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Stabilization of acromioclavicular joint using DogBone dynamic system (Arthrex): a literature review and long-term follow-up

M.S. Ryazantsev[1], D.O. Il'in[1], K.E. Rybin[1,2], N.E. Magnitskaya[1], A.P. Afanasyev[1], A.N. Logvinov[1,2], A.V. Korolev[1,2]

[1]European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation
[2]Peoples Friendship University of Russia, Moscow, Russian Federation

Objectives The purpose of the study was to evaluate long-term follow-ups of stabilized acromioclavicular joint (ACJ) dislocations using button dynamic system applied via arthroscopic technique or mini-open. **Material and methods** The review included follow-ups of 40 patients (39 males, 1 female) who underwent 40 ACJ stabilization procedures with Arthrex DogBone button between 2014 and 2017 using arthroscopy (n = 28) or mini-open technique (n = 12). The mean age of the patients was 34 years (range, 15 to 59 years). Patient reported outcomes were evaluated with UCLA shoulder rating scale, American Shoulder and Elbow Surgeons (ASES) shoulder score and the Constant Shoulder Score (CSS). Coraco-Clavicular Distance (CCD) was measured on pre- and postoperative anteroposterior views. Postoperative AP view was used to measure Clavicular Tunnel Distance (CTD). Arthroscopy patients had available preoperative radiographs (n = 21), postoperative radiographs (n = 26) and patient reported outcomes (n = 18). Mini open group had available preoperative radiographs (n = 2), postoperative radiographs (n=8) and patient reported outcomes (n = 8). **Results** One hundred percent of Arthroscopy/Mini open (26/26) cases were rated as excellent and good on UCLA shoulder rating scale at a long-term follow-up. One hundred percent of Arthroscopy patients (18/18) were rated as excellent and good; 75 % (6/8) of Mini-open cases evaluated as excellent and 25 % (2/8) as good on ASES shoulder score. Sixty seven percent of Arthroscopy (12/18) patients were rated as excellent and 33 % (6/18) as good; 62 % (5/8) of Mini open cases evaluated as excellent and 38 % (3/8) as good. Neither fair nor poor results were observed in both groups. No statistically significant differences were detected in median scores between Arthroscopy and Miniopen groups (p > 0.05). Preoperative radiographs showed Tossy grade IV dislocation (n = 3) and Tossy grade III (n = 20). Distal clavicle fracture was diagnosed in 2 cases. Median preoperative CCD radiologically measured 15.5 mm in both groups (n = 23). Median postoperative CCD and CTD radiologically measured 6.12 mm and 28.9 mm in both groups (n = 35), correspondingly. Decrease in postoperative CCD was significantly different (p = 0.0003). No statistically significant differences in postoperative CCD were detected between Arthroscopy and Miniopen groups (p > 0.05). Statistically significant differences in preoperative CCD were observed in both groups (n = 15) using weight-bearing/no weight-bearing AP views (P = 0.0009). **Conclusion** Stabilization of dislocated ACJ with dynamic systems is the method of choice providing excellent and good outcomes rated by UCLA rating scale, ASES shoulder score and CSS at long-term follow-up. One-stage surgical treatment is an advantage of dynamic systems with no need of construct removal. Standard and weighted stress radiographs of the involved side indicate to ACJ injury in comparison with contralateral side. Further research is needed for a longer term follow-up with the bone reduction maintained with dynamic system.
Keywords: acromioclavicular joint, injury, fixation, DogBone, dynamic system

INTRODUCTION

Injury to the acromioclavicular (AC) joint is a common injury among athletes and accounts for more than 12 % of all shoulder injuries [1–4]. AC joint injuries are most common in individuals younger than 35 years of age, with males sustaining 8 times more traumatic AC joint injuries than females [2]. Isolated AC injuries without clavicle fracture are observed in 93 % of the cases [5]. A longitudinal cohort study of characteristics of AC joint injury at the Military Academy reported by M. Pallis et al. showed an overall incidence of 9 per 1000 persons with 89 % of low-grade injuries Rockwood types I and II [1]. AC injuries are frequently seen after high-risk and collision activities, such as football, hockey, biking, snow sports and other sports-related activities (e.g., skiing) [6]. The most common mechanism of injury is direct trauma [1, 6]. Standard radiographs and weighted stress views (+5 kg) are adequate to make a diagnosis of AC joint injury. There are controversies regarding the best treatment for Rockwood type III injuries [7–11]. Dynamic systems are the gold standard for surgical stabilization of AC joint injuries exhibiting high mechanical properties [12] and providing satisfactory long-term outcomes [2, 4, 13]. The fixator can be applied standalone or augmented with AC repair [14].

