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Double Button Fixation System for Reconstruction of Coracoclavicular Ligament Disruption

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ABSTRACT

Background and aim: Coracoclavicular (CC) ligament disruption is a common orthopedic injury. Many treatment techniques are available and others continue to emerge. However, none of them was considered as the gold standard technique. The current work aimed to evaluate the mid-term results of open surgical fixation of the acute CC ligament disruption by a double-button fixation system.

Patients and Methods: This was a prospective clinical study, including 80 adult patients with CC ligament disruption. All were subjected to clinical, radiological and laboratory evaluation. Then, under general anesthesia, a double-button fixation was performed. All were assessed for postoperative complications, functional outcome (by Constant score, The American shoulder and elbow surgeons standard shoulder assessment form (ASES) score, the disability of the arm, shoulder and hand (DASH) score and visual analogue scale (VAS) score. The final follow-up visit was set at the end of the 6th month after surgery.

Results: The commonest mode of trauma was road traffic accident (55.0%). The left was affected more than the right side (65.0% vs 35.0%). Complications rate was 20.0%. The constant and ASES score significantly increased postoperatively than corresponding preoperative values (95.2±4.7, 97.22±4.8 vs 34.0±5.5 and 39.34±4.34 respectively). Otherwise, the DASH score was reduced from 16 before to 6 after surgery. Finally, DASH score was only significantly associated with mode of trauma.

Conclusion: The double-button fixation system does minimal damage to the soft tissues surrounding the ligaments and is an effective, suitable and safe technique for the management of acute coracoclavicular ligament disruption.

Keywords: Coracoclavicular; Ligament; Double Button; Disruption; DASH score.

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INTRODUCTION

In the practice of orthopedic surgery, the acromioclavicular joint (ACJ) dislocation with coracoclavicular (CC) ligament disruption is a common injury. It accounts for about 12% of all shoulder girdle dislocations and represents about 8.0% of all joint dislocations [1]. It is usually associated with sports activities, road traffic accidents or fall on the side of the body. Athletic or active young adults are more prone to injury with male sex predilection (male to female injury is 5:1) [2, 3]. The increased rate of ACJ dislocation was attributed to its thin joint capsule. However, it has considerable support with its four ligaments (superior, inferior, anterior and posterior). Horizontal stability is mediated by the acromioclavicular (AC) ligaments. The vertical stability on the other side is mediated by coracoclavicular (CC) ligament complex. The trapezius and deltoid muscles also were shared in AC stability [4-6]. The ACJ dislocation with (CC) ligament disruption treatment is a debatable topic, irrespective of the presence of more than 100 treatment techniques. The ideal treatment method is not present. The treatment modality varies according to the severity of injuries [2,7,8].

The surgical treatment for ACJ dislocation has focused on coracoclavicular interval fixation by using a single suspensory device. This was designed in a trial to meet the concept of an ideal fixation technique. This technique used to treat disruption of the coracoclavicular ligament, and at the same time assures the stability of the acromioclavicular joint by providing fixation between the clavicle and the coracoid process. In addition, it maintains the coracoacromial interval until healing of the soft tissues around the coracoclavicular ligament [9,10]. Furthermore, it guarantees equal distribution of the load on the joint. Thus, it prevents the swing effects of the sutures [11]. The results of different treatment techniques depend on variable reconstruction factors (e.g., anatomical or non-anatomical, open or arthroscopic, acute or delayed). The aim of this work was to evaluate the mid-term results (6 months) of open surgical fixation of the acute CC ligament disruption with a double-button fixation system.

PATIENTS AND METHODS

This was a prospective clinical study designed for patients with acute acromioclavicular joint dislocation with coracoclavicular (CC) ligament disruption who were admitted to Two centers (Damietta Specialized Hospital and Al-Azhar University Hospital in Damietta from March 2022 to March 2023. It included 80 adult patients with acute acromioclavicular joint dislocations with coracoclavicular (CC) ligament disruption (A convenient sample). We included adult (≥18 years) patients who have acute ACJ dislocation type III, IV, V according to Rockwood classification, within three weeks of trauma. In addition, the injury must be of closed type and isolated (with no fractures to the surrounding bones). On the other hand, the exclusion criteria were 1) Acute dislocation type II and VI according to Rockwood classification, chronic ACJ dislocation (> 3 weeks) or patients younger than 18 years old.

