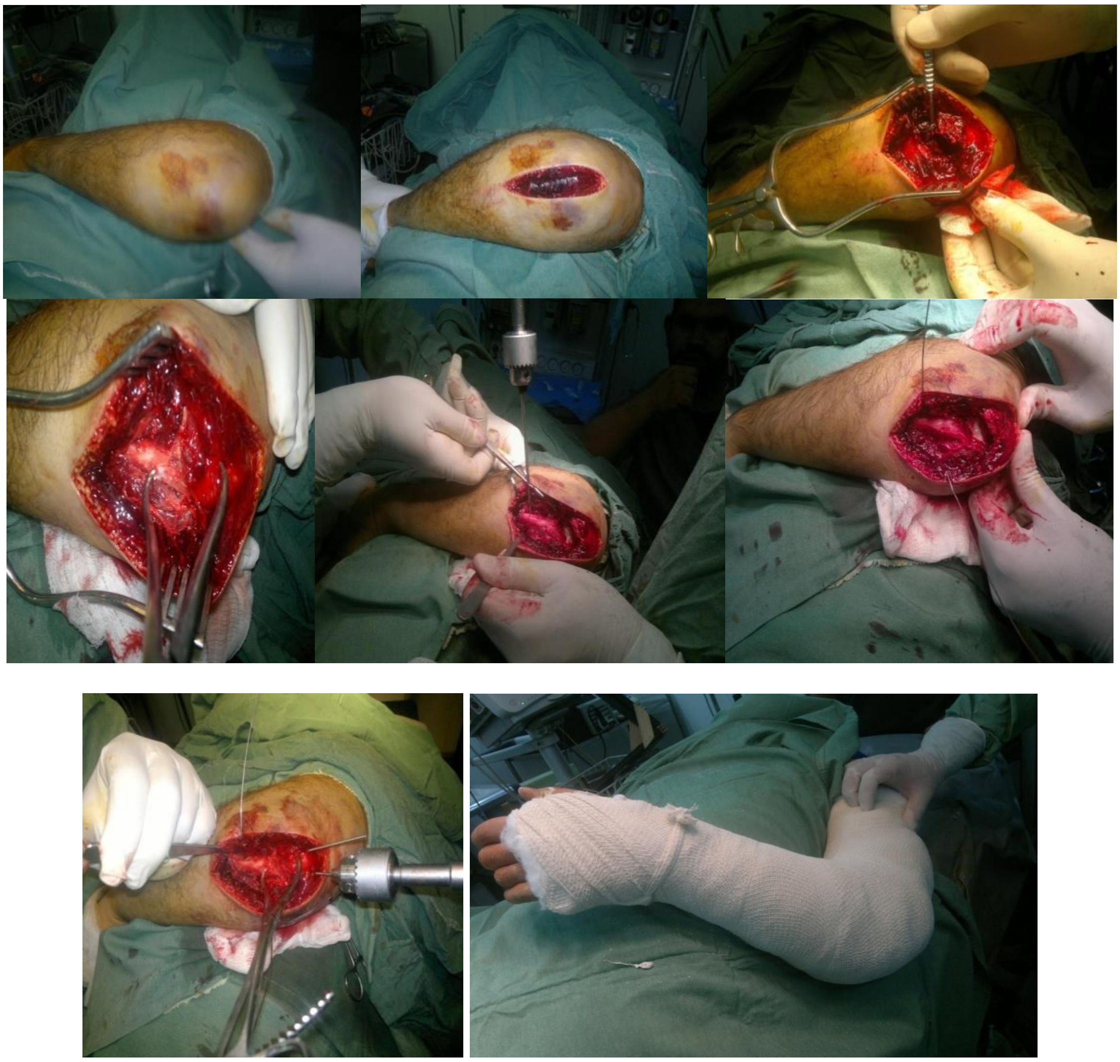

**Figure 2: Longitudinal incision posterior aspect of the elbow, Exposure, and curette of the fracture segment, Reduction & holding fractured segment with bony clamp, Drilling a hole for the tension-band in the posterior cortex, Introduction of the tension-band): Introduction of 1st & 2nd k-wire. Tightening of the tension-band wiring done with bending of the k-wires. Back-slab splint was done at 90º of elbow flexion.**

