

# Comparison of Biomechanical Stability between Tensionband Wiringfixation and Post-Osteotomyolecranonchevronhook Plate

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## Abstract

**Background:** The distal humerus fracture is a challenging type of fracture for Orthopedic & Traumatologic surgeons due to the complexity of articular anatomy, limited area of fixation, osteoporotic bone, and intraarticular comminution. The most popular field surgery technique is olecranon osteotomy and olecranon osteotomy Fixation, usually using Tension Band Wiring. However, a high level of complications raises the discourse to look for better implant alternatives.

**Objective:** To compare the biomechanical stability between Tension Band Wiring and the post osteotomy Chevron olecranon Hook Plate

**Method:** We divided the sample into two groups, each with 7 ulna bones. Chevron osteotomy was conducted on Olecranon, and then reduced, and fixed. Tension Band Wiring was installed using 2 Kirschner wire 1.6 which was paralleled and loop wire 1.0 which formed the number 8. Hook plate using 3.5, 7 hole GSM® plate. The screw lag was mounted on the proximal hole. The biomechanical test using the Shimadzu AG-10TE autograft engine, performed by 200 N recurring tugs. The shift between the two osteotomical fragments was measured using a digital thrust range after a 10x, 20x, 50x, and 100x tension.

**Result:** The 10x tensile test showed an insignificant difference ( $p = 0.091$ ). When the recurring tensile test was continued, the results show significant differences after 20x ( $p = 0,007$ ), 50x ( $p = 0.004$ ), 100x ( $p = 0.001$ ). The results showed that the olecranon osteotomy fragment shift after fixation with Hook Plate was less than that of the Wiring Tension Band.

**Conclusion:** Biochemically Hook Plate is better than post-osteotomy Chevron olecranon Tension Band Wiring.

**Keywords:** *Fraktur distal humerus, osteotomi Chevron olecranon, Tension Band Wiring, Hook Plate, stabilitas biomekanik.*

## Introduction

A distal humerus fracture is one of the most challenging fractures for Orthopedic & Traumatologic

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surgeons due to the complexity of articular anatomy, limited area of fixation, osteoporosis, and intraarticular cominary trends<sup>1,2</sup>. The distal humerus fracture occurs in 2% of all adult fractures, with a ratio of 5.7 cases per 100,000 adult population<sup>5</sup>. The incidence of this fracture tends to increase with increasing life expectancy and the incidence of osteoporosis in geriatric patients<sup>6</sup>. This fracture requires anatomical reduction and stable fixation to facilitate early mobilization<sup>7</sup>. Preservation of extensor mechanisms and minimizing soft tissue damage will improve clinical outcomes<sup>2</sup>. The most commonly

used operating field opening is posteriorly by osteotomy of olecranon<sup>6,7</sup>. Tension band wiring, screw, or plating may be used for Post-osteotomy Olecranon fixation<sup>10</sup>. However, the ideal fixation of olecranon osteotomy remains unanswered.

Tension band wiring is the most commonly used olecranon fixation technique (2,9,10). This wiring olecranon tension band technique was first introduced by Weber and Vasey<sup>13</sup>. The principle of tension bands on transverse olecranon fracture is based on the understanding that the distraction force in the outer cortex will be converted into compression forces on the side of the joint surface when elbow flexion. Fracture compression is not associated with active flexion, but appears when the active extension is between 30-120°<sup>14</sup>. The installation procedure of Tension Band Wiring requires only simple instruments, and is financially cheaper<sup>15</sup>. However, Tension band wiring has several complications, namely implants that protrude into soft tissue causing irritation (3-80%), Kirschner wire uprooted, fractured shift fragments, malposition, elbow joint stiffness, heterotopic ossification, non union, or injury to important structures in the vicinity, the ulnar artery, the ulnar nerve, and the anterior interosseous nerve<sup>16</sup>. Transverse olecranon osteotomy fixed with Tension Band Wiring, non-union risk is 30% and loss of reduction is 60%<sup>17</sup>.

The risk of higher complications post olecranon fixation makes the selection of Tension Band Wiring implants to be reviewed. The alternative to olecranon fixation is to use plating. Plating olecranon has a lower loss of reduction risk compared with Tension Band Wiring in retrospective clinical and radiological trials<sup>13</sup>. 17 patients were treated using olecranon osteotomy and fixation using plate, all union, with 1 screw complication of the proximal radioulnar joint, and only 1 patient requested a plate release<sup>19</sup>.

