Acta Biomed 2015; Vol. 86, N. 3: 251-259

Original article

The treatment of acute Rockwood type III acromio-clavicular joint dislocations by two different surgical techniques

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Summary. *Background and aim of the work:* The treatment of acute type III acromio-clavicular Rockwood dislocations is still a matter of discussion in orthopaedic surgery. The purpose of this study, retrospective and comparative, is to evaluate the long-term results of two different surgical techniques of temporary stabilization using K-wires with and without tension band wiring. *Methods:* One hundred patients, treated from January 2007 and November 2010, were subdivided into two groups according to the surgical method used. They were clinically and radiographically assessed, and the results were compared with those present in the literature. *Results:* The patients were clinically and radiologically evaluated with a mean follow-up of 44.7 months (range 25-60 months). According to the Constant Score, the positive results were 87.4% in group A and 90.2% in group B, without significant statistical difference (p>0.05). However, there were numerous complications, especially metal-work mobilization. *Conclusions:* The results that we have obtained, in part disappointing on the short-term, but positive overall and in line with the literature at long-term follow-up, do not clarify which of the two techniques is superior (www.actabiomedica.it)

Key words: acromio-clavicular dislocation, acromio-clavicular surgical treatment, acromio-clavicular joint, coraco-clavicular and coraco-acromial ligaments; type III AC Rockwood dislocations

Introduction

Acromion-clavicular joint dislocation is a common injury, even if its actual incidence may be underestimated having a reported range between 4 to 8% of all joint dislocations in the body (1,2) and between 9 to 12% of dislocations of the shoulder (3). The most common causes of the lesion are sports injuries, which account for 20% of all shoulder injury in alpine skiers, 41% in elite college football players (4) and 32% of all injury in professional English rugby players (5); of the remaining lesions, 35% are caused by traffic accidents and accidental falls (6,7). Occurrence is five times higher in males, with a maximum frequency between 20 and 30 years of age (8). The mechanism of injury is usually a direct trauma from falling on the supero-lateral face of the shoulder, with the limb near the chest and adducted, or with the limb extended and adducted, involving the upper part of the acromion in relation to the lateral extremity of the clavicle (9). In particular, Rockwood type III acromio-clavicular dislocation (ACD) occurs secondarily after complete rupture of the *acromio-clavicular (AC) ligament* and *coraco-clavicular (CC) ligaments* with the distal clavicle superiorly translated, horizontally and vertically unstable (10).

The appropriate indication of treatment for this grade of lesion is still a matter of discussion in orthopaedic trauma surgery and sports medicine. Conserva-

tive treatment is known as the gold standard for type I and II Rockwood injuries, and surgery remains the ideal solution for the severe degrees (IV-VI) (1,3,5). However, for type III AC dislocation, different methods of treatment have been proposed, both surgical and conservative (6-12), confirming the lack of an unequivocal, widely recognized solution. Some authors (11,12,13), recommend operative reduction in physically active young adults, as well as in athletes and patients with jobs involving physical labor. The different surgical techniques proposed in the last few years to reduce and maintain the reduction of ACJ involve the use of metallic devices, usually difficult to place, often expensive, and frequently associated with complications. Percutaneous pinning, wire fixation in open repair or tension banding using two AC trans-articular percutaneous K-wires and a cerclage are still used to treat acute grade III ACD and remain simple and cost-effective procedures (14).

The objectives of this study were to evaluate long-term clinical and radiological results of a consecutive series of patients diagnosed with acute type III Rockwood ACD treated by employing two different surgical methods of temporary stabilization. K-wires with and without tension band wiring are evaluated here, and the results compared with those present in the literature in order to determine which surgical technique has a better outcome and to clarify the most adequate method of treatment for this controversial degree of dislocation.

Materials and methods

Patients

Reported here is a clinical, retrospective and comparative study of a consecutive series of 123 patients with a diagnosis of type III Rockwood ACD, hospitalized and surgically treated between January 2007 and November 2010 at our institution. Inclusion criteria: were complete, acute (< 2 weeks after trauma), monolateral, isolated (mono-trauma) ACD of type III, according to Rockwood et al. classification (7); patients between 18 and 70 years of age; and pain at rest and during activity. Exclusion criteria: were other traumas in the same arm, previous ACJ trauma, chronic ACJ dislocations, cerebral trauma and systemic diseases (neuromuscular, rheumatic, psychiatric or metabolic disorders). No particular exclusion criteria were adopted concerning the cause of the dislocation. All patients gave their written consent to undergo surgery. The patients included in the study were treated between 1 and 11 days (average 6.4 +/- 2.1 days) from injury. According to the surgical treatment received, the patients were divided into *two groups*, A and B.