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Objectives The purpose of the study was to evaluate long-term follow-ups of stabilized acromioclavicular joint (ACJ) dislocations using DogBone button dynamic system (Arthrex) applied via arthroscopic technique or mini-open.

MATERIAL AND METHODS

The review included follow-ups of 40 patients (39 males, 1 female) who underwent 40 ACJ stabilization procedures with Arthrex DogBone button between 2014 and 2017 using arthroscopy (n = 28) or mini-open technique (n = 12). The mean age of the patients was 34 years (range, 15 to 59 years). All patients were examined preoperatively and at a long-term follow-up. Patient reported outcomes were evaluated with the University of California at Los Angeles Shoulder Score (UCLA Shoulder Score), American Shoulder and Elbow Surgeons (ASES) shoulder score and the Constant Shoulder Score (CSS). All the scales were translated from the source language into Russian. Interpretation of long-term follow-ups is presented in Table 1.

Table 1

Interpretation of long-term outcomes of surgical treatment with shoulder rating scales

Rating	Rating scale / scores		
	UCLA	ASES	CSS *
Poor	< 27	< 70	> 30
Fair		70–79	21–30
Good	> 27	80–89	11–20
Excellent		⩾ 90	< 11

*Difference between involved and intact sides included in CSS

Radiographic evaluation included preoperative standard radiographs of the shoulder and weighted stress views (+5 kg) of AC joint. AC injuries were classified using the 6-type system classification offered by Tossy and modified by Rockwood [15]. Standard radiographs of the shoulder were performed for all the patients next day postsurgery. Coraco-Clavicular Distance (CCD) measured as the distance between the superior cortex of the coracoid process and the undersurface of the clavicle on pre- and postoperative anteroposterior views was used to assess clavicle reduction [16]. Clavicular Tunnel Distance (CTD) measured as the distance between the distal end of the clavicle and the center of the tunnel on postoperative AP view was used to evaluate the tunnel created in the clavicle (**Fig. 1**).

Arthroscopy patients had available preoperative radiographs (n = 21), postoperative radiographs (n = 26) and patient reported outcomes (n = 18). Mini open group had available preoperative radiographs (n = 2), postoperative radiographs (n = 8) and patient reported outcomes (n = 8).