By far, the Tension Band Wiring has been the choice of olecranon osteotomy fixation, but with the risk of more frequent complications arising, it has arisen to compare the biomechanical strength of the locally made olecranon hook plate with Tension Band Wiring olecranon. The biomechanical strength of the two implants is measured by comparing the displacement of fracture fragments when given the pull force of the triceps muscle. In this study, osteotomy of Chevron olecranon was made in the cervical ulna bone. This study is expected to provide answers on implants that are

superior in biomechanical strength and whether locally made olecranon hook plates can be an alternative to post osteotomy olecranon fixation.

## Method

The subjects in this study were ulna cadaveric bones that met the criteria. Subject inclusion criteria included male cadaveric ulna bones between the ages of 20-60 years and the ulna cadaver bone that died within less than 3 years ago. Subject exclusion criteria including damaged ulna cadaver bone and maladronic cadaver ulna bone. The samples were collected by 14 ulna bones, which were then divided randomly into 2 groups, namely the Tension Band Wiring group and the Hook Plate olecranon group (each group of 7 ulna bones).

This is an analytic-prospective study conducted by comparing the displacement of fracture fragments post-fixation and repetitive load on cadaveric bone. The samples were divided into two groups, i.e. the group treated with displacement measured by comparing the distance between the two points before and after being given repeated loading. The initial distance between the two points was 10 mm. The load was given at 200 N, repeated periodically by 10x, 20x, 50x, and 100x. Measurement displacement (shift) was done by measuring the distance between two points, each located in the proximal and distal fracture fragments.

The study procedure included olecranon osteotomy performed by making a V pattern with the distal end (apex distal), then proceed by cutting olecranon using oscillating saw. The bone was placed on the bone holder, then the olecranon fracture was reduced using pointed reduction forceps. Kirschner wire 1.6 was drilled on a proximal fragment, penetrating the fracture line leading to the anterior cortex. One other Kirschner wire 1.6 was drilled in the direction of the first. After penetrating the anterior cortex, both wires were pulled back for ±1 cm. The hole for the wire loop on the diaphysis was made using 2.0, 4 cm of drill bit from the fracture line and 0.5 cm from the posterior edge of the ulna. Holes were made through two cortices.

The wire loop was twisted at 1/3 of length, then inserted into the hole in the diaphysis. Loop wire 1.0 was formed to resemble the number 8 by passing both ends of Kirschner wire. Both ends of the wire were united and twisted. Both twists were played simultaneously and headed in the same direction, leading Tension Band Wire tension to be balanced. Torsion was performed

until compression occurs from the fracture line. The two ends of the Kirschner wire were cut and bent, then imprinted into the bone. The ulna bone was placed on the bone holder. Fractures were reduced using pointed reduction forceps. After the compression of the fracture, both other holes were drilled using a 2.5 drill, measured with depth gauge, and taped. The two 3.5 cortical screws were placed corresponding to the depth of the hole.

Biomechanical test was conducted by measuring friction fragment shift when tensile test was carried out using autograft machine. Bone that has been fixed using Tension Band Wiring olecranon or Hook Plate olecranon placed on autograft machine. The triceps tension on the olecranon was replaced with a 1.0 wire loop inserted on the olecranon, and attached to the top side autograft puller. The direction of the wire loop was perpendicular to the long axis of the ulna to condition the pull of the triceps muscle when the elbow is in a 90° flexion position. Proximal ulna difection was perforated and fastened with a 1.0 wire loop on the underside of the lower side autograft machine to resist the pulling force. In both fragments each fracture was marked a point then installed Kirschner wire 1.0 perpendicularly as a marker. Prior to the tensile strength testing, the distance between the two point markers was measured first using the digital throw term. Automatic drag force was given for 200 N, and was repeated continuously. At 10x, 20x, 50x, and 100x repetitions, the engine tension was suspended and measured at both markers. The collected data were analyzed statistically using SPSS program version 23.0 (SPSS, Inc., Chicago, IL)<sup>17,18,19</sup>.

