



## EVALUATION OF FUNCTIONAL OUTCOME OF MODIFIED TENSION BAND WIRING AT 6 MONTHS IN ISOLATED OLECRANON FRACTURES IN ADULTS

<b>Dr Pulak Saha</b>	MS (Orthopaedics). Resident. Dept of Orthopaedics. Agartala Govt Medical Collage.
<b>Dr Sankar Debroy</b>	MS (Orthopaedics). Associate professor. Dept of Orthopaedics. Agartala Govt Medical Collage.
<b>Dr Arnab Panda</b>	PGT Dept of Orthopaedics. Agartala Govt Medical Collage.

**ABSTRACT** **Introduction:** Fractures of the olecranon account for 8 - 10 % of all fractures around the elbow joint. An uncomplicated fracture of the olecranon is considered to be a common injury. Incidence in adult population is approximately 11.5% per 100000 population<sup>1</sup>. Younger individuals suffer fracture olecranon due to high energy trauma and older individuals due to simple fall<sup>64</sup>. When displaced, open reduction and internal fixation is usually required to obtain anatomical realignment of the articular surface and restore normal elbow function. The fixation should be stable, allow active elbow flexion and extension and promote union of the fracture. There are other modalities of fixation of isolated olecranon fractures, such as olecranon hook plate and cannulated lag screws as well but tension band wiring is less costly and operative complications are less in non comminuted olecranon fractures. **Material and methods:** This prospective observational study was done over a period of 2 years on transverse and oblique fractures of olecranon. **Results:** the outcome of our study was favorable in support of tension band wiring in transverse and oblique fracture of olecranon in respect to union rate, early initiation of physiotherapy and final range of motion. **Conclusion:** By this method post-operative immobilization in POP is greatly minimized. Thereby avoiding fracture disease. Because of rigid fixation between the fracture fragments, early active and functional movements can be given to the patient reducing the chances of joint stiffness. Early initiation of physiotherapy program within 2 – 3 weeks induces compression between the fragments. This compression hastens fracture healing. Because of early union of fracture, patient is back to work earlier.

**KEYWORDS :** Olecranon fracture, Modified tension band wiring, Mayo elbow score.

Fractures of the olecranon account for 8 - 10 % of all fractures around the elbow joint. An uncomplicated fracture of the olecranon is considered to be a common injury. Incidence in adult population is approximately 11.5% per 100000 population<sup>1</sup>. Fracture olecranon has a bimodal distribution of incidence. Younger individuals suffer fracture olecranon due to high energy trauma and older individuals due to simple fall<sup>64</sup>.

Before the days of a sepsis, the olecranon was immobilised in full extension for 4-6 weeks. But this resulted in stiff elbow in absolutely non functional position. So, later on immobilization in flexion was attempted. In this position non-union become fairly common owing to the wide separation of fractured fragment.

When displaced, open reduction and internal fixation is usually required to obtain anatomical realignment of the articular surface and restore normal elbow function. The fixation should be stable, allow active elbow flexion and extension and promote union of the fracture.<sup>48</sup>

In the past, closed reduction and plaster cast application was the treatment for fracture of olecranon. But prolonged immobilization with its own complications increased the morbidity of patients.<sup>2</sup>

Tension band wiring technique is a method of internal fixation developed by the Arbeitsgemeinschaft Fur Osteosynthesefragen group. The basic principle is to counteract the tensile forces that act across the fracture site and convert them into compressive forces. In order to accomplish this, the wire is passed in a figure of eight fashion around the insertion of the triceps tendon and then distally beyond the fracture site into a transverse drill hole on the posterior border of the olecranon. In modified tension band wiring improved alignment and greater stability can be provided by introducing 2 parallel Kirschner wires across the fracture site before applying the tension band (Weber & Vasey 1963.) They serve to neutralize the shearing, translational and torsional forces. The counter pressure of the trochlea under tension by the triceps muscle causes a compression force across the fracture site sufficiently strong to allow immediate active range of motion. Pauwels borrowed (1935) the principle of tension band fixation from mechanics and demonstrated its application in orthopaedics. In order to achieve an increase in inter fragmental compression we must place the wire wherever we have maximal tensile forces, i.e furthest from the load axis<sup>5</sup>. There are other modalities of fixation of isolated olecranon fractures, such as olecranon hook plate and cannulated lag screws as well but tension band wiring is less costly and operative complications are less in non comminuted olecranon fractures.