Surgical procedures and treatment

All surgeries were performed by one of two experienced surgeons (I.C. or B.A.), the senior authors of this study, who chose one of the two different methods of fixation according to their personal preference and experience. The operations were performed with the patients in the beach-chair position and using inter-scalene anaesthesia. Antibiotic prophylaxis was performed intra-operatively with 1g of Cefazolin and continued postoperatively at a dosage of 1g every 6 h in the subsequent 24 hours. No antithrombotic prophylaxis was used during the entire treatment.

G*roup A* included the patients who underwent surgical reduction and stabilization of ACJ with tension band wiring (Fig. 1). By a vertical skin incision over the lateral clavicle toward the coracoid process, the ACJ was exposed. After manual ACJ reduction, the joint was stabilized by two 1.8 mm trans-acromial K-wires inserted in parallel consecutively from the lateral end of the acromion into the clavicle and with Weber "*8*" cerclage. This technique consists in insert-

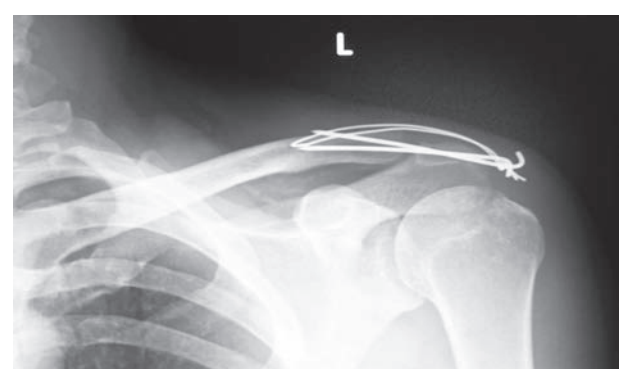

Figure 1. Fixation using tension band wiring (*group A*)

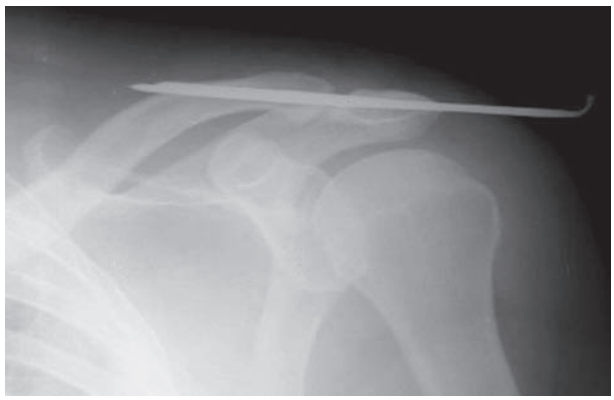

Figure 2. Fixation with two parallel percutaneous non-threaded K-wires (*group B*)

ing a trans-acromial and trans-clavicular tension band whose function is to juxtapose the two articular surfaces of the clavicle and the acromion.

In *group B*, the surgical technique was aimed at reducing the ACD by acromio-clavicular fixation with two parallel percutaneous non-threaded K-wires (Fig. 2). After an incision of 5-7 cm at the level of the ACJ, the surface of the joint was cleaned and the intra-articular meniscus removed where necessary. The dislocation was then reduced with two 1.8 mm parallel percutaneous trans-acromial K-wires inserted from the lateral end of the acromion into the clavicle. The lateral pin ends were bent to prevent proximal K-wire migration.

In both groups, any residue of damaged meniscus were removed, while the CC ligaments, usually very degenerated, and the AC ligaments were repaired as much as possible using absorbable sutures, taking also special care of the muscular plasticity of the deltoid and the trapezius. Finally, the subcutaneous tissues and skin were closed in the usual manner.

Postoperative care

Immediately after the operation, in both groups, the arm was immobilized with a Desault bandage, which was initially recommended for 30 days. Then, according to individual treating surgeon indications, and based on each patient outcome evaluation, it was removed before or maintained. Physiotherapy was started 6 weeks postoperatively with gradual return to normal daily activities. The metalwork was removed at the time established by the personal indications of the treating surgeons. After the removal of the metalwork, the patients were sent for further physiatric evaluation and subsequent physiotherapy in different centres agreed upon with the hospital.

