International Journal of Advanced Research in Orthopaedics
ISSN: 2642-0155
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Research Article *Volume 5 Issue 1*

Comparison between Hook Plate Fixation with and without Additional Anchor Fixation for Acute Acromioclavicular Joint Dislocations

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Received Date: February 20, 2023; **Published Date:** May 08, 2023

Abstract

Background: Hook plate fixation is popular fixation methos for the acromioclavicular (AC) joint injuries. However, there are various complications related to the stress concentration at the hook were reported. The purpose of the present study was to analysis the clinical outcomes of hook plate fixation with additional anchor fixation for AC joint injuries in comparison with isolated hook plate fixation without additional anchor fixation.

Methods: The study included 90 patients with acute AC joint injuries who underwent surgery. The patients were divided into 43 patient groups with hook plate fixation and additional anchor fixation and 47 patient groups without additional anchor fixation. For clinical assessments, the American Shoulder and Elbow Surgeons (ASES) score, constant score, and time for hardware removal were recorded. The coracoclavicular (CC) distance and the CC distance ratio were used for the assessment of reduction. Typically reported complications, such as secondary dislocation, peri-implant fracture, postoperative acromioclavicular joint arthrosis, implant failure or loosening, and acromion osteolysis were also analyzed.

Results: There was no statistically significant difference in the clinical result between the two groups. The last follow-up CC distance ratio was significantly low in the hook and anchor fixation group than in isolated hook fixation groups (106.6 ± 12.5% vs 126.3 ± 39.7, respectively, $p < 0.05$). Time for hardware removal was significantly shorter in the hook plate and anchor fixation group than in the isolated hook plate fixation group. The complication rate was also significantly low in the hook and anchor fixation group than in isolated hook fixation groups (37.0% vs 63.8%, respectively, $p < 0.05$).

Conclusion: The hook plate with additional anchor fixation was better for maintenance of reduction and minimizing complication than the hook plate fixation without additional anchor fixation. Although, there was no difference in clinical results between the two groups.

Keywords: Acromioclavicular Joint; Coracoclavicular Ligament; Coracoclavicular Distance; Hook Plate

Introduction

Acromioclavicular (AC) joint separation is a common shoulder injury that occurs after a outstretch indirect injury in an abducted shoulder position or a direct blow injury to the shoulder [1,2]. The incidence of AC joint injuries is 92 per 10000 individuals per year.(2, 3) Among AC joint dislocations, Rockwood classification type III dislocations remain controversial with respect to operative treatment. For high-grade injuries, many surgeons prefer surgical treatment that enables high activity levels for athletes and young patients [2,3].

Several studies have described that maintenance of reduction was not correlated with the clinical outcome; however, most clinical evaluations did not include AC joint-specific clinical evaluations, such as those provided by AC joint instability score or the Taft score [1,3]. Maintenance of AC joint reduction prevents poor outcomes and joint deformities, including secondary AC joint arthritis and persistent discomfort [3,4].

Various techniques have been reported for the reduction of displaced AC separation [4-7]. Among various methods, hook plating is one of the most common procedure frequently used for the reduction of separated AC joint. As a result, hook plating showed the various issues according to the stress concentration, including acromial erosion, hook-related irritation, and periprosthetic fractures. Recently, coracoclavicular (CC) fixation with suture anchors has shown reliable outcomes in CC ligament injuries [7-9].

This study aimed to evaluate and compare the hook plating with additional suture anchor fixation and isolated hook plating for AC joint injuries. We hypothesized that the outcomes would be better in the additional suture anchor fixation group than those in the isolated hook fixation group.