Reflection of the skin edges was done with its underlying subcutaneous tissue to minimize possibility of skin sloughing in the future. The olecranon is subcutaneous bone and comes in to field by incising the periostum longitudinally and with use of curette as in figure (2), or periosteal elevator, we expose the fracture site, washing of the fracture site with 0.9% normal saline was done, and with a small bone -holding clamp, the displaced proximal and distal fragments of the fracture were brought together into anatomical position, as in figure(2), and while holding them there, internally fixed with either tension-band figure-of eight loop or lag screw. In group1 a hole is drilled from side to side in the posterior third of the distal segment about 5-7cm from the fracture line creating 3.2mm drill bit, as in figure (2), then a no. 5USP stainless steel wire pass through this transverse hole in the distal segment, and1, 5-2mm smooth parallel kirschner wires drilled perpendicular to the fracture line passing from the proximal segment toward the medullary canal of the ulna and to the Anterior cortex,, and making the tension-band in figure-of- eight loop pattern over the posterior surface of the olecranon, and pass it around protruding k-wires and tighten it, and secure it with a twist which can be in one limb of the figure –eight loop, as in figure (2),or both limbs(according to the surgeon preference) of figure-eight twisted (which made the compression more uniform and fixation more rigid), then we bend the proximal ends of k-wires and tap the cut ends back into the proximal fragment. In group 2 a slit is made through the triceps aponeurosis reaching to the cortex of the proximal fragment, then a gliding hole of 4.5 mm is drilled into the olecranon toward the medullary canal of the ulna, then tapping with 6.5mm cancellous tap done in the cortex of the proximal fragment, then 6.5mm AO partially threaded with 32mm thread part, a cancellous screw with washer is used, with the use of a screw ranging from 100-110 mm in length, we drive the screw in to the proximal fragment and drill it and as the threaded part of the screw has passing beyond the fracture line into the medullary canal, the fracture line will be compressed as the thread purchase into the trabeculae of the distal fragment. We do flexion and extension of the elbow intra-operatively to check the rigidity and stability of the fixation. At the end of the operation, we released the tourniquet, obtained haemostasis, and closed the wound with interrupted suture, we avoided tight stitches to prevent necrosis of the skin edges. We applied thick padding and a posterior plaster splint is applied with the elbow at 75-90°of flexion and the forearm is supinated, as in figure (2), (which prevent the firm pull of the triceps muscle when the elbow is in more flexion). After treatment: The patient was instructed for elevation of the involved limb for approximately 2-3 days postoperatively to decrease the swelling of the involved limb after the surgery. Administration of injectable antibiotics started soon after the surgery, in which broad spectrum antibiotics used and changed into oral antibiotics as in patients discharged to home and continued for 7-10 days after discharging. in addition, analgesia was administrated postoperatively. Post-oprative x-ray was taken with anteroposterior and lateral views, as in figure (3)

**Figure 3: Anteroposterior and lateral post-operative x-ray films.**

The patient was encouraged to do active exercises of the fingers and shoulder and do fine activities of the fingers as writing. The patient discharged from the hospital at the 2nd post-operative day. Follow-up: All the patients followed up every two weeks starting from the end of the operation till complete healing achieved clinically and radiologically. After 10-14 days, the stitches were removed, and the wound examined for any sign of infection. the posterior plaster splint was changed, and the patient was instructed to remove it every day and to start active exercises till full range of motion achieved. The plaster was removed after 4-6 weeks in group1 patients while it lasted for 6-8 weeks in group2 patients, and the movement is gained by the patient's own gentle efforts. Rehabilitation program: In young patients, the range of motion and strength returns quickly and referral to physical therapist may not be necessary. we motivated the young patients to complete rehabilitation at home and to perform active arm muscles stretching and strengthening exercises along with range -of-motion activities. A cast brace is used which permits motion as soon as after 2 weeks in group1 patients and after 6 weeks in group 2 patients. In older patients, the rehabilitation should be started earlier, as early as 2 weeks, and referral for physiotherapist may be required for successfully regain strength and range-of- motion. Evaluation: We evaluate the patients clinically, radiologically, and functionally after complete healing of the olecranon fracture using Mayo Elbow Performance Score by Morrey BF, 1993. (table 2) The scores for each component of this scale were assessed by use of a questionnaire, in combination with clinical objective criteria. The scoring scale has a maximum of 100 points (≥ 91excellent results, 81-90 good results, 71-80 fair results, ≤70 poor results).All data were arranged and tabulated in number, percent, and mean± standard deviation. association between different variables measured by using Chi-square, and Fisher's exact test, by using EP16. ≤0.05 considered as a level of significance.