Ethical considerations: The study protocol was investigated and approved by the Institutional review board (IRB), Damietta Faculty of Medicine (Al-Azhar University) (IRB00012367-20-03-009). The value of the study and the whole procedures were explained for each patient, and an informed consent was signed by each patient. Patients were anonymized before analysis, and their rights were guaranteed. The collected data was not used for any purposes other than the study. The study and data reported were in line with Helsinki declarations of research conduct and reporting.

Methods:

All patients were subjected to complete history taking (e.g., personal data, special habits, occupations, mode of trauma, injury side, and associated comorbidities). In addition, all were clinically assessed. The diagnosis was confirmed by an erect X-ray imaging (AP, zanca, and stress views) for injuries and non-injured sides. However, in critically traumatized patients clinical and radiological assessment were done after stabilization of general condition. The coracoclavicular intervals (CCI) were measured using x-ray of the same view on both shoulders (injured and normal shoulders). Then, the injury was classified according to Rockwood Classification, and patients were prepared for surgical intervention. All were evaluated by routine laboratory investigations (e.g., complete blood count, prothrombin time, partial thromboplastin time, international normalization ratio, random blood sugar, hepatic and renal function tests). A preoperative antibiotic (third generation cephalosporin) was given one hour before surgery.

Operative technique:

All operations were completed under general anesthesia in the beach chair position. The involved limb was draped free. A campaign approach, oblique incision about 7 cm, was made from upper border of trapezius down to the coracoids 2-3 cm medial to AC joint (Figure 1). Proper homeostasis was achieved. Then, the deltopectoral fascia was incised using diathermy electrode at anterior aspect of the shoulder to expose clavicle and AC joint (Figure 2). Blunt splitting of the anterior deltoid fibers to expose coracoid process was performed (Figure 3). Gentle medial retraction on conjoint tendon was applied to ease passage of a nylon tape, and the conjoint tendon did not retracted laterally to avoid traction on musculocutaneous nerve. Drill holes using 4.5 mm drill bit were made one on the clavicle (midway between anatomical attachments of CCL), 2.5 – 3 cm medial to AC joint and another drill hole 4.5 mm on the base of coracoid (Figure 4). The double button system was prepared. Passing suture was threaded from clavicular hole to the coracoid hole to its under surface. Then, threads of the rope were passed loaded on endobutton through under surface of coracoid then clavicle by passing suture (Figure 5). A passing suture or nylon loop was used for easy extraction of rope through the drill hole. The rope was passed through the second endobutton over superior surface of clavicle (Figure 6). Over-reduction of AC joint was achieved manually by pushing distal end of clavicle downward with upward force directed to flexed elbow and arm. The C-arm was used for assurance of the reduction and to confirm position of the

buttons (Figure 7). Finally, deltopectoral fascia was sutured, the wound was irrigated with saline 0.9%. The wound was closed in layers and covered with dressing (Figure 8).

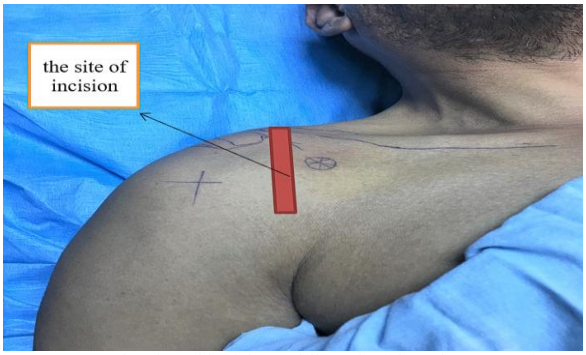

Figure (1): The site of incision (oblique incision about 7cm from upper border of trapezius down to the coracoids 2-3cm medial to AC joint).