Methods

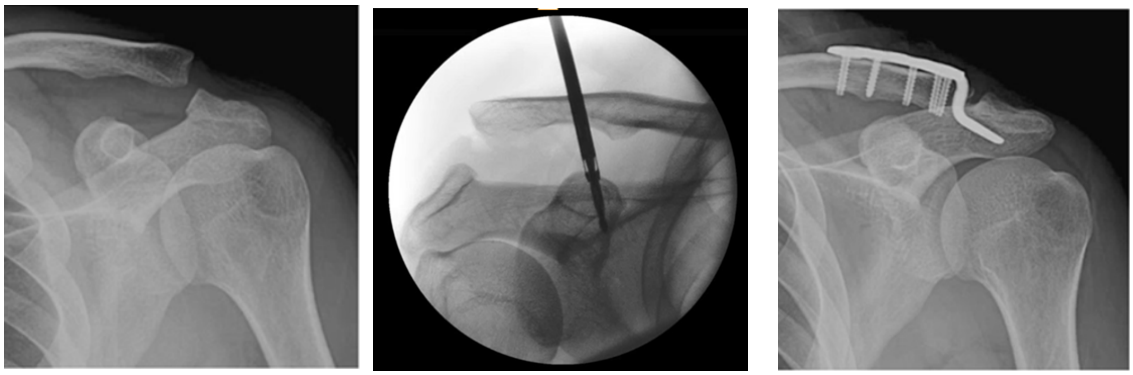
This study was acknowledged by the research ethics committee of our hospital, and written informed consent was obtained from the patients. In total, 90 consecutive patients who underwent Arix hook locking compression plate (LCP) (Jeil Medical, Seoul, South Korea) fixation for Rockwood type III and V AC joint dislocations at our institution from January 2016 to December 2020 were enrolled.

Unstable AC joint injuries were radiologically and clinically diagnosed. The clinical diagnosis was based on the assessment of tenderness and pain after a frank injury. Preoperative radiological examinations included cephalic tilt and anteroposterior views taken with the same position to obtain an exact interpretation of the radiographs. To confirm the Rockwood classification, stress anteroposterior view of the shoulder was evaluated, with the patient holding 4 kg weights with the arm hanging down and standing.

A retrospective cohort study design was adopted, with the following inclusion criteria: (1) acute and Rockwood classification III or V AC joint injuries, (2) operative treatment using hook plate, (3) a minimum follow-up period of 1 year after surgery, and (4) a history of unrestricted and painless shoulder function prior to the trauma. The exclusion criteria were as follows: (1) previous surgical history of the shoulder, (2) concomitant fracture around the shoulder, (3) fracture dislocation and open dislocations of the AC joint, and (4) chronic and neglected AC joint injuries (>4 weeks). The first 47 patients underwent hook plate fixation without additional anchor fixation (Group A), and the next 43 patients underwent hook plate fixation without additional anchor fixation (Group B); the procedures were performed by a single shoulder surgeon (J.S.Y.). Data regarding patient characteristics, time to surgery, injury mechanism, and follow-up period were collected.

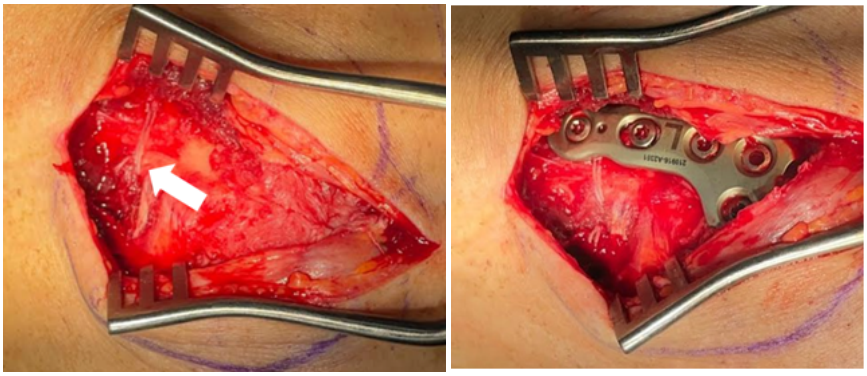
The Surgical Procedure Of Hook Plate Fixation With Additional Anchor Fixation