In our state no study has been done till date on the functional outcome

of tension band wiring in isolated fractures of olecranon, that's why this study was planned.

### MATERIAL AND METHODS:

**Study design:** Prospective study.

**Study type:** Observational study.

**Study Place:** Department of Orthopaedics, Agartala Government Medical College, Agartala, West, Tripura.

**Study period:**

TWO years. Enrolment for 1.5 years and follow-up for 6 months. September 2018 to August 2020

### Study population:

28 patients with isolated olecranon fractures attended department of Orthopaedics in Agartala Government Medical college and G.B pant Hospital, during the study period who fulfilled our inclusion and exclusion criteria.

Among the 28 patients attending and operated in department of Orthopaedics in AGMC & GBP Hospital. 2 patients were lost during follow-up. Therefore 26 patients were included in this study.

**Sampling method:** Census sampling by fulfilling inclusion and exclusion criteria.

### INCLUSION CRITERIA: -

Patients with isolated fracture of olecranon (>18 years).

### EXCLUSION CRITERIA:

- Patients with poly-trauma.
- Patients with open fracture olecranon.
- Patients with Avulsion and comminuted fracture of olecranon.
- Patients not given fitness for anesthesia.
- Patients not willing to participate in the study.

**OPERATIONAL DEFINITION:** The outcome of study will be defined as favorable if MEPI score is more than 60.

### METHOD OF COLLECTION OF DATA :

Collection of data from patients coming with isolated fracture of olecranon to AGMC and GBP hospital for a period of 2 years from as follows:

- History by Verbal communication with patients and their attendants.
- Clinical examination, both local and systemic.
- Diagnosis: Clinical and Radiological.

- Base line investigations.
- Basic Radiological Examination.
- CT scan in selected cases.
- Pre anesthetic check up.

**OPERATIVE PROCEDURE:**

- Anaesthesia - The operation was performed under general anaesthesia or regional block.
- Position and Tourniquet - Mid arm tourniquet was applied with patient in lateral position. Site of the surgery was draped after thorough painting with povidine iodine and spirit.
- Exposure - Exposure of the olecranon was done by Campbell's postero-lateral approach.

**Post-operative care & follow-up:** Following stitch removal patient assessed clinically and was given ROM exercises as per patient's tolerability of pain or discomfort.

Then the patients called up again at 4 -6 week intervals for next three months and then at the end of six months.

**Clinical assessment for functional outcome:** Mayo elbow performance index.<sup>60</sup>

The functional score is determined on the basis of the patient's ability to perform normal activities of daily living. The total score ranges from 5 to 100 points, with higher scores indicating better function. If the total score is included between 90 and 100 points, it can be considered excellent; between 75 and 89 points, good; between 60 and 74 points, fair; less than 60 point, poor.<sup>60</sup>

**Mayo Elbow Performance Index:**

Variable	Definition	No. of points
PAIN (max., 45 points)	None	45
	Mild	30
	Moderate	15
	Severe	0
RANGE OF MOTION (max., 20 points)	Arc >100 degrees	20
	Arc 50 to 100 degrees	15
	Arc <50 degrees	5
STABILITY (max., 10 points)	Stable	10
	Moderately unstable	5
	Grossly unstable	0
FUNCTION (max., 25 points)	Able to comb hair	5
	Able to feed oneself	5
	Able to perform personal hygiene tasks	5
	Able to on shirt	5
	Able to put on shoes	5

**DATA COLLECTION:** All the patients attending orthopaedics outdoor and fulfilling inclusion criteria were included in the study and informed consent taken from each patient. Demographic information will be collected. Physical examination ,X-ray of Elbow(AP & lateral) and clinical assessment done during first visit in opd or emergency and after that during every follow up. All the data collected and recorded in a proforma.