Figure (2): Incision of the skin and deltotrapezoid fascia

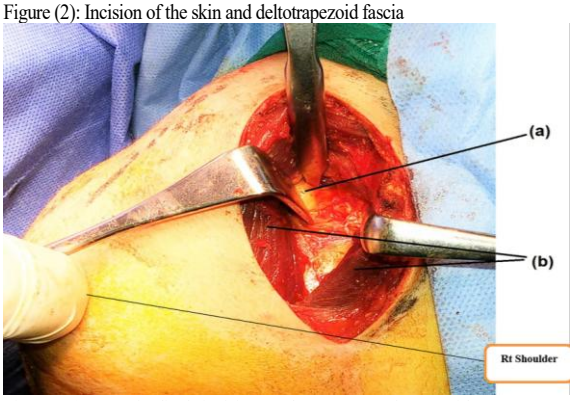

Figure (3): Longitudinal incision and exposure of coracoid process (Rt Shoulder); (a) Exposure of coracoid process after blunt splitting of (b) Anterior deltoid.

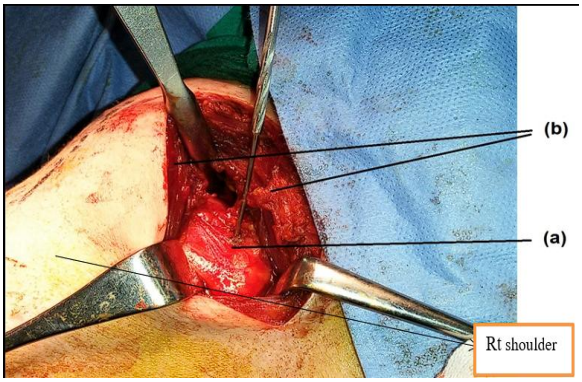

Figure (4): (a) Drilling of coracoid process using 4.5 drill bit; (b) Retracted anterior deltoid.

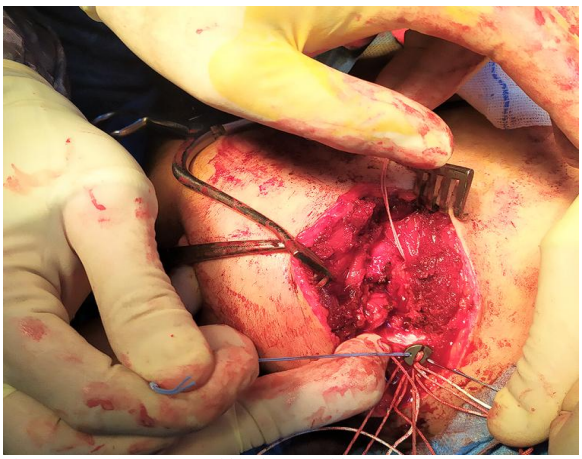

Figure (5): Passing the rope within the coracoid process

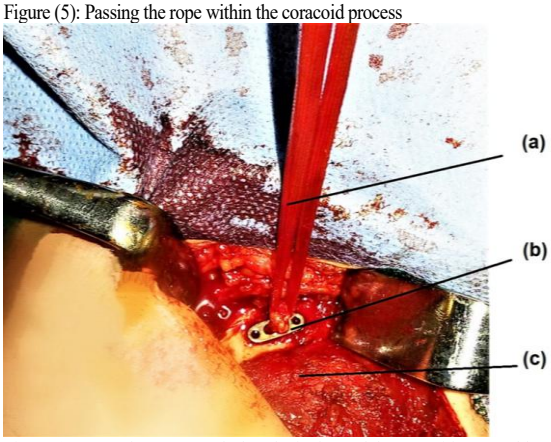

Figure (6): (a)Nylon tape used, (b) Clavicular endobutton with secured knots, (c) Anterior deltoid

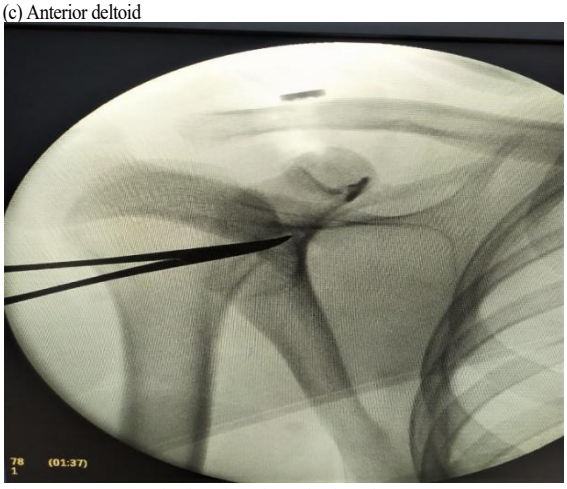

Figure (7): Intraoperative imaging after reduction of ACJ.