**Table 2: Mayo Elbow Performance Score by Morrey BF, 1993.**

| Function | Score |
|---|---|
| Pain (max., 45 points) | |
| None | (45 points) |
| Mild | (30points) |
| Moderate | (15 points) |
| Severe | (0 points) |
| Range of motion(max.,20 points) | |
| Arc > 100 degrees | (20 points) |
| Arc50 to 100 degrees | (15 points) |
| Arc< 50 degrees | (5 points) |
| Stability(max.,10 points) | |
| Stable | (10 points) |
| Moderately unstable | (5points) |
| Grossly unstable | (0 points) |
| Function (max., 25points) | |
| Able to comb hair | (5 points) |
| Able to feed on self | (5 points) |
| Able to perform personal hygiene tasks | (5 points) |
| Able to on shirt | (5 points) |
| Able to put on shoes | (5 points) |
| Mean total( max., 100 points) | |

## 1. RESULTS

The patients′ data and correlated results are shown in table (3), and the groups′ statistics are shown in table (4). There were not much significant differences between the two groups in age (mean 33.4 years), sex, fracture type (transverse or oblique), and aetiology (fall with sudden extension, or direct trauma). Clinically, there was hardware prominence in 10 patients in group1 (50%), with one case of hardware prominence in group 2(10%). The loss in the range -of-motion was in group 1, as follow: loss of extension by 15-20°, flexion by 10°, while in group 2: the loss of movements was in extension by 30°, flexion by 10°, and no significant loss in pronation nor supination in both groups Postoperative radiographs reveal anatomical reduction in both groups. The series of radiographs showed fixation failure, (separation of the fracture line more than 2mm due to proximal migration of the implant), in one case in group1 (5%), and also in one case in group 2 (10%), but no one require revision of the surgery. The mean time for radiological bone union (indicated by disappearance of the fracture line) was 7.7 weeks-about 54 days (ranging from 6 to 11 weeks) in group 1 patients, and 10 weeks-about 70 days (ranging from 8 to 12 weeks) in group 2 patients, as in figure (4)

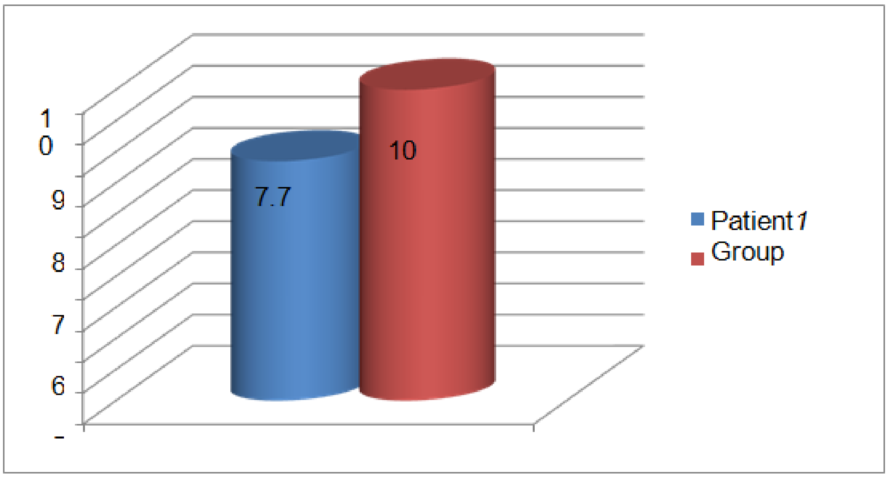


**Figure 4: Mean time of radiological union.**

All the cases have got complete union of the olecranon fracture by 12 weeks after the surgery, and the patient can use the involved limb in the daily activities, as in figures:(5).