**DATA MANAGEMENT:** Data entry and analysis performed in computer using SPSS-20 for windows. Data presented with the help of text, tables, charts etc. chi square test used for qualitative data and t-test used for quantitative data for tests of significance and P< 0.05 considered as significant.

**ETHICAL CONSIDERATION:** Data obtained from this study kept confidential and used for research purpose only. Approval of Institutional Ethical Committee of Agartala Govt Medical College, obtained for this study.

**RESULTS**

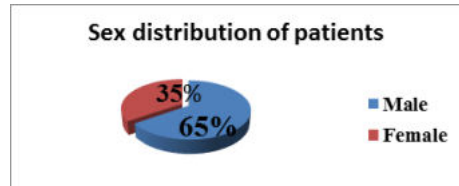
28 Patients attended AGMC & GBPH during the period September 2018 to August 2020 with olecranon fracture who got operated with Modified Tension wiring technique. However 2 patients were lost during follow-up, therefore this study includes 26 patients with Olecranon fracture treated by Modified tension band wiring during this period. The analysis of result of different parameters are as follows:

**1) Age group distribution**

**Table-1: Age group distribution of patients**

	Frequency	Percent
<30	14	53.8
31-50	6	23.1
>50	6	23.1
Total	26	100.0

**2) Sex distribution**



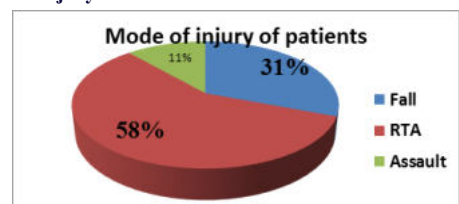
**Chart 1: Pie Chart of sex distribution of patients.**

**3) Side of involvement**

**Table-2: Side of involvement of patients.**

Frequency	Percent	
right	10	38.5
left	16	61.5
Total	26	100.0

**4) Mode of injury**



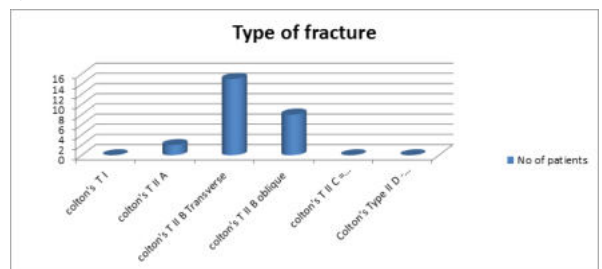
**Chart 2 – Mode of injury**

**5) Age group and mode of injury Cross-tabulation :**

**Table -3: Age group and injury pattern cross tabulation**

Age group	mode of injury			Total
	RTA	FALL	ASSAULT	
<30	9	4	1	14
31-50	3	2	1	6
>50	3	2	1	6
Total	15	8	3	26

**6) Colton's classification**



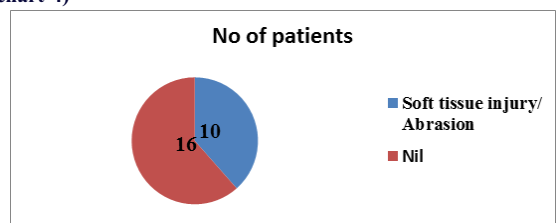
**Chart –3: Fracture type.**

**7) Time interval from injury to surgery**

**Table-4: Time interval from injury to surgery.**

	Minimum	Maximum	Mean
Time from injury to surgery	3	17	8.62

**8) Associated fracture or soft tissue injury or systemic injury (chart-4)**



**9) Incision size**

**Table -5: Average incision size.**

Mean	12.50 cm
Minimum	10 cm
Maximum	16 cm

**10) MAYO ELBOW PERFORMANCE INDEX**

**SECTION-1 Pain intensity.**

**Table-6: Pain Intensity**

Score	Pain Intensity	No. of cases	Percentage
45	None	24	92.3
30	Mild	2	7.7
15	Moderate	-	-
-	Severe	-	-