All surgeries were performed under regional anesthesia, with the patient in a sitting position. The deltoid–trapezoidal fascia cut incision was made in line with the lateral clavicle. A double-loaded Q-fix ® All-Suture Anchor (Smith & Nephew, Memphis, TN, USA) was inserted at the coracoid process after a 3-mm Q-fix ® disposable drill bit without additional deltoid incision under fluoroscopy Figure 1. And then the sutures were tied around the clavicle. After the reduction was held with anchor fixation, the Arix hook plate (Jeil medical, Seoul, Korea) was placed on the anchor fixation. After plate fixation with cortical screw, locking screw was performed Figure 2.



(1A) **(1B)** **(1C)**

Figure 1: (A) Preoperative anteroposterior radiograph showing a Rockwood type V acromioclavicular joint dislocation. **(B)** The anchor was inserted at the coracoid process under fluoroscopy. **(C)** Postoperative radiograph after hook plate with all-suture anchor fixation.



(2A) (2B)

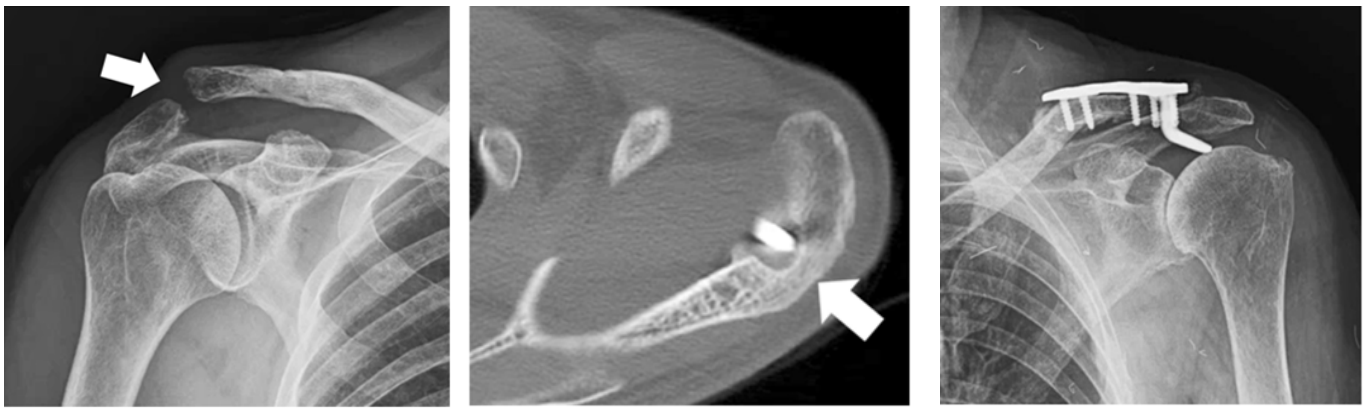
Figure 2: Intraoperative photographs of a 54-year-old man's left shoulder: **A:** A double-loaded All-Suture Anchor was inserted at the coracoid, and then the sutures were tied around the clavicle**; 2B:** Hook plate was placed on the anchor fixation.

Postoperative Protocol And Hardware Removal

The affected shoulder was kept in a sling for 4 weeks after surgery. Pendulum, gradual passive range-of-motion (ROM) exercises, and self-assisted circumduction were started 3 days after surgery, as tolerable. Active ROM exercises were started 4 weeks after surgery. In the hook and anchor fixation group, the implant was removed after 3 months and an anchor was not removed. In the isolated hook fixation group, the implant was removed after 3–5 months. If the patient had shoulder stiffness at the time of hardware removal, arthroscopic capsulectomy or brisement under regional anesthesia was concomitantly performed before implant removal. When implant removal, the authors prefer to incise only the superior tissue of the plate without further soft tissue detachment. Active and passive ROM exercises were started after implant removal.

