

1 **Short Term Clinical Outcomes of Hook Plate Compared to Continuous Loop Double**  
2 **Endobutton Fixations in Acute Acromioclavicular Joint Dislocation**

3 **Running title: acromioclavicular joint dislocations**

4 **Abstract:**

5 **Background:** This study was conducted to evaluate the clinical outcomes of  
6 acromioclavicular joint (ACJ) fixation with hook plate (HP) and continuous loop double  
7 endobutton fixation (CLDE) in treatment of the acute acromioclavicular joint (ACJ)  
8 dislocation.

9 **Methods:** In this retrospective study, 8 patients with HP and 9 patients with CLDE fixations  
10 were compared for acute ACJ dislocations. The patients were evaluated by various criteria  
11 including disabilities of the arm, shoulder and hand (DASH), American shoulder and elbow  
12 surgeons standardized shoulder assessment (ASES), UCLA shoulder rating scale, shoulder  
13 constant score, simple shoulder test (SST) and CC distance.

14 **Results:** The differences between the mean VAS scores for pain, DASH, ASES, UCLA  
15 shoulder rating scale, shoulder constant and SST were statistically significant in favor of the  
16 CLDE group. The mean differences of CC distance was  $8.6 \pm 0.9$ mm in HP while it was  
17  $11.6 \pm 1.2$  mm for CLDE; the operation time was in favor of HP fixation ( $51 \pm 13.3$  min versus  
18  $105 \pm 9.7$  min) ( $p < 0.001$  and  $P = 0.008$ ). There were 6 concomitant subacromial erosions and  
19 osteoarthritis in the ACJ of the HP group.

20 **Conclusion:** CLDE fixation had better clinical outcomes than HP fixation; however, it was a  
21 technically demanding procedure. HP maintained the CC distance better and its application  
22 was technically easy. HP needs a second surgery for removal and development of

23 subacromial erosion and osteoarthritis of the ACJ which can be regarded as the major  
24 concerns.

25 **Key words:** Acromioclavicular dislocation; Double endobutton; Hook plate; Closed-loop

26 **Level of evidence: Therapeutic III.**

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40 **Introduction:**

41 The acromioclavicular joint (ACJ) represents the link between the clavicle and the scapula,  
42 which is responsible for the synchronized dynamic of the shoulder girdle. (1) ACJ dislocation  
43 with a prevalence of 9-12 % is a common shoulder girdle injury in active young adults (1, 2).  
44 ACJ dislocation is associated with acromioclavicular (AC) and coracoclavicular (CC)  
45 ligaments injuries. Rockwood classified ACJ dislocations into types I to VI based on the  
46 amounts of horizontal and vertical displacement of the lateral clavicle and CC distance (3).  
47 Biomechanical studies have demonstrated the importance of anatomical reconstruction of the  
48 AC and CC ligaments in cases of unstable ACJ injuries. The change in anatomical orientation  
49 of the scapula in unstable ACJ dislocations may lead to scapular dyskinesis in 70% of the  
50 patients were treated with non-surgically methods and 45% of patients may present with  
51 SICK scapula syndrome including scapular malposition, inferior medial scapular winging,  
52 coracoid tenderness and scapular dyskinesis. Scapular dyskinesis changes the dynamics of the  
53 rotator cuff which can predispose to chronic shoulder pain (4-7).  
54 Non-operative treatments have been generally accepted as the gold standard of treatment in  
55 Rockwood I and II lesions, whereas the treatment of grade III is controversial and  
56 individualized. ACJ dislocations grades IV–VI generally require operative treatment. There is  
57 no gold standard treatment for ACJ dislocations type III and greater. The literature provides  
58 non-homogeneous comparative studies between the treatments of ACJ dislocations type III  
59 and greater (8-23).  
60 The aim of this study is to compare the clinical and radiographic results of acute Rockwood  
61 type III and greater ACJ dislocations treated with either rigid trans-articular hook plate (HP)  
62 or non-rigid extra-articular with continuous loop double endobutton (CLDE) fixations. The  
63 hypothesis of this study is that the clinical results of HP and CLDE CC fixations for acute  
64 ACJ dislocations had equal functional and radiographic outcomes.

