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Comparison of biomechanical stability of plate and screw fixation with tension band wiring and lag screw in ulnar styloid fractures: a cadaver test

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Abstract

Background: The management of ulnar styloid is often not appreciated in comparison to its larger counterpart, the radius. There are several surgical treatment recommendations such as fixation with tension band fixation or lag screw compression, and relative techniques, i.e., osteosynthesis with plates and screws. Each technique has their own advantages and disadvantages. Therefore, the researchers require scientific data that compares the three techniques biomechanically. **Purpose:** To evaluate the biomechanical stability of fixation with tension band wiring, lag screw compression, and plate and screw osteosynthesis. **Method**: Samples were randomly divided into three groups, i.e., P1 group (tension band wiring), P2 group (lag screw), and P3 group (plate and screw) and each group consisted of nine ulna bones. The fixation of the fracture fragments was completed using tension band wiring, lag screw, and plate and screw fixation. The biomechanical test is used to determine the stability of the three groups of fixation techniques. ANOVA test is used to determine the differences between each group. **Result**: The statistical calculation with the ANOVA test suggested that the tensile test with 150 N force results in significantly different results between fixation groups in the 10-time tensile test ($p = 0.00$), 20-time tensile test ($p = 0.00$), 50-time tensile test ($p = 0.001$), and 100-time tensile test ($p = 0.00$). This result indicates that biomechanically fixation with plate and screw is the stablest. **Conclusion**: Mechanically, plate and screw fixation are stabler than tension band wiring and lag screw compression in ulnar styloid fractures.

Keywords: ulnar styloid fracture, plate and screw fixation, tension band wiring fixation, lag screw

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INTRODUCTION

Ulna styloid has an important role in the biomechanics of the wrist joint. The ulna styloid is an important structure for the triangular fibrocartilage complex (TFCC), which plays the main role in stabilizing the distal radioulnar joint (DRUJ) by inserting on the base of the ulna styloid and fovea. Furthermore, the ulna styloid also plays a role in stabilizing the extensor carpi ulnaris (ECU), and the ulnocarpal ligament (Gogna, et al. 2014).

Ulnar styloid fractures are often associated with distal radius fractures, which is approximately 50% to 65% (Meluzinová, et al. 2017. Patel, Latkar, Patil, 2018) Patients suffering from distal radius fractures with ulnar styloid fractures are reported to have an impact on the reduced holding strength and movement of the wrist joint. It has an impact on the results of the evaluation of the worse score toward the Disabilities of the Arm, Shoulder, and Hand (DASH) (Krämer, et al. 2013). Ulnar styloid fracture causes clinical effects, such as instability, disability, and pain in DRUJ. This fact shows the importance of surgical treatment of ulnar styloid fracture to prevent the disability of the wrist joint, instability of DRUJ, and patient complaints (Krämer, et al. 2013; Shokanov, et al,2018).

In type 2 nonunions (with large fragments of the ulna styloid), it can cause DRUJ instability because the fracture fragment involves the insertion of a radioulnar ligament. Therefore, Open Reduction and Internal Fixation (ORIF) is a recommendation for the management of type 2 nonunion ulnar styloid fractures (Sammer, Det al. 2009. Nunez Jr, Luo, & Nunez Sr, 2017). Ulnar styloid nonunion fragments can be a loose body irritation source and cause of stylocarpal impaction

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and focal chondromalacia in the triquetrum. Moreover, ulnar styloid malunion can also be a problem. For instance, severe malunion in ulnar styloid can suppress the ECU, and causes discomfort and tendinitis. (Sammer, Det al. 2009).