Short and mid-term clinical and radiographic outcome

In addition to the immediate postoperative radiograms following hospital discharge, all patients were clinically and radiologically examined at regular follow-up visits of 15 and 30 days, and at 6 months after surgery *(short-term outcome)* by the senior authors (B.C., B.A. and I.C.). Then, both clinical and radiological analyses were carried out by two independent investigators, the junior authors (C.A. and T.S.), not involved in the treatment of the patients, who also reviewed the medical records and assessed the short-term X-rays *(mid-term outcome)*.

Clinical assessment

During the *short-term outcome*, the wound condition and complications were recorded and managed, but no specific evaluation score was used to assess the patients. For the *mid-term outcome*, the Imatani (8) modified score was used to evaluate pain, functionality, mobility and deformity. The results with an overall score over 90 points were considered excellent; good, from 80 to 89 points; fair, from 70 to 79 points; sufficient, from 60 to 69; and poor, those with a total score of less than 60. The Constant and Murley score (15) was also used, and the results were considered excellent with a score > 90; good, from 80 to 90; fair, from 70-79; sufficient, from 60 to 69 and poor if < 60. Patients were also examined for ACJ pain on palpation or during passive mobilization, instability during active mobilization or lifting weights, and the presence of deformity and keloids.

Radiographic assessment

For the *short-term outcome* radiographic follow-up, the alignment of the ACJ was evaluated, both in the AP projection and in that of Zanca (6). Any mechanical and methodological failures and the mi-

gration of wires were also evaluated in this period. Instead, for the *mid-term outcome*, comparative radiographs of both clavicles in the antero-posterior (AP) standing, first with, and then without, a 5 kg weight on the hand, were performed. In this way, by the stress-mode AP radiographs and comparison with the contralateral side, the ACJ stability was evaluated and the degree of displacement was quantified. The ACJ was considered stable if it showed no dislocation compared to the contralateral joint, subluxated if the dislocation was < 50% of the contralateral joint or dislocated if there was complete dislocation. The presence of osteoarthritis and distal clavicular osteolysis signs was also assessed.

Statistical analysis

We determined if there was a statistically significant difference between the two groups, considering $p < 0.05$, in the sum of the excellent, good, fair and sufficient results using the Student's t test. We used GraphPad software for the statistical analysis of the data found.

Results

Of the original 123 cases having undergone open reduction and stabilization, 23 cases were excluded, as they did not meet the described inclusion criteria. There were 4 treated after 6 weeks from the time of the trauma; 12 polytraumatized, with cerebral trauma and associated humerus, scapula or clavicle fractures. Finally, 7 patients did not come to the follow-up after the removal of the metalwork. The 100 patients were mostly male: 94 men and 6 women. Their mean age was 37 (range of 18-69 years). The left side (53%) was slightly more involved than the right (47%). The non-dominant side was affected in 36 cases (36%). The principal causes of the injuries were as follows: traffic accidents (80%), among which pedestrians hit by cars (51%), bicycle accidents (34%) and motorcycle accidents (15%); followed by sports injuries (17%) and accidental falls (3%). The patients of our cohort were clinically and radiologically evaluated with a mean follow-up of 44.7 months (range 25-60 months).

Clinical outcomes

In *group A*, sufficient-to-excellent functional results were obtained, according to Imatani's table, in 91.7% of 48 patients treated with surgical reduction and stabilization with K-wires and Weber cerclage; according to the Constant Score, the results were positive in 87.4% at the *mid-term follow-up* (Tab. 1). The patients in this group were immobilized with Desault bandaging for an average period of 24 days (range of 15-30), and the removal of the metalwork was done after an average of 73 days (range of 50-120). Furthermore, 22 patients complained of moderate or occasional pain on palpation or during passive mobilization; 17 reported ACJ instability during active mobilization or lifting weights; while in 9 cases, there was ACJ deformity; and in 4, the presence of keloids.

In *group B* of 52 patients having undergone reduction of the dislocation and stabilization with 2 percutaneous trans-acromial K-wires, the following results, according to Imatani's table, were sufficient-to-excellent in 96.1% cases*;* according to the Constant Score, the results were sufficient-to-excellent in 90.2% cases at the *mid-term follow-up* (Tab. 1). The metalwork was maintained for an average of 49 days (range of 30-90), while the postoperative immobilization with Desault bandaging was maintained for an average period of 29 days (range of 15-40). Furthermore, 15 patients complained of moderate or occasional pain on palpation or during passive mobilization; 21 reported ACJ instability during active mobilization or lifting weights, while in 4 cases there was ACJ deformity and the presence of keloids in 4 patients . The complications observed during the course of the study were closely related to the use of metalwork (Tab. 2): migration, osteolysis, distal clavicular arthrosis, rupture (Fig. 3) and intolerance.