**SECTION-2: RANGE OF MOTION.**

**Table -7 :range Of Motion.**

Score	Range of motion	No.of cases	Percentage
20	Arc of motion greater than 100 degrees	24	92.3
15	Arc of motion between 50 and 100 degree	2	7.7
5	Arc of motion less than 50 degrees	-	-

**SECTION-3 Stability.**

**Table -8: Stability**

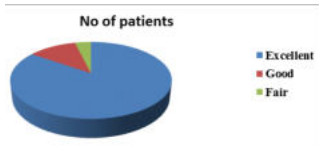
Score	Stability	No. of cases	Percentage
10	Stable	23	88.5
5	Moderate instability	3	11.5
-	Grossly unstable	-	-

**SECTION-4: Functional Evaluation.**

**Table-9 : Functional Evaluation**

Score	Function	No. of patients	Percentage
5	Can comb hair	23	88.46
5	Can eat	26	100
5	Can perform hygiene	26	100
5	Can don shirt	23	88.46
5	Can don shoe	26	100

**11) MEPI score at 6 months**



**Chart 5: MEPI score of patients.**

In our study 84.6% (22) patients had excellent outcome, Good score noted in 11.5% (3) patients and in 1 patient fair result achieved. No patient had poor result.

**12) Time taken for fracture union**

**Table-10: Time taken for fracture union.**

Frequency	Percent	
< 4monthss	22	84.6
4 - 6 months	4	15.4
Total	26	100.0

**13) Type of fracture and time taken for fracture union - Cross tabulation.**

**Table11: Cross tabulation between type of fracture and union time.**

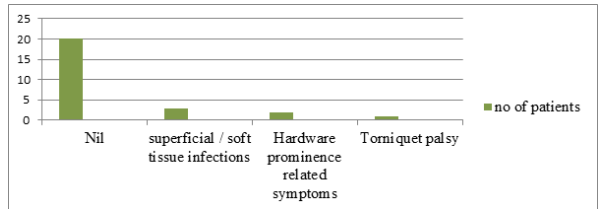
	time taken for fracture union		Total	Pearson chi-square P-Value 0.177
	< 4monthss	4 - 6 months		
colton's Type I = Un-displaced fracture	3	0	3	
colton's Type II B = Transverse	11	4	15	
colton's Type II B = Oblique	8	0	8	
Total	22	4	26	

**14) Physiotherapy initiation time**

**Table-12: Physiotherapy initiation time.**

	Frequency	Percent
2 - 3 weeks	18	69.2
3 - 5 weeks	7	26.9
> 5 weeks	1	3.8
Total	26	100.0

**15) Complications**



**Chart -6: Bar chart of complications**

**Physiotherapy initiation time and final MEPI score at 6 months Cross-tabulation.**

**Table-13: Physiotherapy initiation and final MEPI score cross-tabulation.**

Physiotherapy initiation	MEPI score at 6 months			Total
	Excellent Score 90-100	Good Score 75-89	Fair Score 60 - 74	
2 - 3 weeks	18	0	0	18
3 - 5 weeks	4	3	0	7
> 5 weeks	0	0	1	1
Total	22	3	1	26

From the above comparison it is seen that patients in whom physiotherapy started early within 2 – 3 weeks (18 patients out of 18 patients – 100%) have achieved excellent MEPI score, whereas only 4 out of 7 patients (57%) achieved excellent result when physiotherapy started at 3 -5 weeks and rest 3 could achieve only good MEPI score. In 1 patient physiotherapy could be started only after 5 weeks due to complications like soft tissue infection and pain and he achieved fair score

**DISCUSSION**

In our study 26 cases of fractures of the olecranon were treated with Modified tension band wiring with Kirschner wires for isolated transverse and oblique fractures. Our experience with this method of fixation has given favorable results. The findings, the end results and various other parameters are analyzed here and compared in the following discussion.

**1)AGE INCIDENCE:**

The average age incidence; in the present study was found to be 34.77 years. This is well in accordance with the authors Macko Donald and Szabo28 California (1985) Jiang Xieuan46 (2000) is his study average age was 38 years and average age was 35.5 years (15-76 years).