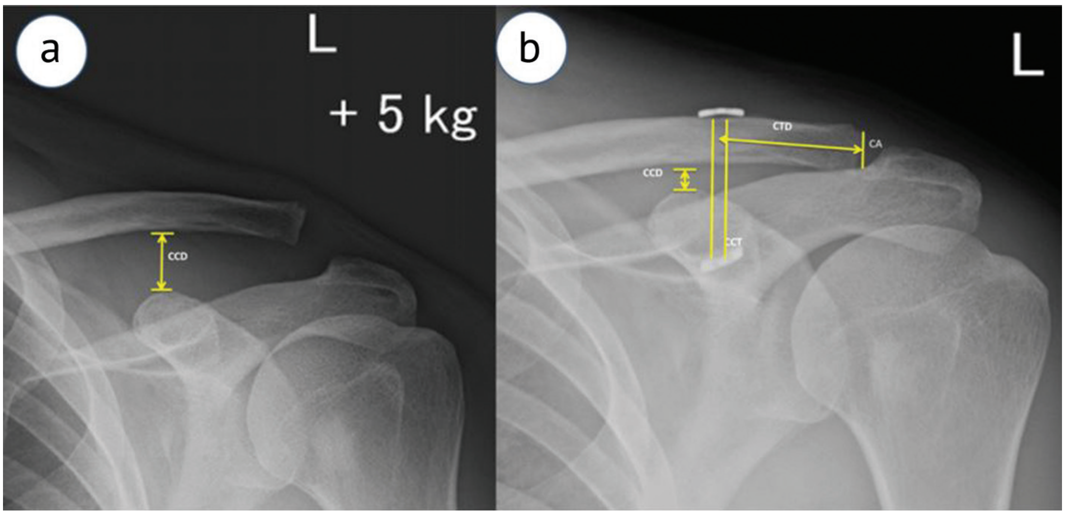

Fig. 1 AP view of the left shoulder before and after AS joint stabilization with dynamic system showing (a) preoperative weighted stress film (+5kg); (b) postoperative view. Abbreviations: CCD, Coraco-Clavicular distance measured as the distance between the superior cortex of the coracoid process and the undersurface of the clavicle; CTD, Clavicular Tunnel Distance measured as the distance between the distal end of the clavicle and the center of the tunnel; CCT, Coraco-Clavicular Tunnel (coaxial tunnel formed in the clavicle and the coracoid process); CA, Clavicula Acromiale (acromial end of the clavicle)

Statistical analysis

Statistical data analysis was performed using Statistica 12.0 computer program, Stat Soft, Inc. The Shapiro-Wilk test was used to check for normality of distribution in groups. For normally distributed data, the mean ± errors with data range of minimum to maximum were used; for data not normally distributed, the median with interquartile range was applied. Box-whisker plots were used for quantitative data. Wilcoxon rank-sum test was used to compare two related groups and Mann-Whitney test was applied for statistical analysis of data in two independent groups. We set the significance threshold at $p \leqslant 0.05$ (5 % significance).

Surgical technique

Patient's position

The patient was placed in either the beach-chair (n = 5) or lateral decubitus position (n = 35) at the surgeon's preferences. External and palpation landmarkes were used for identification of operative field.

Open stabilization of AC joint using Arthrex DogBone dynamic system

A transverse skin incision of 20 mm was made from approximately 30 mm proximal to the acromial end of the clavicle on the operating table under intravenous anesthesia. Approach to the clavicle was performed sharply and bluntly. A vertical skin incision of 30 mm was made toward the coracoid process to produce approach sharply and bluntly to the base of the coracoid process. An appropriate guide was placed on the coracoid base and a guide sleeve mounted in the middle of clavicle width under C-arm control. The coaxial clavicle and coracoid tunnels were made with the 4.5 or 2.4 mm drill (**Fig. 2**). Guide fibers in place were replaced with tapes (FiberWire, Arhtrex) and looped into the slots of the implant that was seated against the coracoid base.

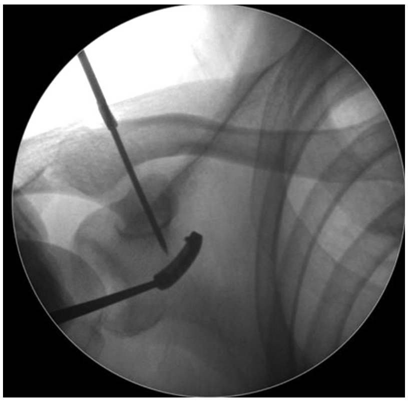

Fig. 2 The coaxial clavicle and coracoid tunnels being made in the right glenohumeral joint

Then the proximal button was placed, fibers tied and the clavicle reduced acutely with the push rod (**Fig. 3**).

Intraoperative reduction of the distal end of the clavicle was assessed using the C-arm. Wounds were sutured layer after layer and aseptic dressings applied. Upper limb was immobilized with Gilchrist bandage.

Stabilization of AC joint with Arthrex DogBone dynamic system using arthroscopic procedure

Standard arthroscopic portals (posterior, superior lateral) were used for arthroscopic repair of the glenohumetral joint with appropriate patient's position. Then the rotator interval was opened and the base of the coracoid exposed. A 300 arthroscope was replaced by 700 arthroscope with limited visualization. A lateral portal was additionally used if needed. An open transverse approach 20 mm long was provided to the clavicle 30 mm off the distal end. The distal end of the clavicle was reduced and fixed using the above technique (**Fig. 4**).