Radiographic findings

In *group A, during the short-term follow-up,* the AP and Zanca X-ray views taken immediately after the operation showed a stable ACJ in 40 patients (83.3%). At one month, one shoulder was subluxated and another one at 6 months. As these patients had satisfactory outcomes, they were not operated on again. During the *mid-term follow-up,* no further cases of

Table 1. Results according to Imatani's Table and Constant score

RESULTS	CUT-OFF	GROUP A IMATAMI	GROUP A COSTANT	GROUP B IMATAMI	GROUP B COSTANT
Excellent	>90	31.3%	14.6%	36.5%	17.3%
Good	80-89	33.3%	25.0%	42.3%	28.8%
Fair	70-79	18.8%	29.1%	13.4%	32.7%
Sufficient	60-69	8.3%	18.7%	3.9%	11.5%
Poor	<60	8.3%	12.6%	3.9%	9.7%
Total E/G/F/Su	/	91.7%	87.4%	96.1%	90.2%

Table 2. Summary table of the cases analysed. *RMW (removal of metalwork) after n days:* days after surgery elapsed until the removal of the metalwork. *Complications:* 1 = Migration of metalwork; 2 = Breakage of metalwork; 3 = Decalcification of the lateral end of the clavicle or ossification; 4 = Intolerance of the metalwork

GROUP	AVERAGE AGE	SEX	TYPE OF OPERATION	IMMOBILISATION	RMW (DAYS)	COMPLICATIONS (%)
A	39	94% M 6% F	TIE ROD	24	73	31.2% (1) 10.4% (2) 18.2% (3) 10.4% (4)
B	38	94% M 6% F	K WIRES	29	49	23.1% (1) 9.6% (2) 9.6% (3) 19.2% (4)

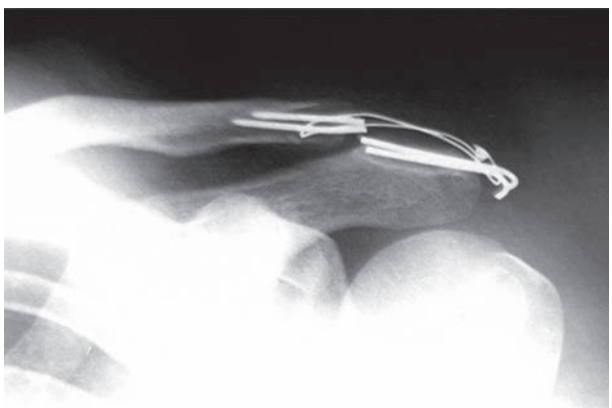

Figure 3. Breakage of metalwork

instability were observed. In the first 6 months, there were 15 cases of K-wire migration (31.2%), 5 cases of K-wire breakage (10.4%), ACJ arthritis or osteolysis of the lateral part of the clavicle was found in 8 cases (18.2%) and in 5 cases metalwork intolerance (10.4%) at the last follow-up (Tab. 2).

In *group B*, *during the short-term follow-up,* the immediate postoperative X-rays showed a stable ACJ in 45 patients (86.5%). However, during the postoperative period, at 15 and 30 days, there were 2 cases of complete ACD, which required a second operation. In the first, a clavicle hook plate was used to stabilize the joint, with poor results. The patient was immobilized for 20 days with a Desault bandage, and the metalwork was removed after 60 days. In the second case, the patient was treated with temporary fixation of the ACJ using K-wires associated with coraco-clavicular tension band wires. The limb was then immobilized with a Desault bandage for 30 days, and the metalwork was removed after 60 days. Further, during the *short-term follow-up* there were 12 cases of K-wire migration (23.1%), 5 cases of metalwork breakage, 5 cases of clavicular ACJ arthritis or osteolysis (9.6%) and 10 cases of metalwork intolerance (19.2%) (Tab. 2). At 6 months, two shoulders were subluxated and another one at 6 months. There were no further cases of instability at the last follow-up.