**2)Sex Incidence:**

Series	Male	Female
1) Jiang Xieyan (2000) <sup>46</sup>	10(66.66%)	5 (33.33%)
2) Hume &Wiss (1992) <sup>33</sup>	30(73.17%)	11(26.82%)
3) Wolfgang Garry. et al (1987) <sup>32</sup>	27(60%)	18(40%)
4) Present study	17(68%)	8(32%)

**3)Side Incidence:**

In this study the involvement of left side [16 patients (61.5%)] was seen more frequent than left side. But according to author Wolfgang G. et al<sup>34</sup>, study right side is more and Hume and Wiss<sup>60</sup> in their study found left side is more involved

**4)Mechanism Of Injury:**

Series	No.of cases	Percentage
1) Jiang Xieyuan (2000) <sup>46</sup>		
• Traffic accident	9	60%
• Fall from height	6	40%
2) Wolfgang G., et al (1987) <sup>32</sup>		
• Fall	22	48.88%
• Motor vehicle accident	20	44.44%

• Direct blow	3	6.66%
3) Present study		
• Road traffic accident	8	30.8%
• Fall from height	15	57.7%
• Assault	3	11.5%

In this study, the patients with Road traffic accident were 13 (52%) patients, with Fall from height were 11 (44%) patients and 1(4%) patient was Assault. Where as according to Jiang Xieyuan series, the patients with traffic accidents were 9(60%) and patients with fall from height were 6 (40%) and according to Wolfgang et al, 22 (48.88%) patients were fall from height 20(44.44%) were due to motor vehicle accident 3 (6.66%) were due to direct blow.

**5) Type Of Fracture:**

Series	No.of cases	Percentage
1) Jiang Xieyuan (2000) <sup>46</sup>		
• Oblique fracture	1	6.67
• Comminuted fracture	14	93.34
2)	Murphy et al (1987) <sup>30</sup>	
• Transverse fracture	26	57.5%
• Oblique fracture	12	26.7%
• Comminuted fracture	7	15.6%
3) Present study		
• Transverse fracture	15	57.7%
• Oblique fracture	8	30.8%
• Avulsion fracture	3	11.5%

In the present series 15 (57.7%) transverse fractures, 8(30.8%) are oblique fractures and 3 (11.5%) Avulsion fractures. In Jiang Xieyuan study 1 (6.67%) oblique fractures and 14 (93.34%) comminuted fractures. In Murphy et al series 26 (57.5%) transverse fracture 12 (26.7%) oblique fractures 7 (15.6%) comminuted fractures.

**6) Postoperative Complications Or Demerits Of This Procedure:**

Complications	Present study	Murphy et al <sup>30</sup>
1. Superficial infection	3 (11.5%)	-
2. Symptomatic metal prominence	2 (7.7%)	3 (6.6%)

**7) RESULTS:**

Study	Results in percentage			
	Excellent	Good	Fair	Poor
1) Murphy et al <sup>30</sup>	60	10	30	-
2) Jiang Xieyuan <sup>46</sup>	53.33	40	6.66	-
3) Present study	84.6	11.5	3.8	-

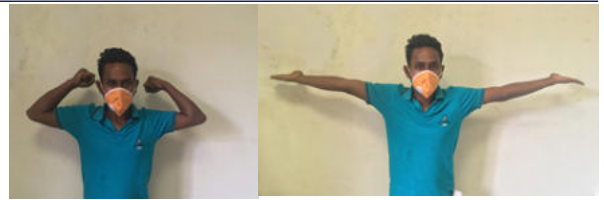
The results were evaluated according to the Mayo elbow performance score. The results obtained in our series were excellent in 22 (84.6%) patients, good in 3(11.5%) patients, fair in 1(3.8%) patients and no poor results.

The results in our series is almost accordance with the studies of Murphy et al and Jiang Xieyuan.

**Clinical And Operative Pictures**



**Pre and Post op X-rays.**



**Fig: Range of motion at final follow-up.**

**CONCLUSION**

From the present study we can conclude that the technique of open reduction and internal fixation with modified tension band wiring for simple transverse and oblique fractures is an effective means and gold standard technique of treating fractures of olecranon and is based on biomechanical principle.