65 **Materials and Methods:**

66 Through a retrospective study between March 2013 and March 2017, young athlete patients  
67 with ACJ dislocation who were candidate to surgery treatment were treated with CLDE or  
68 HP fixations. CLDE or HP fixations was offered and performed on 22 physically active high  
69 demand adult patients because of Rockwood type III and IV ACJ dislocations. We estimated  
70 20 patients based on minitab13 statistical software according to previous study with power of  
71 80%, sigma 0.7 (22). Patients with previous shoulder injury or surgery, congenital deformity  
72 in upper limb, neuromuscular disorder and Rockwood type I and II ACJ dislocations were  
73 excluded.

74 The lesions were the result of road traffic accident in 12 patients (54.5%) and falling on  
75 affected shoulder in 10 patients (45.5%). ACJ dislocations were evaluated by a standard  
76 anteroposterior radiograph of the shoulder and Zanca view. At the final follow-up the vertical  
77 distance between the inferior border of the clavicle and the superior border of the coracoid  
78 (CC distance) was measured in millimeter (mm) in both groups. Increase in CC distance by  
79 50%–100% and more than 100% with respect to the contralateral side was considered as  
80 sublaxation and redislocation, respectively. All the patients had a minimum of six months  
81 follow-up. This study was approved by the ethical committee of the university.

82 Twelve patients (11 males and one female) with the mean age of  $37 \pm 12.2$  underwent CLDE  
83 CC fixations. The mean follow up period was  $19.8 \pm 8.8$  (range 6 – 36) months. We used  
84 open technique described by Struh (5). An auxiliary No. 5 Ethibond suture (Ethicon®) stitch  
85 replicating the course of the trapezoid ligament was tied. To augment the endobutton  
86 construct, the AC capsule and deltotrapezial fascia were imbricated. In one of the patients,  
87 reduction lost immediately after surgery because of fracture at the base of coracoid. He was  
88 treated with a HP and evaluated in the HP group. At the final follow-up ACJ was redislocated

89 in two patients because of displacement of the clavicular and coracoid buttons (Figure 1).  
90 They declined further surgery, therefore, these three patients were excluded and finally nine  
91 patients remained in this group.

92 Eleven patients (10 males and one female) with the mean age of  $38.1 \pm 14.7$  were treated with  
93 HP CC fixation. One patient had been transferred from the CLDE group to this group. The  
94 mean follow-up period was  $23.8 \pm 12.9$  (range 6 – 38) months. The fixation failed in one  
95 patient with morbid obesity and he declined a further surgery (Figure 2). One patient was lost  
96 in follow up and one patient declined to remove her HP. We offered to remove the HPs at  
97 three months post-surgery; however, because of patients' preferences HPs were removed in  
98  $10.7 \pm 4.8$  months in 8 patients. The patients were evaluated at a mean of two months after HP  
99 removal. This group consisted of eight patients. In this group, presence of subacromial  
100 erosion, osteoarthritis and other probable adverse effects of HP were evaluated.

101 Table 1 demonstrates the characteristics of the two groups of patients. There was no  
102 significant difference between the age, gender, Rockwood type of ACJ dislocation, side and  
103 interval between the injury and surgery and follow-up. A significant difference was observed  
104 between the mean operation times of the two groups ( $P= 0.008$ : Man- Whitney test).

105 The patients were subjectively evaluated with the visual analogue scale (VAS) for pain (0; no  
106 pain; 10 worst possible pain), disabilities of the arm, shoulder and hand (DASH) score (0: no  
107 disability; 100: disabled) and American shoulder and elbow surgeons standardized shoulder  
108 assessment (ASES) (100: best score; 0: worst score). The patients were also evaluated  
109 subjectively and objectively with the UCLA shoulder rating scale (Range 0-35:  
110 Good/Excellent  $> 27$ ; Fair/Poor  $< 27$ ), shoulder constant score (100: no pain; 0: maximum  
111 pain) and simple shoulder test (SST) (12: best score; 0: worst score). At the latest follow-up,  
112 the mean CC distances (mm) between the two groups were compared. **This study was**

113 conducted under the supervision of the ethics committee of Urmia University of Medical  
114 Sciences with code of 96-09-63-3041. All patients offered their written consent and they were  
115 free to participate.