Discussion

The main finding of the present study is that good functional and radiographic results can be overall achieved with primary fixation by the two different surgical methods of temporary stabilization using K-wires, with and without tension band wiring (Tab. 3). Further, the statistical analyses do not reveal a significant difference ($p > 0.05$) between the two groups, confirming that one methodology is not superior to the other, although the patients treated by acromio-clavicular fixation with two parallel percutaneous non-threaded K-wires obtained better overall results (Fig. 4). Despite the complications observed, the overall

Table 3. Average follow-up results of our cohort according to: a) Imatani's Table of 100 points. b) Constant score

a) IMATAMI TABLE	PAIN	FUNCTIONALITY	MOTILITY	DEFORMITY	TOTAL SCORE
AVERAGE VALUES	32.7	20.5	17.8	10.4	81.4
b) CONSTANT SCORE	**PAIN**	**DAILY LIVING ACTIVITY**	**R.O.M.**	**STRENGHT**	**TOTAL SCORE**
AVERAGE VALUES	12.6	18.1	33.7	21.4	85.8

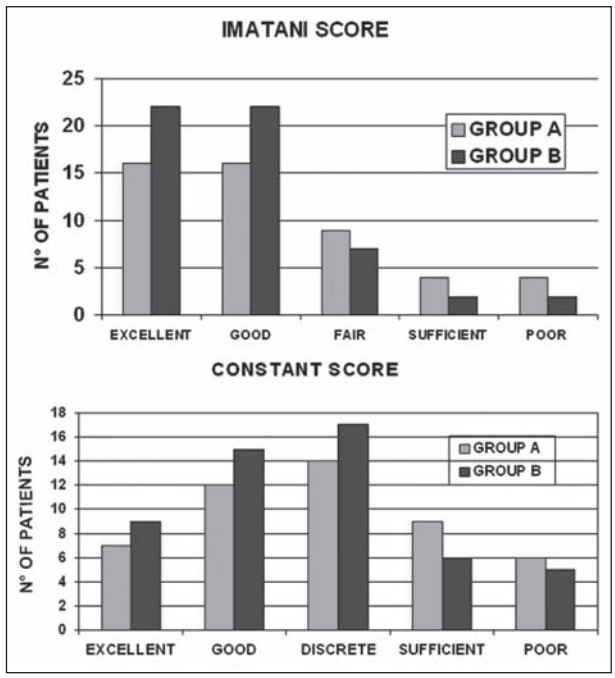

Figure 4. Graphical analysis of the results of both groups, using Imatani and Constant score respectively

sufficient-to-excellent results obtained from the mid-term review of the *two groups* of patients were satisfactory, with a percentage, according to Imatani's table of 91.7% in *group A* and 96.1% in *group B*; and according to the Constant Score, 87.4% for *group A* and 90.2% for *group B*.

Since the first procedure for ACJ repair proposed by Cooper in 1861 (16), more than 150 types of treatment have been described, both surgical and conservative (17-22), but the ideal method for acute type III AC injuries currently remains controversial. Temporary K-wire fixation has been criticized for failing to stabilize the AC joint sufficiently. However, our results are in agreement with previous reports, which describe different methods. Di Francesco et al. (23) analysed 20 cases of ACD, typical of type III Rockwood, with reduction by hook plate, reporting 12 cases with excellent results (60%) and limited complications. Andreani (3) carried out a retrospective study on ACD treated with two different methodologies: the hook plate and the tight-rope system, obtaining encouraging results, especially with the latter method (24). Now, arthroscopic surgery represents a valid alternative, effective and without causing blemishes, for the surgical repair of both CC and AC ligaments. Lafosse et al. (25) described the arthroscopic transposition of the CA ligament to reconstruct the CC ligament with reinsertion at the level of the lower surface of the clavicle through trans-osseous suture fixation, giving satisfactory results. Arthroscopic techniques are suggested both in athletes and workers who need to resume their activities as soon as possible, as well as in patients with high aesthetic demands (26). However, the learning curve for these techniques is long and complex, and they are economically less advantageous than K-wires. From Hootman's review (26) of 600 articles of a total of 1172 patients, it emerged that, in both types of treatment, both conservative and surgical, an overall satisfactory functional outcome was obtained. Specifically, Calvo (27) presented a case study of 43 patients. In the patients treated surgically with two K-wires (32 pts), he noted a stable reduction of the dislocation only in half of the cases, but there were a number of complications, such as osteoarthritis and calcifications of the CC ligament, which were more common than in the patients (11 pts) treated conservatively. Therefore, it appears that the results obtained by conservative and surgical treatment are similar, as demonstrated by the majority of studies showing comparable results (28-30), except for the advantages of the arthroscopic methods. In fact, the non-operative treatment seems to be the preferred choice for elderly patients, while surgical intervention should be reserved only for young active patients and athletes who specifically request it, or for people with chronic pain, cosmetic deformity, shoulder stiffness, joint tenderness and/or instability (10,30). In agreement with other case studies (7), our cohort was also mainly composed of active men, with an average age of 37 and with maximum frequency between 18 and 35 years of age, involved mostly in traffic accidents and sports injuries (6,7).