Clinical And Radiologic Evaluations

All patients were evaluated for a minimum period of one year. For clinical assessments, the American Shoulder and Elbow Surgeons (ASES) score and constant score were recorded at the final follow-up by the physician's assistant. An independent physician who was blinded to the patient's data evaluated all values.



(3A) (3B) (3C)

Figure 3: Complications following hook plate fixation. **A)** Acromioclavicular joint arthrosis. **B)** Acromion osteolysis (arrow). **C)** Periprosthetic fracture

For radiological evaluation, both clavicle anteroposterior view was taken regularly after surgery (at 3, 6 weeks; 3, 6 months; and 1 year). AC joint injury grade was determined via a weight-bearing panoramic view for comparison with the unaffected side. An anteroposterior stress view of both shoulders radiograph with 4kg weight in each hand was taken. The degree of AC joint dislocation (CC distance ratio) was measured using the CC distance and compared with that of the unaffected shoulder on standard radiographs. The CC distance was measured between the lowermost border of the

conoid tubercle and the uppermost border of the coracoid process [10].

All radiologic measurements were measured by two independent examiners (J.S.Y and J.B.S.). The individual value was analyzed, and then the mean value was calculated. All radiographs were analyzed for complications such as peri-implant fracture, acromion osteolysis, implant failure and loosening, and postoperative AC joint arthrosis Figure 3.

Statistical Analysis

To determine the continuous data, the Kolmogorov–Smirnov test was used. Continuous variables were evaluated using an independent t-test, and non-continuous variables were evaluated using Pearson's chi-square test. The Statistical Package for Social Sciences version 25.0 (SPSS, Inc., IBM Co., Chicago, IL, USA) was used for the statistical analysis of this study. Statistical significance was defined at $p < 0.05$ for all analyses.

Results

Demographic data

The study included 15 women and 75 men (age range, 19–78 years). The AC joint injuries were caused by traffic accidents in 8 patients, falls in 48 patients, and sport-related injuries in 34 patients. No significant differences were detected in the demographic data between the two groups Table 1.

Variable	Isolated hook plate fixation (n=47)	Hook plate with anchor fixation (n=43)	p-value
Mean age	44.6 ± 15.4	42.9 ± 17.6	N.S.
Gender (Male: Female)	38:09:00	13:06	N.S.
Dominant arm: Non-dominant arm	45:02:00	40:03:00	N.S.
Height (cm)	170.3 ± 8.7	172.1 ± 7.8	N.S.
Weight (kg)	71.9 ± 11.6	72.4 ± 10.4	N.S.
Body mass index	24.7 ± 3.1	24.4 ± 2.7	N.S.
Smoking: Non-smoking	18:29	20:23	N.S.
ASA class (1:2:3)	27:19:01	24:17:02	N.S.
Mechanism of Injury			N.S.
Traffic accident	5	3	
Fall	26	22	
Sport injury	16	18	
Level of work activity, high:medium or low	22:25	18:25	N.S.
Operating time (minute)	21 ± 4.8	27 ± 5.6	<0.001
Time to surgery (day)	9.7 ± 8.2	7.8 ± 9.7	N.S.
Mean follow-up (month)	18.7 ± 6.2	17.4 ± 4.5	N.S.

ASA: American Society of Anesthesiologists, **N.S:** Non-specific
Table 1: Demographic Data.

Clinical outcomes

There were no significant differences in the ASES score and Constant score between the groups. The mean ASES scores were 87.9 ± 11.2 and 84.0 ± 10.6 in Group A and Group B, respectively. The mean Constant scores were 91.2 ± 12.3 and 85.8 ± 11.2 in groups A and B, respectively Table 2.