**Figure 5: postoperative x-ray after 12 weeks.**

The level of significance in the union rate between the two groups was 0.021(p<0.05), which regarded as significant. According to Mayo elbow performance score system, 5 patients (25%) in group 1 and one patient (10%) in group 2 showed excellent results, good results were found in 11 patients (55%) in group 1 patients and 4 patients(40%)in group2 patients, and fair results were in 3 patients(1s5%) in group1 patients and in 3 patients (30%) in group2 patients, while poor results found to be in one patient (5%) in group 1 patients and in 2 patient(20%) in group 2 patients, see table (3).

**Table 3: the functional results of patients in group 1 and group 2, according to Mayo Elbow Performance Score, which is applied after achievement of radiological union of olecranon fractures (6-12 weeks).**

| Patients' Number | Excellent Results | Good Results | Fair results | Poor results |
|---|---|---|---|---|
| Group 1 Patients | 5 | 11 | 3 | 1 |
| Group 2 Patients | 1 | 4 | 3 | 2 |
| Total | 6 | 15 | 6 | 3 |

Excellent and good results were achieved in 80% in group 1 patients and in 50% in group 2 patients (level of significance was p= 0.017, which is significant).

Complications: Intra-operative: use of instruments such as pointed clamps to align and hold the fragment, can cause crushing or comminution of the olecranon and we had this complication in 3 patients in group 1(15%) and 1 patient in group 2(10%). There were cut -off the tension-band wiring during twisting and tightening in 6 patients in group 1 (30%), we replaced this wire by another new one of same or larger size. In two cases of group 2(20%), when the lag screw drilled into the cortex, there were incomplete compression at the fracture site which was not enough to create a perfect anatomical reduction, and the screws were removed and replaced by longer ones to allow good purchase in the medullary canal of the distal segment. Post - operative: Limitation of movements: early active exercises of the elbow started as early as 10-14 days, and at the end of 12 weeks of follow -up, the loss in elbow extension was 15-30° (mean 20°) in group 1, and 25-35° (mean 30°) in group 2 patients, and the loss of elbow flexion was nearly the same in both groups, which was 5-15° (mean 10°), and the loss in pronation and supination of forearm does not occur in both groups. Pain: ranging from mild to moderate in severity, was found to be in 6 patients in group 1 patients (30%) and 2 patients in group2 (20%), and with use of analgesia, the pain decreased with time. Superficial wound infection: it develops in 2 cases in group 1 patients (1 0%), and in one patient occur in group 2 patients (10%). The condition resolved with local wound care and antibiotics. Hardware prominence: at 12 weeks of follow- up, there were 10 patients in group1(50%) having this complication, which need hardware removal, and in one case occur in group 2 patients. Implant failure: at 12 weeks of follow-up, it occurred in one patient in group 1 patients (10%) and in two patients in group2 patients (20%). Delayed union: in which the fracture healing exceeded 9weeks after the surgery, only one case in group 1 patients (5%) developed this complication, 2 patient developed in group 2(20%).Skin sloughing, ulnar nerve neuropathy, anterior interosseus nerve injury heterotopic ossification, malunion, non-union, painful keloid and stiffness did not encountered as a complication in this study.also postraumatic arthritis and osteoarthritis not developed in this study and may be due to short follow-up duration.

**Table 4: Group Statistics of the study.T-test of the study.**

| Parameter | Group | Number | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Union | TBW | 20 | 53.9 | 8.7 | 1.9 |
| | LS | 10 | 70.3 | 9.8 | 3.1 |
| Mayo score | TBW | 20 | 52.5 | 10.3 | 2.6 |
| | LS | 10 | 63.3 | 4.1 | 1.7 |