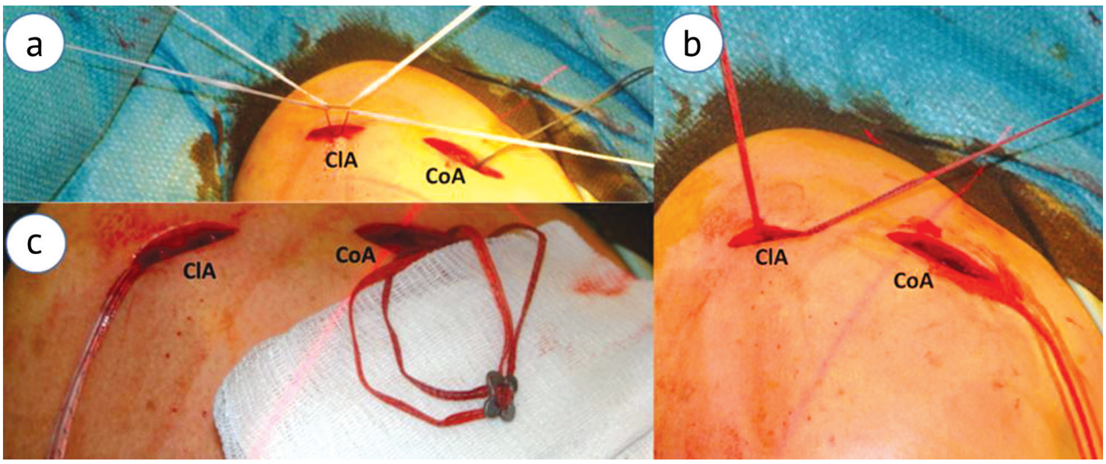

Fig. 3 Open fixation of the distal end of the clavicle using Athrex DogBone dynamic system mounted for the right glenohumeral joint: (a) fibers passing through the clavicle and coracoid tunnels; (b) DogBone button seated at the base of the coracoid; (c) fibers tied through the second clavicle implant. Abbreviations: ClA, Clavicular Approach, transverse approach to the clavicle; CoA – Coracoid Approach

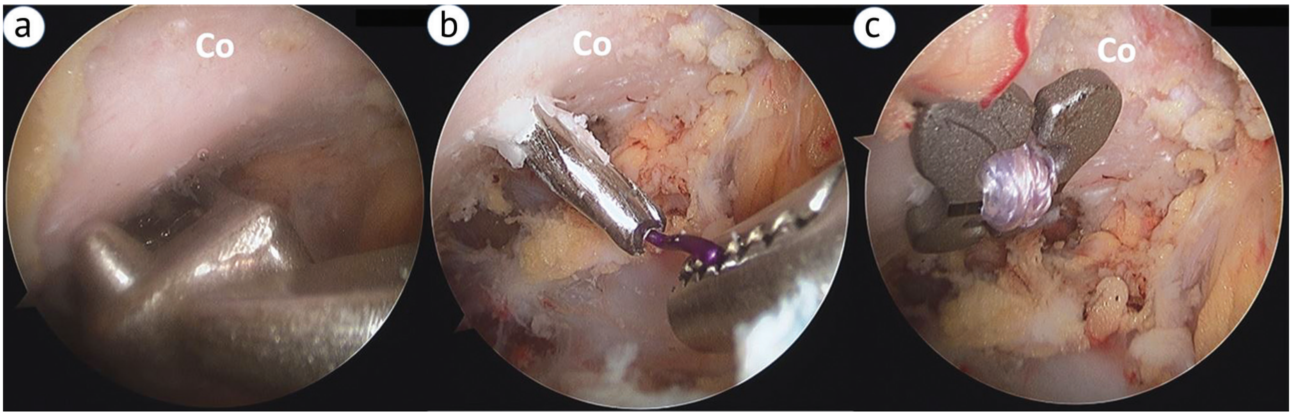

Fig. 4 Arthroscopic stabilization of the right AC joint with Arthrex DogBone dynamic system showing (a) approach to the coracoid base provided and guide placed; (b) the clavicle and coracoid tunnels made with 2.4 mm cannulated drill and fibers being pulled through; (c) DogBone implant finally seated at the base of the coracoid. Co, the base of the coracoid

RESULTS

Patients are distributed with regard to the mechanism of injury (**Fig. 5**). Hockey injuries were most common (14 out of 40).