From the general clinical evaluation of our cohort, it emerged that, in 70% of the cases, joint pain progressively lessened with time to the point of disappearing completely in exact correlation with increase of mobility and function. However, 13 patients, even having recovered excellent mobility in the upper arm, reported cautious and reduced use of the arm, especially due to a sensation of instability in the shoulder to lift

weights. Further, 67% expressed some disappointment about the blemishing resulting from scarring, complicated in 23 cases with keloids. Korsten et al. (10) considered a complication clinically relevant when it required surgical revision or other additional treatment. In agreement with Gstettner et al. (31), who reported clinically symptomatic radiographic abnormalities (osteoarthritis and distal clavicular osteolysis) in only one out of 41 patients, we found that, if on one hand, the loss of reduction occurred frequently during the *short-term follow-up* and the radiographic abnormalities were present at the *mid-term follow-up*, on the other, these had no effect on the *long-term results*. In agreement with other authors (32), patients seem to be bound to have significant improvement of normal functionality at follow-up. Furthermore, most of the operative techniques described in the literature involve the use of metallic devices, different from K-wire internal fixation, to reduce and maintain ACJ reduction.

The principal criticisms of these methods regard the number of early complications, often due to the metalwork dislocation or ruptures and the required removal of the implant before the patient can return to normal activities. These aspects were encountered also in the current study, where the complications observed overall (Fig. 5), none of them serious, were mainly related to K-wire migration (27% of all cases), K-wire breakage (10% of all cases) and metalwork intolerance (15% of all cases), also ACJ arthritis or osteolysis of lateral part of the clavicle were found (13% of all cases).

Some limitations apply to the present study. It was a retrospective cohort study, not randomised and, despite the high number of patients included in this analysis, the surgeon's choice of treatment was not standardized for each case. Further, before starting rehabilitation, as described by many authors (8,15,33,34), all of the patients observed an average period of immobilization of 24 days for *group A* and 29 for *group B* to allow the healing of the injured tissue. The single variations of the period of immobilization, with respect to the 30 days initially recommended, depended on the progress of each patient determined at the clinical and radiological follow-ups at 15 and 30 days from the operation. It could be argued that the variable period of immobilization observed in the two groups is a limitation of this study. However, in *Group B,* where it was longer, the clinical results were better, demonstrating the important role of postoperative immobilization with Desault bandaging for a month in the healing process. Other potential limitations of this study are the variable time of metalwork removal and that we could not attribute the satisfactory results achieved to the healing of the CC ligament, as no magnetic resonance imaging (MRI) study of the ACJ was performed after the removal of metalwork. Although the CC ligament is the suspensory ligament of the upper extremity (35), and it had been reconstructed as much as possible with sutures in both groups because of its degeneration, we do not know exactly the extent of healing and how it may have contributed to joint stabilization. Unfortunately, both procedures analysed in this study do not allow optimal AC and CC ligament reconstruction. Conversely, some other procedures reported in the literature have better results in this respect, such as the TightRope™ system reconstruction (36), with the one or two-tunnel system; semitendinosus tendon graft with good effects in healing and reconstruction (37); CC fixation with either screw or sling (38); and arthroscopically assisted CC ligament reconstruction by suture anchors, which gives good clinical and radiological outcomes (39). However, these techniques also present possible complications: malposition, screw breakage, damage of the CC repair and necessity of systems removal (40). Finally, the importance of CC ligament reconstruction is shown in different biomechanical analyses, but randomized prospective studies comparing reconstruction vs. non-operative treatment are still lacking (11).