**Result**

**Table 1. Implant Biomechanical Parametric Test Results of Wiring (TBW) and Olecranon Hook Plate.**

Tensile Test of 200 N	Implant Type	Mean±SD	p
10x	TBW	0.67±0.80	0.091
	Hook plate	0.07±0.06	
20x	TBW	1.22±0.74	0.007
	Hook plate	0.11±0.06	
50x	TBW	1.39±0.70	0.004
	Hook plate	0.19±0.08	
100x	TBW	1.74±0.66	0.001
	Hook plate	0.30±0.11	

The biomechanical test results showed a shift in the Tension Band Wiring greater than the Hook Plate

olecranon (table 1). The initial hypothesis is that the olecranon Hook Plate biomechanical strength is better than the olecranon tension band. To test the normality of the sample using the Kolmogorov-Smirnov test, from the Tension Band Wiring and Hook Plate olecranon groups,  $p = 0.2$  ( $p > 0.05$ ). This shows that the data represents the population and can be continued for parametric tests. In statistical calculations, it was found that the 200 N tensile test was 10x, no significant difference was found ( $p = 0.068$ ). When the tensile test was continued to 20x, there were significant differences ( $p = 0.002$ ), as well as the 50x tensile test ( $p = 0.001$ ) and 100x ( $p = 0,000$ ). These results indicate that biomechanically, Hook Plate olecranon is better than Tension Band Wiring olecranon (table 1).

**Discussion**

By far, Tension Band Wiring was more often used in post osteotomy olecranon fixation<sup>2,9,10</sup>. This technique is easy to work with and requires only simple and inexpensive equipment<sup>15</sup>. The risk of complications is one of the disadvantages of this implant. Complications that may occur are malposition, implant migration, broken implants, implants irritating surrounding tissue, or about important structures such as the ulnar artery and the anterior inteosseal nerve<sup>14,15,17</sup>

Olecranon plating is one of the alternatives to post osteotomy olecranon fixation. Although economically more expensive, plating has a lower risk of complications, i.e. the screw penetrates the proximal radioulne joints<sup>13,11,16</sup>. The protrusion of the plate and the screw against the soft tissue is relatively dependent on the design and thickness of the implant. The plating time compared to the wiring tension band depends on the operator, the operating technique, and the complexity of the fracture.

This study compares the biomechanical stability between Tension Band Wiring with Hook Plate (local custom design) for ulna cadaveric bone fixation after osteotomy of Chevron olecranon. The initial hypothesis of this research was that the olecranon Hook Plate is more stable biomechanically when compared with Tension Band Wiring. The sample was the ulna cadaveric bone, with the required sample size of each 7 for each group (total 14 bone samples), calculated using the Federer formula. The entire samples were randomized and osteotomy of Chevron on olecranon using oscillating saw. Then, the fracture was reduced and fixed using Tension Band Wiring or Hook Plate.

Construction Tension Band Wiring uses Kirschner wire 1.6 and loop wire 1.0. Hook Plate olecranon 3.5 7 holes (non locking) using local design GSM® implant. The entire sample was tensile test with Shimadzu AG-10TE Autograft engine. The tensile test was carried out with a load of 200 N. The load size was 200 N because the reaction force at the elbow joint at extension is 107 N. The tensile test was carried out repeatedly up to 100x. The measured variable was a shift between the two fragments of bone fracture. Bone shift is measured by comparing the distance between the two points on each bone fragment, marked with Kirschner wire 1.0, before being given a pull, after the pull of 10x, 20x, 50x, and 100x. The distance between the two points was measured using a digital thrust range, and calculated the difference between before tensile test and after tensile test 200 N 10x, 20x, 50x, and 100x. The mean displacement result then was analyzed the significance of the shift difference using paired t test for each treatment (after pull of 10x, 20x, 50x, and 100x) using SPSS 23.

The paired t test results showed that after the tension of 10x there was a difference between Tension Band Wiring to Hook Plate, but this difference was not significant. However, the 20x, 50x, and 100x tension show significant differences. These results indicate that, according to the original hypothesis of the study, the olecranon hook plates are biomechanically more stable than the Tension Band Wiring Olecranon.

This study shows that olecranon hook plates (non locking, local design) can be an alternative to replacing Tension Band Wiring, which is often used for post-fracture olecranon fixation or osteotomy. This study was performed on the cervical ulna bone without any soft tissue around it. Thus, the effect of implants on soft tissue can not be assessed.

### Conclusion

This study shows that biomechanically, Olecranon Hook Plate (non locking, local design) is more stable than Tension Band Wiring. Plate olecranon is one of the alternatives to olecranon osteotomy fixation, with the risk of complications being the screw through the proximal radioulnar joints.

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**Ethical Clearance:** This study was approved by

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