Surgical procedures for internal fixation of the fracture have become the main decision. Adequate fixation is needed to support the fracture healing process (Qulub, Widiyanti, & Ady, 2016). Primary bone healing requires anatomic reduction, without the bone gaps, and absolute stable fixation. A fracture gap of less than 200 μm and absolute stability, osteoclasts can pass through the fracture line, forming a “cutting cone” between the tip of bone fragments. When an unprotected fracture surface has close contact and rigid from the outside, an internal bridge is formed without an intermediate step, also known as contact healing (Nyary, & Scammell, 2018. Blom, Warwick, & Whitehouse, 2017. Miller, & Hart, 2008).The healing process of secondary bones occurs in fixation with relative stability, which is still obtained by the movement of fracture fragments that are still controlled under functional load conditions. Secondary bone healing can be achieved with a fracture gap of no more than 800 μm - 1mm(Marsell, & Einhorn, 2011).

The management of ulnar styloid is often not appreciated in comparison to its larger counterpart,the radius. There are several surgical treatment recommendations such as fixation with tension band fixation or lag screw compression and relative techniques, osteosynthesis with plates and screws. Each technique has advantages and disadvantages in terms of approach, surgical wound, duration of surgery, and costs incurred (Qulub, Widiyanti, & Ady, 2016). Therefore, the researchers require scientific data that compares the three techniques biomechanically. Through these data, orthopedics and traumatologists can be facilitated in determining an effective and efficient treatment biomechanically from various aspects for the management of ulnar styloid fractures.

METHOD

The samples were taken from the anatomic cadaveric bones that had been preserved with 10% formalin, then boiled, and cleaned from soft tissue. Next, the samples taken were 27 ulna bones, then randomly divided into three groups, i.e., P1 group (tension band wiring), P2 group (lag screw), P3 group (plate and screw). Therefore, each group consisted of nine ulna bones.

The fixation methods used included tension band wiring, lag screw, as well as plate, and screw. In tension band wiring, the instrument and materials used included a bone holder, ulna bones, small pointed reduction forceps, Kirschner wire 1.0, cerclage wire 0.8, drill, wire cutter, and plier. The ulna bone was placed on the bone holder. In the lag screw method, the instrument and materials used included bone holder, ulna bone, small pointed reduction forceps, 2.0mm cortical screw, depth gauge, taper 2.0, inner sleeve 2.0, countersink, screwdriver, drill, drill bit 1.5, and drill bit 2.0. In the styloid ulna fixation with plate and screw, the instrument and materials used included bone holder, ulna bone, small pointed reduction forceps, ulna distal hook plate 2.0, set screw 2.0, drill sleeve, depth gauge, tapper, screwdriver, drill, and drill bit 1.5.

The biomechanical test was taken to determine the stability of the three groups of fixation techniques. The biomechanical test was taken by measuring the fracture fragment displacement during the tensile test using an autograft machine. The fixated ulna bone was placed on the autograft machine. By using a hook on the distal fragment connected to the bolt thread, a tension of 150 N force was applied with ten repetitions. The distance between the two points was measured by a digital caliper and then recorded. A force of 150 N was applied again by 10 times (total of 20 times), 30 times (total of 50 times), and 50 times (total of 100 times) in sequence by measuring and recording. If any fixation failed, a record was made on which repetition the fixation failed. The collected data were analyzed statistically. This study obtained quantitative data. The normality test was done using the Shapiro-Wilk test. If the data were normally distributed, the parametric test was conducted. To examine the differences between the three groups, ANOVA test was used.

RESULT

The result of the normality test with Shapiro-Wilk test for each treatment can be seen in **Table 1**. The normality test of the sample using the Shapiro-Wilk test shows that the tension band wiring, lag screw, and plate fixation groups resulted in a p-value of more than 0.05. It shows that the data represents the population and can be continued for a parametric test.

The statistical calculations with the ANOVA test suggested that the tensile test with a 150 N force gave significantly different results between the fixation groups in the10-time tensile test ($p = 0.00$), 20-time tensile test ($p = 0.00$), 50-time tensile test ($p = 0.001$), and 100-time tensile test ($p = 0.00$). These results indicate that biomechanical fixation with plate and screw is the most stable and resistant to forces to cause a shift, compared to the fixation of tension band wiring and lag screw. On the other hand, the tension band wiring fixation technique was found to be more biomechanically stable in ulnar styloid fractures than lag screw fixation.