## 1. DISCUSSION

Even though many reports of operative treatment of olecranon fracture have been published, comparison of the reports is difficult largely because of the lack of uniformity in the subject material and in the criteria to assess the results. According to Mayo elbow performance score (1993), the current study showed that excellent and good results were achieved in 80% of patients in group1, while it was 50% in group 2 patients with 0.017 level of significance. Villanueva[16] in his study, reported excellent and good results in 86%of patients having olecranon fracture and treated by tension-band wiring technique, this difference may be attributed to patient compliance with early active exercises or due to small number of patients applied in our study. In our study, the mean time for radiological bone union was 7.7 weeks, (ranging from 6 to 11 weeks) for group 1 patients, and 10 weeks (ranging from 8 to 12 weeks) for group 2 patients with 0.021 level of significance. This can be explained in that tension-band wiring provided better fixation and stabilization of the fracture reduction than provided by the lag screw fixation[3], and this is seen in study done by Hutchison[17], and another study by Murphy[15], although the biomechanical study found that a lag screw was best for internal fixation of the olecranon, as the posterior tensile forces applied by tension-band wiring changes into articular compression forces by the lag screw, but reported that the stability was insufficient to allow active elbow exercises, while use of tension band wiring with immediate active mobilization has been shown to be very successful in practice.[18] We have experienced only one case of delayed union in group 1(5%) and 2 cases in group2(20%), and no non- union developed.and the fracture took around 12 weeks to unite. In Coonrad study[19], there was 5% of olecranon fractures that end with non- union that are treated by tension- band wiring, so the low incidence of delayed union and non-union in our study might be attributed to stable anatomic reduction and limited soft tissue stripping, or due to small number of cases. The major disadvantage of tension-band wiring was the symptomatic prominent hardware, which requires subsequent surgical procedure for hardware removal, and it occurred in10 patients(50%) of group 1 patients and only in one case in group 2 (10%), which is similar in result to the study done by Mullet[20], in which 45% of patients had symptomatic kirschner wires prominence, also Villanueva showed 50% of patients[16] having such complain and it required hardware removal later on.While Macko in his study showed that 80% of the patients having symptomatic prominence of the K- wires with subsequent surgical removal of the implant and he explained this in to improper seating of the hardware at the time of the surgery.[10] So many authors considered transcortical placement of the kirschner wires in order to lower the rate of wire migration, but this carry the risk of forearm rotational impairment as the wires may pass anteriorly and impinged on the radial neck, supinator muscle, or biceps tendon, as seen in study done by Candal-Couto[14], and another study by Hak.[21] In this study implant failure,(> 2mm of displacement between the fracture fragment)which due to implant migration occur in one patient (5%) in group 1 patients, also in 1 patients (10%) in group 2 patients, regarding the failure of tension-band wiring, the result was nearly similar to implant failure in study done by Molloy[22] which showed 4% failure, which can be attributed to method of surgical application of tension- band wiring or missed concomitant soft tissue injuries. While the lag screw failure, in compare to another study done by Gicquel[23] which is also nearly similar, which show 7% failure, which may be due to insufficient compression applied along the screw (not strong enough purchase done in the medullary canal as in the use of small sized screws). Limitation of movements in this study, was of 20˚extension, 10˚flexion, and 5˚pronation and supination in group1 patients, while it was of 30˚extension, and 10˚flexion in group 2 patients, the poor mechanical stability provided by the lag screw necessities the appliance of a splint for more time than that with tension-band wiring, and this will lead to increase stiffness in elbow motion (especially for extension), while in group1 patients, there were limitation in pronation and supination of forearm which can be attributed to wide soft tissue dissection that was needed with the use of tension band wiring. These results may show similarity with results of Karlsson M.K.[24], who reported in his study that the group treated with tension band wiring showed better range of motion. Other complications such as deep infection, surgical wound breakdown and heterotopic ossification did not recorded in this study, while Macko reported[10], infection rate of 5%, skin breakdown in 20% and heterotopic ossification in 7% in patients treated with tension- band wiring.

## 2. CONCLUSIONS AND RECOMMENDATION

1- The preliminary results of the current study suggest that tension- band wiring may be more valid option for internal fixation of olecranon fracture than lag screw fixation.
2- The tension-band wiring, in practice is more stable fixation than lag screw and allows early active exercises of the elbow.

3- The tension-band wiring is more technically advantageous to be applied for osteoporotic bone.
4- Disadvantage that are related to the use of tension-band wiring fixation may be avoided by careful attention to the surgical technique and meticulous soft tissue handling is important for prevention of postoperative wound complications, delayed union, and joint stiffness.
5- These findings will have to be supported by a randomized clinical trial of larger number of cases and longer follow up duration, and application of other methods of internal fixation (as tension-band with intramedullary screw, or plate fixation,), before recommending the optimum method for olecranon fracture fixation.