The above technique for fractures of the olecranon has the following distinct advantages, provided the surgery is performed as early as possible, giving due care to all the technical details and a good post op physiotherapy program is followed for range of movement recovery.

- 1) By this method post-operative immobilization in POP is greatly minimized. Thereby avoiding fracture disease.
- 2) Because of rigid fixation between the fracture fragments, early active and functional movements can be given to the patient reducing the chances of joint stiffness.
- 3) Early initiation of physiotherapy programme within 2 – 3 weeks induces compression between the fragments. This compression hastens fracture healing. Because of early union of fracture, patient is back to work earlier. This aspect is very important both from the psychological and economical point of view. Also as per our findings it helps in good final outcome in regard to functional outcome.

Considering all the distinct advantages modified tension band wiring with Kirschner wires for transverse and oblique fractures is the treatment of choice for fractures of the olecranon as per our study.

**REFERENCES**

1. David Ring " Elbow fractures and dislocations in 'Rockwood and Green Fractures in Adults' Chapter 32 Vol17", BucholzRW, Heckman JD., Lippincott Williams&Wilkins.2010,936-942.
2. Howard JL, and Urist MR.: "Fracture dislocation of the radius and the ulna at the elbow joint". Clin Orthop,1958 12: 276-284.
3. John R Williams 'Coronoid, Radial head, Olecranon fractures and Elbow Dislocations' Chapter 3-35 Vol -3 in Oxford Text book of Orthopaedics and Trauma.2002 1969-1972pp.
4. Crenshaw, Andrew. H "Fractures of Shoulder, arm and forearm" Chapter54, 'Campbell's Operative Orthopaedics', Vol3, 11<sup>th</sup>Edn, Canale S Terry, James H. Beaty. 2008 3411-3417pp.
5. Cooper, Jerald L. and D'Ambrosia Robert D., " Fracture and Fracture Dislocation about the Elbow" Chapter 33 Operative Orthopaedics, Vol.1 2<sup>nd</sup>Edn. Chapman Michael W.,J.B. Lippincott Company, Philadelphia 1993 :479-482pp.
6. Deane M., "Comminuted fractures of the olecranon : An appliance for internal fixation". Injury (2) 1970: 103-106.
7. Perkins G., "Fractures of the olecranon". Br Med J Clin Res,(2) 1936: 668-669
8. Eliot E, Jr., : "Fracture of the olecranon". Surg Clin North Am, (14): 1934,487-492.
9. Berger P.: "Le traitement de fractures de L'olecrane et particulierment La Suture de L'olecrane par un procede (Cedarg de L'Olecranon), GaHebd Med,(2):1902, 193-199.
10. Fiolee DJ.: "Note sur less fractures de foelcrane par projectiles de Guerre". Marseille Med, 55 1918, :2,41-245.
11. Daland EM.: "Fractures of the olecranon". J Bone Joint Surg,1933 15: 601-607.
12. Rombold C., "A new operative treatment for fractures of the olecranon". J Bone Joint Surg,1934 16: 947-949.
13. Perkins G., "Fractures of the olecranaon". Br Med J Clin Res, 1936, 2: 668-669.
14. Rowe C.: "The management of fractures in elderly patients is different". J Bone Joint Surg,1965, 47A: 1043-1959.
15. Rush LV, and Rush HL., : "A reconstruction operation for comminuted fractures of the upper third of the ulna". Am J Surg,1937 38: 332-333.
16. MacAusland WR.: "The treatment of the olecranon by longitudinal screw or nail fixation". Ann Surg,1942, 116: 293-296.
17. Wainwright D.: "Fractures of the olecranon process". Br J Surg, 1942,29: 403-406.
18. Watson-Jones R., : "Fractures and joint injuries". 4th Edn., Edinburgh, ES, Churchill Livingstone, 1952.
19. Knight RA, Purvix GD., : "Fractures of both bones of the forearm in adults". J Bone Joint Surg,1949 31A: 755.
20. Weber BG, Vasey H., : "Osteosynthesis bei olecranon fraktur". Rev Accid Trav Mal Prol,1963, 56: 90.
21. Taylor TKF and Scham SM., : "A posteromedial approach to the proximal end of the ulna for the internal fixation of olecranon fractures". J Trauma, 1969, 9: 594-602.
22. Deliyannis SM., : "Comminuted fractures of the olecranon treated by Weber- vasey technique". Injury,1973 5: 19-24
23. Kiviluoto O, and Santavirta S., "Fractures of the olecranon". Acta Orthop Scand,1978 49: 28-31.
24. Chapman MW and Mahoney Michael., : "The role of early internal fixation in the management of open fractures". Clin Orthop,1979, 138: 120-131.
25. Rettig AC, Waugh Trand Evanski PM., : "Traumatic elbow injuries in the athlete". Orthop Clin North Am,1979, 33:509-522
26. Gartsman GM, Sculco TP, and Otis JC., : "Operative treatment of olecranon fractures excision or open reduction with internal fixation". J Bone Joint Surg1981, 63A: 718-721.
27. Netz P, and Stromberg L., : "Non-sliding pins in traction absorbing wire of fractures : A modified technique". ActaOrthop Sand,1982 53: 355-360.
28. Holdsworth BJ, and Mossad MM., : "Elbow function following tension band fixation of