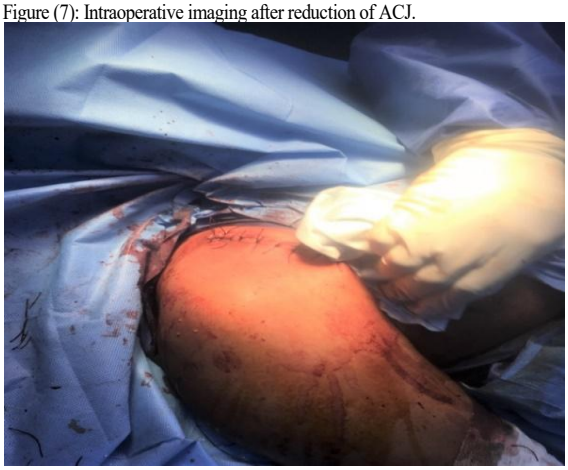

Figure (8): After wound closure and dressing.

Postoperative follow up and rehabilitation:

All patients were kept in the arm sling for a maximum of 6 to 8 weeks postoperatively. They were discharged from hospital two days after operation. They were advised of regular follow-up visits on 2, 4, 6 weeks and on 3 and 6 months. The final outcome was assessed clinically, radiologically and by different scores (e.g., Constant score (12), The American shoulder and elbow surgeons standard shoulder assessment form (ASES) score (13) The disability of the arm, shoulder and hand (DASH) score (14) and visual analogue scale (VAS) score) (15) and Coracoclavicular interval (mm). Finally, any complications were documented.

Data analysis:

Data was fed to the computer and analyzed using IBM Statistical package for Windows, Version 22.0 (Armonk, NY: IBM Corp., USA). Qualitative data were described using number and percentages. Quantitative data were described using mean, standard deviation, minimum and maximum (for parametric data), median and interquartile range for non-parametric data. The data tested for normality using Kolmogorov-Smirnov test. Monte Carlo test used as correction for Chi-Square test for comparison of two or groups when more than 25% of cells have count less than 5. Otherwise, groups were compared by Chi-square test. On the other side, One Way analysis of variance (ANOVA) test was used to compare more than two independent groups with Post hoc Tukey's test to detect pair-wise comparison. However, the same variable compared at two different points of time by paired samples "t" test. P value < 0.05 was considered significant.

RESULTS

In the current work, 80 patients with acute ACJ dislocation with (CC) ligament disruption were included. Their age ranged between 18 to 60 years, and they were mainly males (80.0%). Smoking was reported by 30.0%, while sports were practiced by 15.0%. Most of them had light work (70.0%). The most common mode of trauma was road traffic accident (55.0%) followed by falling (40.0%). The left side was affected more than the right one (65.0% vs 35.0% respectively), while 95.0% of subjects were right hand dominant. No associated fractures were reported among 90.0% and 50.0% had no associated comorbid medical conditions. The commonest injury was Rockwood III (80.0%) (Table 1).

In the current work, different scores to assess functional outcomes revealed significant improvement at the end of follow up (6 months visit). Also, CC interval was significantly reduced after operative intervention. In addition, 20.0% had complications in the form of dislodged button and arthritis (Table 2).

Searching the association between DASH score (as a measure functional outcome) and different variables, we found that it was only associated with mode of trauma, where sport's injury was associated with fair outcome (Table 3).

Table (1): Patient's and trauma characteristics

		Values
Age (years)	Mean ± SD	34.55±11.14
	Min.- Max.	18- 60
Sex	Male	64 (80.0%)
	Female	16 (20.0%)
Smoking		24 (30.0%)
Sports and activity		12 (15.0%)
Occupation	Light work	56 (70.0%)
	Hard work	24 (30.0%)
Mode of trauma	Falling down	32(40.0%)
	Road traffic accident	44 (55.0%)
	Sports injury	4 (5.0%)
Injury side	Left	52(65.0%)
	Right	28 (35.0%)
Dominant hand	Left	4 (5.0%)
	Right	76 (95.0%)
Associated fractures	None	72 (90.0%)
	Fracture proximal humerus and/or distal radius fracture	8 (10.0%)
Associated comorbidities	None	40 (50.0%)
	Diabetes mellitus	12 (15.0%)
	Hypertension	16 (20.0%)
	Diabetes and hypertension	8 (10.0%)
	Bronchial asthma	4 (5.0%)
Rockwood classification	III	64 (80.0%)
	IV	4 (5.0%)
	V	12 (15.0%)