Variable	Isolated hook plate fixation (n=47)	Hook plate with anchor fixation (n=43)	p-value
ASES score	87.9 (±11.2)	91.2 (±12.3)	N.S.
Constant score	84.0 (±10.6)	85.8 (±11.2)	N.S.
Rockwood classification (III:V)	26:21:00	23:20	N.S.

Uninjured side CCD (mm)	7.3 (±1.8)	7.6 (±2.3)	N.S.
Preoperative injured side CCD (mm)	14.4 (±5.7)	15.1 (±6.6)	N.S.
Last follow up injured side CCD (mm)	9.0 (±2.8)	8.1 (±3.3)	0.007
Preoperative CCD ratio (%)	201.3 (±78.3)	203.5 (±64.3)	N.S.
Last follow up CCD ratio (%)	126.3 (±39.7)	106.6 (±12.5)	<0.001

ASES: American Shoulder and Elbow Surgeons, **CCD:** coracoclavicular distance, **N.S:** Non-specific
Table 2: Clinical and Radiologic Outcomes between the Two Groups.

Radiologic outcomes

There were no differences in Rockwood classification between the two groups, there were also no differences in the CC distance of the uninjured side between the two groups; the mean CC distance of the unaffected side were 7.3 ± 1.8 mm and 7.6 ± 2.3 mm in groups A and B, respectively. There were no differences in the preoperative CC distance of the injured side between the two groups; the mean preoperative CC distance of the injured side were 14.4 ± 5.7 mm and 15.1 ± 6.6 mm in groups A and B, respectively. There were no significant differences in the preoperative CC distance ratios between the groups; the mean preoperative CC distance ratios were 201.3 ± 78.3 and 203.5 ± 64.3 in groups A and B, respectively. However, there were significant differences in the CC distance on the affected side at the last follow-up (9.0 ± 2.8 mm and 8.1± 3.3 mm in groups A and B, p = 0.007) and CC distance ratios at the last follow-up (126.3 ± 39.7 and 106.6 ± 12.5 in groups A and B, p =0.001).

Complications

Time for implant removal was significantly shorter in the hook plate and anchor fixation group than in the isolated hook plate fixation group (4.2 ± 0.7 and 3.1 ± 0.2 in groups A and B, p <0.001). The total complication rate was statistically significantly lower in the hook plate and anchor fixation group than in the isolated hook plate fixation group (63.8% and 41.8% in groups A and B, p =0.039).

There were no significant differences in postoperative stiffness was reported in 16 (34.0%) and 13 (30.2%) patients in groups A and B, respectively, although pendulum and self-assisted circumduction exercises were started 3 days after surgery. Brisement or arthroscopic capsulectomy was performed in patients with postoperative stiffness during implant removal. After implant removal, all patients recovered full ROM at the final follow-up.

Subacromial erosion was significantly lower in the hook plate and anchor fixation group than in the isolated hook plate fixation group (40.4% and 20.9% in groups A and B, p <0.001). Post-traumatic ACJ arthrosis was also significantly observed significantly lower in the hook plate and anchor fixation group than in the isolated hook plate fixation group (25.5% and 13.9% in groups A and B, p <0.001, Table 3.

Variable	Isolated hook plate fixation (n=47)	Hook plate with anchor fixation (n=43)	p-value
Time for implant removal (months)	4.2 ± 0.7	3.1 ± 0.2	<0.001
Overall complications (n, %)	33 (63.8%)	16 (37.0%)	<0.001
Infection (%)	-	-	-
Secondary dislocation (%)	-	-	
Implant failure or loosening (%)	-	-	-
Stiffness before implant removal (%)	16 (34.0%)	11 (25.6%)	0.039
Subacromial erosion (%)	19 (40.4%)	9 (20.9%)	<0.001
Posttraumatic ACJ arthrosis (%)	12 (25.5%)	6 (13.9%)	<0.001
Peri-hardware fracture (%)	1 (2.1%)	-	-

ACJ: Acromioclavicular joint, **N.S:** Non-specific
Table 3: Complications between the two groups.