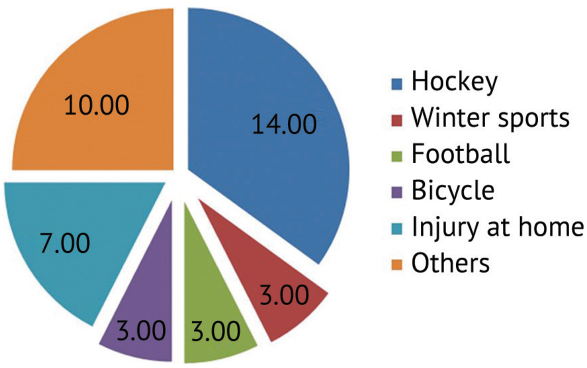

Fig. 5 Distribution of patients with regard to the mechanism of injury (Others include bicycle accidents, riding the horse, broomball and wrestling)

The median time from injury to operative treatment was 5 days (interquartile range, 10 to 12 days). The median time from surgery to patient reported assessments was 3 years (interquartile range, 3 to 3.5 years) in Arthroscopy group and 1 year (interquartile range, 0 to 1 year) in Miniopen patients. Patients reported outcomes using UCLA, ASES and CSS scales are presented in **Figures 6, 7** and **8**.

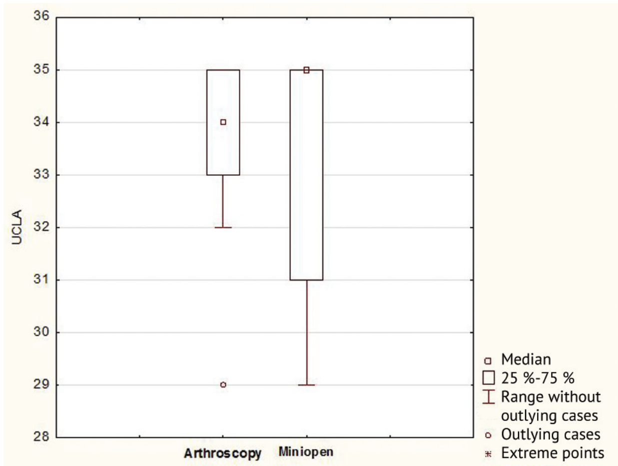

Fig. 6 Distribution of outcomes evaluated with UCLA shoulder rating scale (scores)

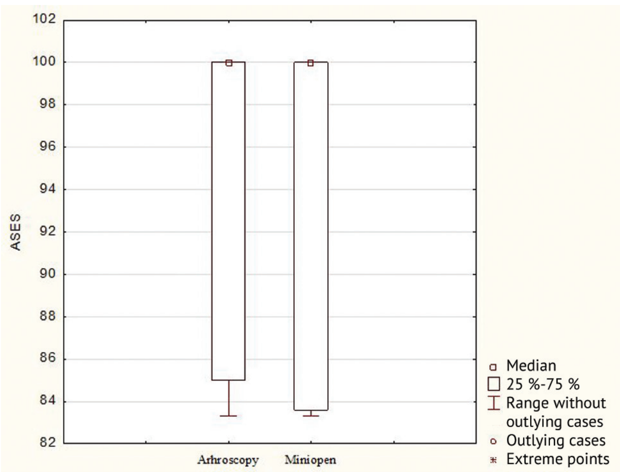

Fig. 7 Distribution of outcomes evaluated with ASES shoulder score (scores)

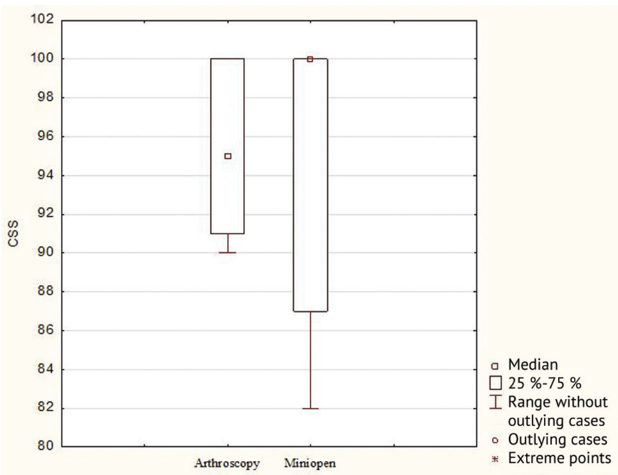

Fig. 8 Distribution of outcomes evaluated with CSS (scores)