116 To characterize the qualitative variables, frequency and percent were used; while the mean  $\pm$   
117 standard deviation and range of variations were employed for quantitative variables. To  
118 conduct inferential analysis, Fisher's exact test was used to compare the qualitative variables  
119 and the non-parametric Mann-Whitney test was applied for quantitative variables. P value  
120 less than 1% was considered statistically significant.

### 121 **Results:**

122 As earlier noted, three (27%) out of 11 patients in the CLDE group had failed surgery and  
123 hence they were excluded from the study. One (9%) out of 11 patients in the HP group had  
124 failed surgery that was also excluded from the study.

125 Table 2 shows the mean scores of the instruments in the both group. The differences between  
126 the mean VAS scores for pain, DASH, ASES, UCLA shoulder rating scale, shoulder constant  
127 and SST were statistically significant in favor of CLDE group.

128 The mean difference of CC distance was in favor of HP fixation. Six (75%) out of the eight  
129 patients had concomitant subacromial erosions and osteoarthritis of the ACJ in the HP group  
130 (Figure 3).

### 131 **Discussion:**

132 In acute ACJ dislocation, the AC and CC ligaments still have the potential to heal; so surgical  
133 techniques are aimed to align the ends of the torn ligaments to facilitate tissue healing. There  
134 are many different types of rigid trans-articular and non-rigid extra-articular fixations. In past,

135 wires and threaded pins were frequently used for temporary trans-articular fixation of the  
136 ACJ. However, pin migration or breakage, pin-site infection, fixation failure and recurrent  
137 instability after pin removal were major concerns with these conventional therapies.  
138 Bosworth screw was also used to stabilize ACJ extra-articularly; it however, may associate  
139 with coracoid fracture, erosion on the clavicle and loosening of screw. Extra-articular  
140 stabilization between coracoid and clavicle with cerclage using heavy sutures or high strength  
141 synthetic materials induced a sawing effect on clavicle due to the rotation of the clavicle.  
142 Meanwhile, sutures may fail because of knot slippage and suture breakage (1, 8, 12, 21).

143 In the recent years the two modern techniques that are commonly used for Rockwood type III  
144 and greater ACJ dislocations are rigid trans-articular CC fixation with HP and non- rigid  
145 extra-articular fixation using a suspensory loop with flip buttons. Each technique has its own  
146 advantages and disadvantages. The suspensory loop may be either a tightrope (single or  
147 double) (8-11), continuous loop with either a single (1) or double (4, 5) or triple endobuttons  
148 (17, 18, 20), synthetic ligament, multistrand titanium cable (16) and absorbable  
149 polydioxansulfate (PDS) sling (8).

150 In the current study, we used HP for rigid trans-articular CC fixation. HP fixation has a  
151 simple and easy technique; however, there are some concerns that HP may lead to shoulder  
152 pain and dysfunction. HP may crowd and violate the subacromial space and produce  
153 impingement syndrome with rotator cuff injury, produce subacromial osteolysis,  
154 osteoarthritis of the ACJ, implant failure and CC ossification (12-14). In this regard, a second  
155 operation is recommended to remove the adverse effects of HP upon ligamentous healing.  
156 Removal of the HP improves the shoulder functional scores (9, 12, 16). Chen et al. removed  
157 HPs in their study 8 to 12 months after the surgery. Among the patients in their study, 10  
158 (30.3%) and 6 (18.1%) patients had subacromial osteolysis and osteoarthritis of ACJ,

159 respectively (12). In the current study, 6 (75%) out of the eight patients showed subacromial  
160 osteolysis and osteoarthritis of the ACJ which can be a major concern similar to other studies  
161 (15, 21).

162 In the current study, we used CLDE for non-rigid extra-articular CC fixation. The CLDE  
163 eliminates the problem of knot breakage and slippage that may occur in suture button  
164 techniques. The CLDE has a double strength of the native tendon. However, it is technically  
165 complex and a demanding task requiring longer operation time. It needs accurate drilling on  
166 the clavicle and at the base of coracoid. A large or misdirected drill holes can produce  
167 fracture through clavicle and coracoids (4, 5). In the current study, 3 (27%) out of the 11  
168 patients had reduction loss and failed surgery.