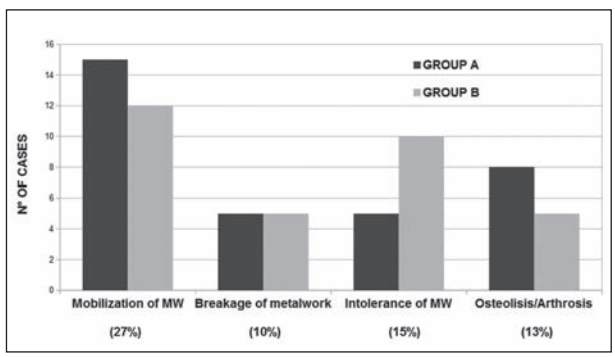

Figure 5. Graphical analysis of the overall complications encountered, distinguished by type and group

Conclusions

The data found in this study confirm the reliability of both techniques for restoring stability to the AC joint after grade III separations and demonstrate their mid-term efficacy analysed with regard to pain relief, range of motion and functionality. However, the results that we have obtained do not provide the answer to the question of which of the two techniques is superior, though the patients treated by acromio-clavicular fixation with two parallel percutaneous non-threaded K-wires obtained overall better results. Moreover, although the number of publications about new surgical procedures has increased in the last years, most of the studies available at present, specifically reporting the outcome of acute type III Rockwood ACDs, are retrospective; only a few are prospective, and none is randomised. Hence, we believe that further research and prospective, randomized controlled trial providing level 1 evidence is desirable, in order to identify the gold standard of treatment for this debated grade of injury.

References

1. Riand N, Sadowski C, Hoffmeyer P. Acute acromionclavicular dislocations. Acta Orthop Belg 1999; 65 (4): 393-403.
2. Mazzocca AD, Arciero RA, Bicos J Evaluation and treatment of acromioclavicular joint incurie. Am J Sports Med 2007; 35: 316-29.
3. Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L. Acromio-clavicular repair using two different techniques. Eur J Orthop Surg Traumatol 2012; DOI 10.1007/s00590-013-1186-1
4. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. Am J Sports Med 2005; 33: 1142-6.
5. Headey J, Brooks JH, Kemp SP. The epidemiology of shoulder injury in English professional rugby union. Am J Sports Med 2007; 35 (9): 1537-43.
6. Zanca P. Shoulder pain: involvement of AC joint (analysis of 1000 cases). Am J Roentgenol Radium Ther Nucl Med 1971; 112 (3): 493-506.
7. Rockwood CA, Williams GR, Disorders of the acromioclavicular joint. In: Rockwood CR, Matsen FA, Wirth MA, Lippit SB (eds) The Shoulder, 3rd edn. Saunders, Philadelphia 2004; 597-646,
8. Imatani RJ, Hanlon JJ, Cady GW. Acute, complete acromioclavicular separations. J Bone Joint Surg Am 1975; 57 (3): 328-32.
9. Luis GE, Yong CK, Singh DA, Sengupta S, Choon DS. Acromioclavicular joint dislocation: a comparative biomechanical study of the palmaris-longus tendon graft reconstruction with other augmentative methods in cadaveric models. J Orthop surg Res 2007; 2: 22.
10. Korsten K, Gunning AC, Leenen LPH. Operative or conservative treatment in patients with Rockwod type III acromionclavicular dislocation: a systematic review and update of current literature. Int Orthop 2014; 38: 831-38; DOI 10.1007/s00264-013-2143-7.
11. Johansen JA, Grutter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: indications for treatment and treatment options. J Shoulder Elbow 2011; 20: S70-S82.
12. Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III AC dislocations: surgical versus conservative treatment. J Shoulder Elbow Surg 2008; 17 (2): 220-5.
13. Rawes M, Dias J. Long term results of conservative treatment for acromioclavicular dislocations. J Bone Joint Surg Br 1996; 78: 410-2.
14. Leidel BA, Braunstein V, Kirchhoff C, Pilotto S, Mutschler W, Biberthaler P. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. J Trauma 2009; 66 (6): 1666-71.
15. Constant CR, Murlay AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987; 214: 160-4.
16. Cooper ES. New method of treating long standing dislocations of the scapula-clavicular articulation. Am J Med Sci 1861; 1: 389-92.
17. Salem K H, Schmelz A Treatment of Tossy III acromioclavicular joint injuries using hook plates and ligament suture. J Orthop Trauma 2009; 23: 565-9.
18. Basyoni Y, El-Ganainy AE, Aboul-Saad M. Acromioclavicular joint reconstruction using anchor sutures: surgical technique and preliminary results. Acta Orthop Belg 2010; 76: 307-11.
19. De Berardino TM, Pensak MJ, Ferreira J, Mazzocca AD. Arthroscopic stabilization of acromioclavicular joint dislocation using the AC graftrope system. J Shoulder Elbow Surg 2010; 19: 47-52.
20. Petersen W, Wellmann M, Rosslenbroich S, Zantop T. Minimally Invasive Acromioclavicular Joint Reconstruction (MINAR). Oper Orthop Traumatol 2010; 22: 52-61.
21. Salzmann G M, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. Am J Sports Med 2010; 38: 1179-8.
22. Yoo Jc, Ahn JH, Yoon JR, Yang JH. Clinical results of single-tunnel coracoclavicular ligament reconstruction using autogenous semitendinosus tendon. Am J Sports Med 2010; 38: 950-7.
23. Di Francesco A, Zoccali C, Colafarina O, Pizzoferrato R, Flamini S. The use of hook plate in type III and V acromioclavicular Rockwood dislocations: Clinical and radiological midterm results and MRI evaluation in 42 patients. Injury 2012; 43: 147-52.