UCLA shoulder rating scale showed 100 % (26/26) excellent and good results in both Arthroscopy and Miniopen groups. ASES shoulder score showed 100 % (18/18) excellent results in Arthroscopy group and 75 % (6/8) excellent and 25 % (2/8) good results in Miniopen group. CSS demonstrated 67 % (12/18) excellent and 33 % (6/18) good results in Arthroscopy patients, and 62 % (5/8) excellent and 38 % (3/8) good results in Miniopen group. Neither fair nor poor outcomes were observed. No statistically significant differences in patient reported outcome measures were seen in both groups ($p > 0.05$).

Preoperative radiographs showed Tossy IV (n = 3) and Tossy III injury (n = 20). Fracture of the distal part of the clavicle was diagnosed in 2 cases.

The median CCD measured 15.5 mm (interquartile range, 11.9 to 18.3 mm) on preoperative radiographs of both groups (n = 23). The median CCD measured 6.12 mm (interquartile range, 4.8 to 8.5 mm) on postoperative radiographs of both groups (n = 35), and the median CTD was 28.9 mm (interquartile range, 27 to 32.9 mm). Postoperative decrease in CCD was statistically significant ($p = 0.0003$). Distribution of measurements is presented in **Figure 9**.

No statistically significant differences in CCD measurements were observed on postoperative radiographs of Arthroscopy and Miniopen groups ($p > 0.05$). Significant statistical dependence in CCD measurements was seen on preoperative standard and weighted stress radiographs of both groups (n = 15) ($p = 0.0009$) (**Fig. 10**).

Recurrent dislocation of the distal end of the clavicle resulted from lifting a heavy object (n = 1) and inappropriate postoperative loading (n = 1) (**Fig. 11**). Implants were removed in the first case and revision stabilization of AC joint with autologous semitendinosus graft produced at 3 months of index surgery. The second patient chose to undergo conservative treatment and presented no complaints of discomfort in AC joint at the last follow-up visit.

Additional intraoperative findings:

– associated pathological shoulder lesions revealed intraoperatively in 11 % of the cases (3/28). Tenodesis of the long head of the biceps tendon was produced in the proximal portion of the bicipital groove due to its instability;

– unstable fragments of the rotator cuff were excised in two cases due to partial-thickness tear;

– unstable fragments of the superior labrum glenoidale was excised in one case.

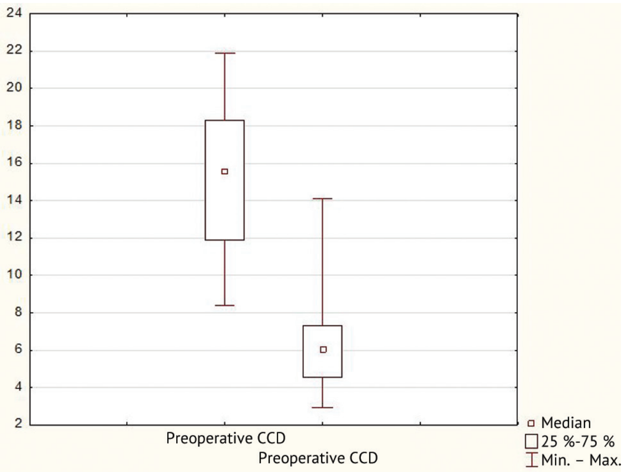

Fig. 9 Distribution of preoperative and postoperative CCD measurements (mm)