**REFERENCES**


1. P.M. Rommens, R.U. Schneider, M.Reuter.Functional Results after Operative Treatment of Olecranon Fractures. Acta chir belg, 2004; 104: 191-197.
2. Robert T.Trousdale, Scott P. Steinmann: Ortho. Srug Board review manual, 2001; 7(3): P3-10.
3. FyfeIS, Mossad MM, Holdsworth BJ.Methods of fixation of olecranon fractures. An experimental mechanical study. J Bone Joint Surg Br, 1985; 67B: 367-72.
4. Susan Standring, PhD, DSc, FKC.Gray's Anatomy.40 ed. Emeritus Professor of Anatomy, King's College London, London, UK, 2008; 680-685.
5. Morrey BF, Askew LJ, Chao EY. A biomechanical study of normal functional elbow motion. J Bone Joint Surg Am, 1981; 63-A: 872-7.
6. Londeon JT. Kinematics of the elbow. J Bone Joint Surg Am, 1981; 63-A: 529-35.
7. Solomon L, Warwich D, Nayagam S. Apley's system of Orthopedics and fractures. Tenth ed.London: Arnold, 2018; 777-778.
8. J.N. Wilson. Watson-Jones fractures and joint injuries. Seventh ed. Churchill Livingstone, 2009; 2: 650-53.
9. O'DriscollSW. Olecranonand coronoidfracture, in: Norris TR, editor, Orthopaedic knowledge update. Shoulder and elbow. Rosmont (IL): American Academy of orthopaedic surgery, 1997; 409-13.
10. Macko D, Szabo RM. Complications of tension-band wiring of olecranon fracture. J Bone Joint Surg Am, 1985; 67(9): 1396-401.
11. Finlay D.B.L. and Allen MJ; Elbow in radiological diagnosis of fractures. 1st publish. Baillere Tindal, eastbourne, 1984; 35: 54.
12. Mark D. Miller. Review of orthopaedics. Eighth ed. Saunders, 2016; 1603- 1612.
13. S. Terry Canale. Campbell's operative orthopedics.Fourteen ed.philadelphia: Mosby company, 2021; 3094-3095.
14. Candal-Couto, J. Williams, Sanderson PL.Impaired forearm rotation after tension-band wiring fixation of olecranon fracture: evaluation of the transcortical K-wire technique. England, 2005 Aug; 19(7): 480-82.
15. Murphy DF, GreeneWB, Dameron TB Jr. displaced olecranon fractures in adults:clinical evaluation. ClinOrthop, 1987; 224: 215-23.
16. Villanueva P, Osorio F. Commesstti M. Tension-band wiring for olecranon fractures: analysis of risk factors for failure. J shoulder elbow surg, 2006 May-Jun; 15(3): 351-6.
17. Hutchinson DT, Horwitz DS. Cyclic loading of olecranon fracture fixation constructs. J Bone Joint Surg Am, 2003 May; 85-A: 831-7.
18. Alexander RV, Kenneth JK. Orthopedic Knowledge update 8.American academy of orthopedic surgeons.Rosemont IL, 2005; 311.
19. Coonrad RW. Management of olecranon fractures and non union.In:Morrey BF, editor. The elbow. NewYork: raven press, 1994; 1-95.
20. Mullett JH,Shannon F.K-wire position in tension – band wiring of the olecranon, acomparison of two techniques. Dublin, Injury, 2000 Jul; 427-31.
21. Hak DJ, Golladay GJ. Olecranon fractures: treatment options. J Am Acad Orthop. Surg, 2000 Jul- AUG; 266-75.
22. Molloy S, Jasper LE, Elliott DS.Biomechanical evaluation of intramedullary nail versus tension band fixation for transverse olecranon fractures.Baltimore, USA, 2004 Mar; 18(3): 170-4.
23. Gicquel P, Maximin MC. Biomechanical analysis of olecranon fracture fixation in children. J Pediatric orthop, 2002 Jan- Feb; 22(1): 17-21.
24. Karlsson MK, Hasserius R. Comparison of tension – band and figure-of- eight wiring techniques for treatment of olecranon fractures. J shoulder elbow surg, 2002 Jul-Aug; 11(4): 377-82.