- displaced fractures of the olecranon". *Injury*,1984, 16: 182-187.
28. Macko D, and Szabo RM.: "Complications of tension band wiring of olecranon fractures". *J Bone Joint Surg*,1985, 57B: 399
  29. Fyfe IS, Mossad MM, and Holdsworth BJ, : "Methods of fixation of olecranon fractures : An experimental mechanical study". *J Bone Joint Surg*, 1985,67B: 367-372.
  30. Murphy D.F., et al : "Displaced olecranon fractures in adults. Biomechanical analysis of fixation methods". *Clin Orthop*,1987, 224: 210-4.
  31. Larsen E., Lyndrup P., : "Netz or Kirschner pins in the treatment of olecranon fractures". *J Trauma*, 1987,27(6): 664-6.
  32. Wolfgang G., et al : "Surgical treatment of displaced olecranon fractures by tension band wiring technique". *Clin Orthop*,1987, 224: 192-204.
  33. Hume, Mary C, and Wiss, Donald A., "Olecranon fractures". 1992, *Clin Orthop*,285: 229-235.
  34. Prayson M.J., et al., : "Biomechanical comparison of fixation methods in transverse olecranon fractures : A cadaveric study". *J Orthop Trauma*,1997 11(8): 565-72.
  35. Hak D.J., Golladay G.J., : "Olecranon fractures - treatment options". *J Am Acad Orthop Surg*,2000, 8(4): 266-75.
  36. Mullett J.H., et al : "K-wire position in tension band wiring of the olecranon - a comparison of two techniques". *Injury*,2000, 31(6): 427-31.
  37. Patricia Villaneva, et al : Tension band wiring for olecranon fractures, Analysis of risk factors for failure. *J Shoulder and Elbow surgery vol- 15, issue 3, 351-356 may 2006.*
  38. Byron E Chaldis , Nick C Sachinis, Efthimios P Samoladas 'Is tension band wiring technique the "gold standard" for the treatment of olecranon fractures. *Journal of orthopaedic surgery and research*.2008,3:9.
  39. Muhammad Inam, et al 'Study to assess clinical and radiological out come of Tension band wiring of olecranon fractures'. *Professional Med J Jul-Aug 2012 19(4) 537-541.*
  40. Williams Peter L. and Roger Werrwick, 'Joints of the upper limb". Chapter-4,in *Arthrology,Gray's Anatomy, 36th Edn., London, Churchill Livingstone, 1980: 460-464pp.*
  41. Watson-Jones R, : "Fractures and joint injuries". 4th Edn., Edinburgh, ES, Churchill Livingstone,1952.
  42. Wainwright D. : "Fractures of the olecranon process". *Br J Surg*,1942 29: 403-406.
  43. MorreyBF, An KN, Functional evaluation of the elbow. In :Morrey BF, editor. *The elbow and its disorders*.3<sup>rd</sup>ed Philadelphia: WB Saunders;2000.p82.
  44. Jiang Xieyuan et al. "Operative treatment of olecranon fracture associated with anterior dislocation of the elbow". *Chinese J of Orthop*,2000;20(3): 154- 156.
  45. Hume, Mary C, and Wiss, Donald A.; "Olecranon fractures". 1992, *Clin Orthop*, 285: 229-235.
  46. Rush LV, and Rush HL,; "A reconstruction operation for comminuted fractures of the upper third of the ulna". *Am J Surg*,1937, 38: 332-333.