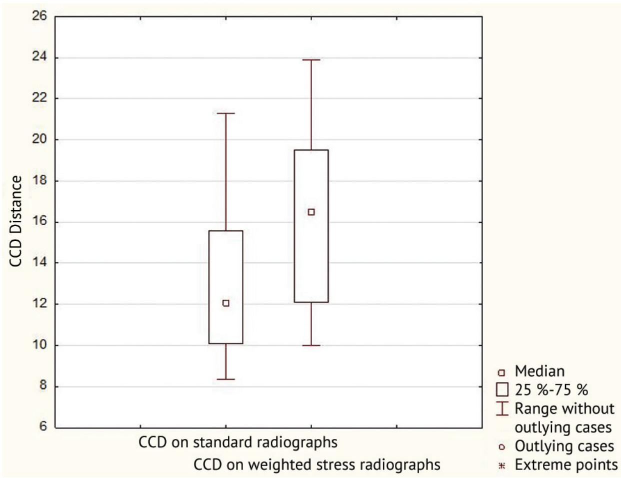

Fig. 10 Distribution of CCD measurements on standard and weighted stress radiographs (mm)

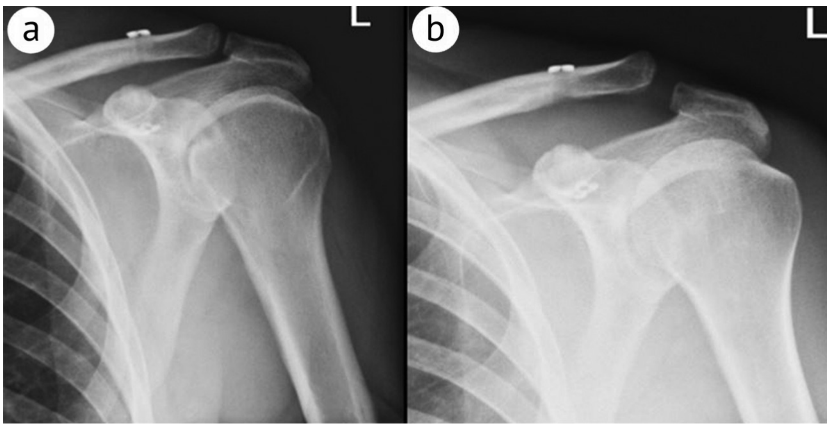

Fig. 11 Recurrent instability of the distal end of the clavicle of the left glenohumeral joint: (a) AP view next day postsurgery; (b) lost correction at 3-month follow-up

DISCUSSION

Surgical treatment of ACJ injury has come a long way and now there is a variety of improved surgical techniques in the armory of orthopaedic surgery for stabilizing ACJ [17]. Fixation of AC joint with dynamic systems using arthroscopic procedure is gaining popularity. Good results at a long term are reported in the literature with the usage of dynamic systems [2–4, 6, 11, 14]. We found 3 publications reporting long-term outcomes of AC joint reconstructive surgery using Arthrex DogBone button that are presented in Table 2.

Our findings of patient outcomes evaluated with shoulder assessments forms were similar to those reported by the researchers (Table 2). Unfortunately, there are no uniform standards to assess function of AC joint and different authors use different assessment scales. Associated pathological shoulder lesion was observed in 11 % of our patients (3/28). P. Arrigoni et al. evaluated the incidence of associated pathological lesions that were addressed surgically in Tossy grade 3 AC joint dislocations with the overall rate of 30 % and rotator cuff tear being most common [21]. T. Tischer et al. detected intra-articular injuries in 18 % of the cases [22]. The data indicated to the importance of arthroscopic examination of glenohumeral joint during surgery. The description of surgical technique with Arthrex DogBone construct includes positioning the clavicle tunnel 30 mm off the distal end of the clavicle [13]. External and palpation landmarkes were used for identification of operative field in each procedure and interquartile range of the distance between the distal end of the clavicle and the mid tunnel measured 27 to 32.9 mm. B. Shliemann et al. showed the significance of positioning the fixator (for MINAR systems) on the clavicle and at the base of the coracoid after stabilization of AC joint [23]. The authors indicated to a higher risk of lost reduction with the button placed laterally at the base of the coracoid and with clavicular and coracoid buttons being not perpendicular to each other. S.Sumanont et al. compared the stability of AC joint fixed with DogBone alone and augmented with coracoclavicular joint repair [14]. The authors advocate coracoclavicular fixation combined with AC joint repair for Rockwood high-grade injuries of the AC joint to improve clavicular stability and reduce stress to the dynamic system. Recurrent dislocation of the distal end of the clavicle occurred in 5 % (2/40) of our patients due to inappropriate loading (n = 1) and an occasional injury (n = 1). P. Lee et al. reported 3 % (1/33) of recurrent dislocation due to a fall in the postoperative period [19]. P. Vulliet et al. revealed loss of reduction in more than half of the DogBone cases comparing CCD on the last follow-up radiographs [20]. Our findings of CCD are in line with those measured after stabilization with different constructs. L. Murena et al. described 16 cases of AC joint stabilized with Endobuttons No. 2 who showed a mean CCD of 10 mm (range, 6 to 16 mm) postoperatively [16].