169 The literature provides a plethora of heterogeneous comparative studies between non-rigid  
170 extra-articular and rigid trans-articular CC fixations for ACJ dislocations with contradictory  
171 outcomes. The majority of the studies are retrospective with a relatively low number of  
172 subjects and short term follow-up that can pool the acute and chronic ACJ dislocations as  
173 well as different types of Rockwood classification for ACJ dislocation together (4, 19). The  
174 authors have used minimally invasive, arthroscopic and open surgical techniques (7, 10, 19).  
175 In some studies, patients with radiographically displaced and redislocated ACJ were not  
176 excluded from the final evaluation and the inferential analysis (7, 11, 15). Cai et al. did not  
177 remove HPs at their final evaluation (11).

178 Metzloff et al. found no significant clinical difference between the HP and minimally  
179 invasive reconstruction of suspensory loop with two flip buttons (19). Eschler et al. compared  
180 HP fixation with absorbable PDS sling in ACJ dislocations. They found no significant  
181 difference in functional outcomes of both groups; however, HP restored CC distance more  
182 accurately than PDS sling (15).



183 In a retrospective multicenter study, Natera-Cisneros et al. compared arthroscopy assisted  
184 tightrope fixation and HP fixation for acute high grade ACJ dislocations. Patients with non-  
185 rigid fixations had a better quality of life. However, 12 (60%) out of 20 tightrope patients  
186 achieved anatomic ACJ reduction. In their study, HPs were removed (on average) 3.98  
187 months after surgery; but 7(63.63%) out of 11 patients achieved anatomic ACJ reduction (7).

188 In a systematic review and meta-analysis, Arirachakaran et al. compared clinical outcomes  
189 and complications of the loop suspensory fixation devices including tightrope, synthetic  
190 ligament or absorbable PDS sling with hook plate fixation for the treatment of acute ACJ  
191 injury. They found that in short term, loop suspensory fixation had higher postoperative  
192 Constant–Murley score and lower post-operative pain; however, loop suspensory fixation  
193 showed higher complication rates (8).

194 In a prospective randomized study by Cai et al., HP was compared with tightrope fixation in  
195 Rockwood type III ACJ dislocations. For one year follow-up, there was no significant  
196 difference between Constant–Murley scores of the two groups. The difference of VAS scores  
197 was in favor of the tightrope group. Both groups achieved reasonable and satisfactory clinical  
198 and radiological outcomes. 3 (10%) out of 30 patients with tightrope fixations had complete  
199 ACJ redislocations. The authors did not remove HP during the study (11).

200 In the current study similar to other researches, the non-rigid extra-articular CLDE CC  
201 fixation exhibited better clinical outcomes compared to rigid fixation with HP (in short term).  
202 However, it was a technically demanding procedure with a longer operation time and higher  
203 rate of failure. HP maintained the CC distance better and its application was more feasible.  
204 HP needs a second surgery for removal and development of subacromial erosion and  
205 osteoarthritis of the ACJ which is one of its major concerns.

206 The limitations of study were low sample size due to low incidence of ACJ dislocation. The  
207 contaminant reconstruction of ligament with the CLDE or HP techniques was useful and need  
208 to more evaluate in the future studies. However in this study we appropriate follow-up of our  
209 patients after HP discharge and all complications were recorded honestly.

210 The current study was a short term, retrospective, single center study with a small number of  
211 patients. We suggest further multicenter studies with a larger number of patients, longer  
212 follow-ups, randomized and prospective design.

### 213 **Acknowledgments**

214 This study was financially supported by ..... University of Medical sciences.

### 215 **Conflict of Interest**

216 There is no conflict of interest for report.

### 217 **Ethical Issues**

218 This study was confirmed by ethics committee of .....University of Medical Sciences.

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288 **Figure captions:**

289 **Figure 1:** Re-dislocation of ACJ because of CLDE failure at the clavicular button

290 **Figure 2:** Re-dislocation of ACJ with HP.

291 **Figure 3:** Subacromial erosion and osteoarthritis of the ACJ. HP removed 13 months after  
292 fixation

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