Table (2): Outcome among study subjects

		Preoperative	Postoperative (at 6 months)	Test	P
Constant score		34.0±5.5	95.2±4.7	*74.12*	*<0.001**
ASES score		39.34±4.34	97.22±4.8	*93.12*	*<0.001**
DASH score (median, IQR)		16 (11.7 – 24.2)	6.0 (0.0-18.0)	*7.70*	*<0.001**
VAS score (median, IQR)		4 (3-7)	0.0 (0-3)	*7.86*	*<0.001**
Coracoclavicular interval (mm)		14.5±1.62	10.35±2.11	*15.21*	*<0.001**
Complications	Dislodge of button	8 (10.0%)			
	Arthritis	8 (10.0%)			

Table (3): Relation between DASH score and studied variables

		DASH score			Test	p
		Fair (n=8)	**Good (n=40)**	**Excellent (n=32)**		
Age		29.12±10.4	36.02±11.23	34.06±11.06	1.34	0.26
Sex	Male	8 (100.0%)	29(72.5%)	27(84.4%)	3.78	0.15
	Female	0 (0.0%)	11 (27.5%)	5 (15.6%)		
Occupation	**Manual worker**	3 (37.5%)	20(50.0%)	13(40.6%)	10.09	0.12
	Student	3 (37.5%)	8(20.0%)	3(9.4%)		
	Employee	2(25.0%)	12(30.0%)	12 (37.5%)		
	Housewife	0 (0.0%)	0 (0.0%)	4(12.5%)		
Mode of trauma	Road traffic accident	4(50.0%)	16 (40.0%)	24 (75.0%)	*49.0*	*0.001**
	Fall on adducted shoulder or hand	0 (0.0%)	24 (60.0%)	8 (25.0%)		
	Sport's injury	4(50.0%)	0 (0.0%)	0 (0.0%)		
Trauma side	Right	4(50.0%)	15 (37.5%)	9 (28.1%)	1.56	0.45
	Left	4(50.0%)	25 (62.5%)	23 (71.9%)		
Associated injuries	None	8(100.0%)	32 (80.0%)	32 (100.0%)	8.83	0.07
	Fracture proximal humerus	0 (0.0%)	4 (10.0%)	0 (0.0%)		
	Distal radius fracture	0 (0.0%)	4 (10.0%)	0 (0.0%)		
Complications	None	4(50.0%)	35 (87.5%)	29 (90.6%)	8.80	0.08
	Dislodge of button	3 (37.5%)	4 (10.0%)	2 (6.3%)		
	Arthritis	1 (12.5%)	1 (2.5%)	1 (3.1%)		
Dominant hand	Right	1 (12.5%)	2 (5.0%)	1 (3.1%)	1.18	0.55
	Left	3 (37.5%)	38 (95.0%)	31 (96.9%)		
Injury classification	III	6 (75.0%)	34 (85.0%)	31 (96.9%)	4.99	0.28
	IV	1 (12.5%)	4 (10.0%)	0 (0.0%)		
	V	1 (12.5%)	2 (5.0%)	1 (3.1%)		

DISCUSSION

In present study, significant improvement of clinical scores were reported at the final follow up when compared to preoperative values. The CC interval was significantly reduced after than before surgical intervention. This data reflected efficacy of the use of double button fixation system for coracoclavicular (CC) ligament disruption through open techniques.

Salzmann *et al.* [16] introduced tight rope reconstruction for acute higher grades ACJ separations. They stated that this technique is a minimally invasive method for the management of the torn conoid and trapezoid ligaments in the presence of ACJ dislocation. With time, the technique gains acceptance and literature started to report results about the technique regarding its indications, applications and outcome. **Patzer *et al.*** [17] compared a single to a double tight rope technique and reported that, the double technique is associated with lower CC distances. However, the difference was statistically non-significant. Both provide satisfactory functional outcomes. **Scheibel *et al.*** [18] confirmed the safety of double rope technique with good- to excellent early clinical outcomes. However, particle recurrent instability of the AC joint was reported both in vertical and horizontal planes. **Gerhardt et al.** [19] also reported favorable clinical functional results after AC joint stabilization using the double button fixation system technique.