DISCUSSION

Tension band wiring fixation shows biomechanical stability better than lag screw compression fixation. This is indicated by the smaller shift rate in the tension band

Table 1. The Result of Normality Test Shapiro-Wilk

	Fixation techniques	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Displacement 10x tensile	*Tension Band*	.127	9	.200	.942	9	.598
	Lag Screw	.152	9	.200	.951	9	.703
	Plate	.192	9	.200	.861	9	.099
Displacement 20x tensile	*Tension Band*	.127	9	.200	.942	9	.598
	Lag Screw	.152	9	.200	.951	9	.703
	Plate	.192	9	.200	.861	9	.099
Displacement 50x tensile	*Tension Band*	.108	9	.200	.990	9	.996
	Lag Screw	.177	9	.200	.932	9	.502
	Plate	.250	9	.200	.914	9	.344
Displacement 100x tensile	*Tension Band*	.142	9	.200	.963	9	.828
	Lag Screw	.184	9	.200	.934	9	.518
	Plate	.213	9	.200	.942	9	.599

Table 2. The result of Anova Parametric Test in Biomechanics of Plate and Screw with Tension Band Wiring and Lag Screw

Tensile test 150 N	Type of implant	Average (mm)	p
10x	*Tension Band Wiring*	0,11 ± 0,023	0,000
	Lag Screw	0,24 ± 0,068	
	Plate dan *Screw*	0,09 ± 0,026	
20x	*Tension Band Wiring*	0,3 ± 0,075	0,000
	Lag Screw	0,47 ± 0,070	
	Plate dan *Screw*	0,24 ± 0,1	
50x	*Tension Band Wiring*	0,74 ± 0,676	0,001
	Lag Screw	0,67 ± 0,118	
	Plate dan *Screw*	0,54 ± 0,105	
100x	*Tension Band Wiring*	1,14 ± 0,144	0,000
	Lag Screw	1,45 ± 0,187	
	Plate dan *Screw*	0,95 ± 0,096	

wiring fixation group which is also statistically significant. This is in line with previous studies that state ulnar styloid fixation with tension band wiring biomechanically better than the screw and K-wire fixation. Tension band wiring fixation has better stability in radial deviation force than twoother fixations (Mullett, Brannigan, & Fitzpatrick, 2004).

Ulna styloid is very influential in the stability function of joint motion without pain. However, the surgical management criteria for fixation of the ulna styloid remain unable to be determined. The management of ulna styloid fixation is still a controversy to this day (Chen, et al. 2018). The choice of the ulnar styloid fixation technique still considers various factors. In clinical use, the three techniques have their own advantages and disadvantages. Plate and screw fixation is better in the cases of ulnar styloid fractures with comminution fragments. However, this fixation method was not tested in this study. The drawbacks of plate and screw fixation include the need for longer incisions, relatively longer surgery duration, and higher costs compared to other fixation techniques. Plate and screw fixation techniques also require good soft tissue conditions and injury.

Tension band wiring fixation is commonly employed in ulnar styloid fractures with relatively small fracture fragments. The advantage of this fixation technique include lower cost than other fixations. Nevertheless, this technique also requires a fairly wide incision and cannot work optimally on comminuted fractures. This fixation technique also requires a fairly good psychomotor capability of an orthopedist. Ulnar styloid fixation with lag screw compression is used for fractures with larger fragments. The advantage of this technique include the relatively small incision and shorter operating time. On the other hand, lag screw fixation is less than optimal in the configuration of comminuted fractures or where there is the lost of bone fragments. This lag screw fixation is also not the best in terms of biomechanical stability and the costs incurred.

CONCLUSION

Mechanically, plate and screw fixation are more stable than tension band wiring and lag screw compression in ulnar styloid fractures.

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