Discussion

This study aimed to compare the clinical and radiologic outcomes of hook plate fixation with and without additional suture anchor fixation for acute AC joint dislocation. According to our hypothesis, maintenance of reduction, subacromial erosion, and posttraumatic AC joint arthrosis were better in the hook plate with anchor fixation group than in the isolated hook fixation group. However, contrary to our initial hypothesis, there was no difference in clinical outcomes between the two groups.

Although various surgical methods have been reported for the repair of AC joint injuries, no optimal surgical procedure has been agreed upon [11-15]. Among the various surgical methods, hook plate is a one of the popular techniques for AC joint injuries. However, loss of reduction of CC distance is a concern related with hardware removal after hook plate fixation. Jensen, et al. [12] reported that 68% of patients who underwent hook plate fixation showed more than 2mm loss of reduction of CC distance. Stein, et al. [16] also described that the mean CC distance ratio of 27 patients at 2 years after hook plate fixation was 141.8%. Several studies have described satisfactory clinical results despite loss of reduction of CC distance [4,17-20]. However, they used shoulder scores for clinical assessment without analyzing the AC joint-specific evaluations (AC joint instability score or Taft score).

Moreover, the subacromial hook frequently involves the subacromial joint and often causes some complications including acromion osteolysis, shoulder impingement, and rotator cuff injuries [21]. An autopsy study found the hook tail significantly reduced the subacromial space, and impingement between the humeral head and the lateral hook easily occurred during the movement of the shoulder joint [22]. Seo, et al. [10] suggested CC instability might increase the risk of hook plate-specific complications. The suture anchor is a kind of miniature internal fixation that is used to connect tendons, ligaments, and bones. It is simple to operate and can effectively reconstruct CC ligaments; thus, it has been considered to treat distal clavicular fractures [22-24].

Lee, et al. [25] reported that the stress of the hook plates indicates that stress concentration was found in the corner of the hook plate. As a result, subacromion erosion was an inevitable hook related complication of contact stress concentration at the hook [9,26]. Few reports have been published on peri-implant fractures at the medial end of the plate as a rare complication of hook plates [10,23]. Lee, et al. also described that based on the stress applied to the screws in the clavicle, the most medial screw located at the proximal end of the clavicle results in more stress on the clavicle, regardless of differences in hook depths or plate materials [25]. Suture anchor fixation can resist the upward pull at the AC joint, and enhance the vertical stability of AC joint and hook plates. Although there has been no study on biomechanical analysis of stress concentration at the coracoid with anchor fixation, we believe that stress distribution with additional suture anchor fixation can reduce the risk of hook-related complications by stress distribution, increasing stability and limiting the movement of the hook. In this study, time for hardware removal, subacromial erosion, and posttraumatic AC joint arthrosis was significantly lower in the hook and anchor fixation group than in the isolated hook fixation group.

It is already widely reported a high rate of hook plate-related complications in previous studies [6,10,23]. In 2018, Yin, et al. [27] reported that 16 of 26 patients (61.5%) treated with hook plate fixation showed complications. In a systematic review, 66 of 162 patients (40.7%) treated with hook plate osteosynthesis experienced complications. This study showed higher complication rates in both groups (63.8% vs 41.8%) than those of the previous studies, we believed that the reason for the higher complication rate of the present study is a difference in the method to define the complication.

This study has several limitations. First, this was a non-randomized retrospective study. Second, only the Constant and ASES scores were analyzed without ACJ-specific evaluations (Taft score or ACJ instability score) in this study. Third, the limited sample size and relatively short follow-up duration might weaken the strength of the results. Finally, strict biomechanical research is required to strengthen the outcomes of this clinical observation study.

Conclusion

Although no differences in clinical results were observed between the two groups in this study, hook plate with additional suture anchor fixation was better than isolated hook plate fixation for maintenance of reduction, reducing hook-related complications.

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