Walz *et al.* [20] demonstrated that anatomic reconstruction of the CC ligament by the double button fixation system technique is stable with good functional and anatomical reconstruction. It displayed favorable results with equivalent or even higher forces than native ligaments. This was confirmed in the current study by reduced CC distance after than before surgery. **Horst *et al.*** [21] in a retrospective study concluded that, the use of a double button fixation system for CC ligament disruption is an effective and safe procedure for higher degree of ACJ luxation. However, they recommended future studies to address the long-term clinical and radiographic outcomes.

Beris *et al.* [22] used a double-button fixation system to manage acute coracoclavicular ligament disruption for 12 subjects (eight were of grade III and 4 of grade IV). Their mean age was 27.5 years which is younger than our patients. They used different scores to assess the functional outcome (e.g., DASH, Constant and VAS scores). In addition, they measured the CC distance. They reported significant increase of constant score at the last follow up when compared to preoperative values (94.8 vs 34.4, respectively). In addition, mean DASH score significantly

reduced from 19.6 preoperatively, to 0.25 at the last follow up visit, and VAS reduced from 5.75 to 0.2. However, they did not find significant differences in CC distances. No significant complications were observed in their study. These results are in line with the current work except for CC distances. **Struhl and wolfson** [23] treated 35 patients for type 3 or greater AC joint dislocation by continuous loop double endobutton. They added an extra suture fixation to anterior clavicle (25 chronic and 5 acute). The construct remained stable in all cases, with no cases of gross failure. The mean constant score was 98 and the mean ASES score was 98. These results showed close similarity with the current study.

Torkaman *et al.* [9] included 28 patients with CC ligament disruption treated by the double endobutton technique. Two titanium buttons with sutures were used on the superior and inferior sides. Subsequently, the load on the joint was disturbed equally; therefore, preventing the sawing effect of the sutures. The postoperative constant score was significantly higher, while DASH and VAS scores were significantly lower when compared to preoperative values. Patients had higher satisfaction with the procedure. Only two patients had heterotrophic ossification during the period of follow up.

Xu J, *et al*. [24] studied 78 consecutive patients picked and divided into single and double groups with 39 cases in each group and they declared that both single and double techniques achieved a satisfactory outcome with less complications in treating acute Rockwood type IV ACJ dislocation. However, better outcome was observed in the double (paired) group. Complications like redislocation, button slippage, erosion, or ACJ instability reported in the single group, while the complication in the double group was rare. These complications may be due to mal-positioning of the tunnels, excessive tension of the double endobutton bearings. Thus, increasing slippage force, especially when the endobutton was laid on the uneven face of the clavicle or the coracoid process. Furthermore, bone erosion due to excessive tension on the clavicle or coracoid process with ACJ joint laxity may be responsible [25]. Finally, the sutures were perhaps unable to bear such a strong traction force between the coracoid and clavicle, thus resulting in suture lengthening or rupture and causing ACJ laxity or re-dislocation [26,27].

Arirachakaran *et al.* [28] conducted a systematic review and meta-analysis about suspensory loop fixation (SLF) device versus hook plate in acute unstable AC joint dislocation and showed the following: LSF implants have higher shoulder function and lower shoulder pain reported by CMS and VAS scores of 2.2 and 1.2 points, respectively, which is higher when compared to HP fixation but this difference is not statistically significant. However, LSF displayed a higher complication rate after surgery, (wound problems, loss of reduction, implant migration and osteolysis) being 1.7 times higher than HP fixation in acute unstable ACJ injury. However, HP fixation is a double procedure that also requires a second surgery for plate removal.

In conclusion, the double-button fixation system does minimal damage to the soft tissues surrounding the CC ligaments and is a suitable technique for the management of acute coracoclavicular ligament disruption. However, the absence of comparison groups and small number of subjects included are limiting steps of the current study. Thus, future research comparing the selected procedure with other available methods for treatment of CC ligament disruption is highly recommended. In addition, the short duration of follow up represents another limiting step. However, the current study is valuable and adds to the available literature regarding the efficacy and safety of the double-button fixation system for acute CC ligament disruption. The ability to early application of the device in acute cases represents an advantage of the procedure.

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