Table 2

Reported outcomes of AC joint repair using DogBone button

Description	M. Faggiani et al., 2016 [18]		P. Lee et al., 2016 [19]	P. Vulliet et al., 2017 [20]	
Fixation system (number of patients)	MINAR (n = 8)	DogBone (n = 8)	DogBone (n = 33)	TightRope (n = 22)	DogBone (n = 18)
Rockwood type of injury (number of patients)	type III (n = 4)	type III (n = 4)	type III (n = 8)	type III (n = 11)	type III (n = 10)
	type IV(n = 4)	type IV(n = 4)	type IV(n = 8)		
			type V(n = 6)	type V(n = 11)	type V (n = 8)
			Fracture of the distal end of the clavicle (n = 6)		
Follow-up period	13 months (range, 6 to 27)	14 months (range, 2 to 26)	24.1 ± 5 months		
CSS	91.10 (range, 82.76 to 96.66)	–	94.3 ± 4.4	95.0 ± 6.1	
OSS	46.19 (range, 42.00 to 48.00)	–	–	–	
SPORTS	7.88 (range, 3 to 10)	–	–	–	
Quick-DASH	–		2.0 ± 2.6	3.4 ± 3.3	
ASES	–	89.4 (range, 56.7 to 100)	–	–	
DASH	–	12.5 (range, 0 to 55.8)	–	–	
VAS	–		0.5 ± 1.1	1.0 ± 1.9	
Complications	–	–	Infection 3 % (1/33)	–	–

The mean (± standard deviation) or the mean (range, min to max) is quoted. CSS, Constant Shoulder Score; OSS, Oxford Shoulder Score; SPORTS, Subjective Patient Outcome for Return to Sports; ASES, American Shoulder and Elbow Surgeons standardized shoulder assessment form; DASH, The Disabilities of the Arm, Shoulder and Hand Score; VAS, Визуально-аналоговая шкала

We were unable to find comparative studies of DogBone button applied via arthroscope and miniopen. No statistically significant differences were found in our series. S. Defoort et al. compared outcomes of open and arthroscopic AC joint stabilization using Arthrex Tightrope fixation system and found arthroscopic procedure yielding better functional results [24]. M. Faggiani et al. concluded that patients treated with additional mini-open coracoid surgery could return to sports with less pain [18].

Limitations of our work include absence of comparative findings of preoperative and postoperative shoulder assessment scales as well as the last follow-up radiographs.

CONCLUSION

Stabilization of dislocated ACJ with dynamic systems is the method of choice providing excellent and good outcomes rated by UCLA rating scale, ASES shoulder score and CSS at long-term follow-up. One-stage surgical treatment is an advantage of dynamic systems with no need of construct removal. Standard and weighted stress radiographs of the involved side indicate to ACJ injury in comparison with contralateral side. Further research is needed for a longer term follow-up with the bone reduction maintained with dynamic system.

Conflict of interests: Prof. A.V.Korolev and Dr. D.O. Il'in are authorized lecturers and consultants for Arthrex company.

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Information about the authors:

1. Mikhail S. Ryazantsev M.D., Ph.D.,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation,
Email: mryazantsev@emcmos.ru
2. Dmitrii O. Il’in M.D., Ph.D.,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation
3. Kirill E. Rybin M.D.,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation,
Peoples Friendship University of Russia, Moscow, Russian Federation
4. Nina E. Magnitskaya M.D., Ph.D.,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation
5. Aleksei P. Afanasyev M.D., Ph.D.,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation
6. Aleksei N. Logvinov M.D.,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation,
Peoples Friendship University of Russia, Moscow, Russian Federation
7. Andrey V. Korolev M.D., Ph.D., Professor,
European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation,
Peoples Friendship University of Russia, Moscow, Russian Federation