  47. Weseley MS, Barnefeld PA and Eisenstein AL.; "The use of zuelzer Hook plate in fixation of olecranon fractures". *J Bone Joint Surg*,1976, 5A: 859-863.
  48. Kenneth A. Egol, Kenneth J. Koval, Joseph D. Zuckerman. olecranon. In *Themi Protopsalitis. Handbook of fractures*. 5<sup>th</sup> ed. USA. Wolters kluwer;2017; P239-45
  49. Low C.K, Low B.Y. Olecranon fracture and tension band wiring. *Sing med j*. 1988; 29: 480-84
  50. Marco M. Schneider , Tobias E. Nowak ,Leonard Bastian ,Jan C. Kathagen , Jörg Isenberg & Pol M. Rommens & Lars P. Müller & Klaus J. Burkhart. Tension band wiring in olecranon fractures: the myth of technical simplicity and osteosynthetic perfection. *International Orthopaedics (SICOT)*. 2014; 38:p847-855.
  51. Dr. Deepak K Aher, Dr. Shailandra Kumar Pandey, Dr. Saurabh Alawa. Evaluation of functional outcome of tension band wiring in olecranon fractures and factors affecting the overall functional outcome. *International Journal of Orthopaedics Sciences* 2018; 4(2);p 334-6.
  52. Villanueva P, Osorio F, Commessatti M , Sanchez-Sotelo J. Tension-band wiring for olecranon fractures: analysis of risk factors for failure. *J Shoulder Elbow Surg*. 2006 ;15(3):p351-6.
  53. Mohammed KM, Ali, Catherine Hatzantonis, C. A. Mbah, Amol Tambe, D. I. Clark ,et al Tension band wire fixation in olecranon fractures: a retrospective study. *International Surgery Journal*. 2016. 3(3):p 1244-48.
  54. Femke M. A. P. Claessen, Michel P. J. van den Bekerom, C. Niek van Dijk, J. Carel Goslings,Gino M. M. J. Kerkhoffs, Job N. Doornberg, Tension band wiring for simple olecranon fractures: evaluation of surgical technique. *J Orthop Traumatology*. 2017 Sep; 18(3): 275-281.
  55. van der Linden SC, van Kampen A, Jaarsma RL. K-wire position in tension-band wiring technique affects stability of wires and long-term outcome in surgical treatment of olecranon fractures. *J Shoulder Elbow Surg*. 2012;21(3):405-11
  56. Brink PR, Windolf M, de Boer P et al (2013) Tension band wiring of the olecranon: is it really a dynamic principle of osteosynthesis. *Injury* 44(4):518-522.
  57. Rommens PM, Küchle R, Schneider RU et al (2004) Olecranon fractures in adults: factors influencing outcome. *Injury* 35(11):1149-1157.
  58. Van der Linden SC, Van Kampen A, Jaarsma RL (2012) K-wire position in tension-band wiring technique affects stability of wires and long-term outcome in surgical treatment of olecranon fractures. *J Shoulder Elbow Surg* 21(3):405-411.
  59. Lukas Willinger, Martin Lucke, Moritz Crönlein, Gunther H. Sandmann, Peter Biberthaler, and Sebastian Siebenlist Parker JR, Conroy J, Campbell DA (2005) Anterior interosseus nerve injury following tension band wiring of the olecranon. *Injury* 36(10):1252-1253.
  60. Umile Giuseppe Longo et al Rating systems for evaluation of the elbow. *British Medical Bulletin*.2008; 87(1): p131-161.