24. Gunnar J, Katthagen JC, Alvarado LE, Lill H, Voigt C. Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? Knee Surg Sports Traumatol Arthrosc 2012. DOI 10.1007/s00167-012-2270-5
25. Lafosse L, Baier GP, Leuzinger J. Arthroscopic treatment of acute and chronic acromionclavicular joint dislocation. Arthroscopy 2005; 21 (8): 1017.
26. Hootman JM. Acromioclavicular Dislocation: Conservative or Surgical Therapy. J Athl Train 2004; 39 (10): 10-1.
27. Calvo E, Lopez-Franco M, Arribas IM. Clinical and radiologic outcomes of surgical and conservative treatment of type III acromioclavicular joint injury. J Shoulder Elbow Surg 2006; 15 (3): 300-5.
28. Prokop A, Helling H, Andermahr J, Mönig S, Rehm K. AC-gelenksprengungen typ tossy III. Der Orthopäde 2003; 32 (5): 432-6.
29. Esen E, Özturk A, Doğramaci Y, Kanatli U, Bölökbaşi S. Comparison of surgical treatment and conservative approach for type III acromionclavicular dislocations. Turkiye Klinikleri J Med Sci 2011; 31 (1): 109-14.
30. Schlegel TF, Burks RT, Marcus RL, Dunn HK. A prospective evaluation of unrated acute grade III aromioclavicular separations. Am J Sports Med 2001; 29: 699-703.
31. Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromionclavicular dislocation: Surgical versus conservative treatment. J Shoulder Elbow Surg 2008; 17 (2): 220-5.
32. Rawes ML, Dias JJ. Long-term results of conservative treatment for acromioclavicular dislocation. J Bone Joint Surg (Br) 1996; 78: 410-2.
33. Mazzocca AD, Santangelo SA, Johnson ST, Rios CG, Dumonski ML, Arciero RA. A biomechanical evaluation of an anatomical bracoclavicular ligament reconstruction. Am J Sports Med 2006; 34 (2): 236-46.
34. Weaver JK, Dunn HP. Treatment of acromionclavicular injuries, especially complete acromionclavicular dislocation. J Bone Joint Surgery 1972; 54A: 1187.
35. Salter EG Jr, Nasca RJ, Shelley BS. Anatomical observations on the acromionclavicular joint and supporting ligaments. Am J Sports Med 1987; 15: 199-206.
36. De Carli A, Lanzetti RM, Ciompi A, Lupariello D, Rota P, Ferretti A. Acromioclavicular third degree dislocation: surgical treatment in acute cases. Journal of Orthopaedic Surgery and Research 2015; 10.1: 13.
37. Maristella F Saccomanno, Fodale M, Capasso L, Cazzato G, Milano G. Reconstruction of the coracoclavicular and acromioclavicular ligaments with semitendinosus tendon graft: a pilot study. Joints 2014; 2 (1): 6.
38. Kim S, Blank A, Strauss E. Management of Type 3 Acromioclavicular Joint Dislocations. Bullettin of the Hospital for Joint Diseases 2014; 72 (1): 53-60.
39. Virtanen KJ, Remes VM, Tulikoura ITA, Pajarinen JT, Savolainen VT, Bjorkenheim JMG, Paavola MP. Surgical treatment of Rockwood grade-V acromioclavicular joint dislocations, 50 patients followed for 15-22 years. Acta Orthopaedica 2013; 84 (2): x-x.
40. Tauber M. Management of acute acromioclavicular joint dislocations: current concepts. Arch Orthop Trauma Surg 2013; 133: 985-95.

Received: 25 March 2015
Accepetd: 13 May 2015
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