European Journal of Orthopaedic Surgery & Traumatology (2019) 29:567–573
https://doi.org/10.1007/s00590-018-2321-9

ORIGINAL ARTICLE • SHOULDER - TRAUMA

Clinical effectiveness of surgical treatment with polyester tapes and temporary K-wires on complete acromioclavicular dislocation

Marco Bigoni[1,2] · Massimiliano Piatti[1] · Nicolò Zanchi[2] · Massimo Gorla[1] · Diego Gaddi[1] · Luca Rigamonti[2] · Robert J. Omeljaniuk[4] · Giovanni Zatti[1,2] · Marco Turati[1,2,3]

Received: 5 July 2018 / Accepted: 6 October 2018 / Published online: 16 October 2018

Abstract

Introduction Ideal treatment of acute acromioclavicular joint (ACJ) dislocation remains unresolved. We evaluated ACJ reconstruction using polyester tapes and temporary Kirschner wire (KW) and presented clinical and radiological outcomes.

Materials and methods Patients were retrospectively evaluated and classified according to Rockwood classification, clinical and sportive characteristics. Constant Score (CS) and ACJ joint instability (ACJI) score were collected. Zanca's, Alexander, axillary, standard, and stress AP views were collected. Radiographic coracoclavicular distance (CCd) of healthy and injured shoulders was measured pre-operatively, at 3 months and at minimum 2-year follow-up. Heterotopic ossifications and clavicular osteolysis were evaluated. Influence of patients' characteristics and AC joint type on clinical and radiological outcomes were determined.

Results Sixteen patients (13 type V and 3 type III ACJ dislocation) reached the end of follow-up (mean 2.4 years; range 22–72 months). Mean CS was 99.63 (range 96–100), while the mean ACJI score was 96.19 (range 85–100). The CCd of the treated shoulder was comparable with the healthy shoulder at 3 months and at last follow-up; moreover, there was no difference in CCd scores at 3 months and at 2 years. CCd scores were lower in sedentary patients compared with physically active (sporty) patients. Heterotopic ossifications were observed in three patients. No osteolysis was reported.

Conclusion This technique provides good results with few complications and should be considered as an effective method to treat ACJ acute dislocation. CCd scores correlate with overuse factors but not with other clinical scores.

Keywords Acromionclavicular joint · Dislocation · K-wire · Synthetic graft

Introduction

AC joint dislocations represent 9% of shoulder injuries, with a high incidence in both contact and non-contact sports [1]. The AC joint is a complex diarthrodial joint, and the principal restraints to anteroposterior translation between the clavicle and acromion are the joint capsule and AC ligaments [2]. CC ligaments, which include the conoid ligament medially and the trapezoid ligament laterally, maintain vertical stability of the AC [3, 4]. The AC joint connects the upper limb to the axial skeleton, and the most frequent trauma pattern is a fall onto the anterior and superior edge of the acromion with the arm in the adducted position; this trauma first injures the AC ligament and then secondarily the CC ligament [5]. According to the Rockwood AC joint dislocation classification, the degree of clavicular displacement depends primarily on the extent of the injury to the AC and CC ligaments [6]. For type I and type II AC joint dislocation, treatment is conservative; by comparison, for type IV–V–VI AC joint dislocation, the clavicle, deltoid, and trapezius are affected and these grades typically necessitate surgical treatment. Treatment of type III AC joint dislocation, in which the AC and CC ligaments are ruptured, is varied, and surgical treatment remains controversial [7]. Recent surgical

✉ Marco Turati
turati.mrc@gmail.com

1 Orthopedic Department, San Gerardo Hospital, University of Milano-Bicocca, Via Pergolesi 33, Monza 20900, Italy

2 Department of Medicine and Surgery, University of Milano-Bicocca, 20900 Monza, Italy

3 Department of Paediatric Orthopedic Surgery, University Hospital Grenoble-Alpes, University Grenoble-Alpes, Grenoble, France

4 Department of Biology, Lakehead University, Thunder Bay, ON P7B5E1, Canada

treatments of type III dislocations have improved patient-rated outcomes; however, this treatment is associated with surgical complications necessitating extraordinary vigilance in selecting the correct treatment option [8].

AC joint dislocation is considered to be chronic after 3–6 weeks from the initial injury [9]. Surgical intervention in both acute and chronic dislocations achieves satisfactory clinical results; nonetheless, remediation of chronic dislocations is associated with a higher rate of deformity recurrence and poorer functional outcomes. Consequently, surgical remediation of chronic dislocations typically calls for anatomic reconstruction with allografts or autografts [9, 10]. Despite the frequency of injury, there is a wide range of interventions for AC joint repair; a recent systematic review described more than 150 treatment variations for this pathology [11].

Arthroscopically, assisted treatment of acute AC joint dislocation provides good clinical results, is minimally invasive, and has few complications but needs specific devices and specialist surgeon skills and, consequently, is a more expensive treatment option; moreover, it represents a more expansive choice, and actually in despite of the same outcomes, economic advantages are very important factors to decide the selection of a specific surgical techniques [12]. Anatomic procedures find greater consensus in the literature than non-anatomic AC reconstructions; anatomic techniques could involve biological autografts or synthetic grafts [13, 14]. Different synthetic grafts have been proposed; to illustrate, polyester tape remains a promising option in light positive results achieved with its use in surgical treatment of coracoclavicular ligament injuries [15].

The aim of our study is to describe our acute anatomic AC reconstruction technique using a synthetic graft (polyester tapes) and temporary KW. As well, we describe how overuse, time to surgery, AC dislocation type, and patient characteristics correlate with radiological assessments (precise radiographic expression of AC reduction loosening) and clinical outcomes in short and midterm follow-up.

Materials and methods

Patient population

We performed a retrospective clinical and radiological study that included patients who underwent surgery for acute AC joint dislocation from January 2009 till the end of September 2015.

Surgical treatment was indicated on the basis of type of AC joint dislocation (type III, among manual/overhead workers and athletes; type IV; type V; type VI). Other patients with AC joint injuries type I, II, III (with low function demand patients) and those who refused surgical intervention were treated conservatively and excluded from this study.

Inclusion criteria included: Rockwood type III–IV and V dislocation treated with an anatomic AC reconstruction with polyester tapes and temporary KW, with the occurrence of first event injury and AC joint dislocation within 3 weeks.

Exclusion criteria included: (1) concomitant fractures, (2) glenohumeral associated lesions, (3) patients younger than 18 years or older than 65, (4) any previous surgical interventions on the upper limbs, (5) a minimum follow-up of 2 years.

All the patient's jobs and sports habits were registered during occupational history. All patients were informed about risks and benefits of the surgical technique; all provided written informed consent conforming to Ethical Standards of the 1964 Declaration of Helsinki as revised in 2000.

Surgical technique and post-operative care

A senior surgeon using a standardized procedure with two synthetic grafts, plus two temporary KW performed all operations. All patients were submitted to peripheral anaesthetic bloc of brachial plexus and general anaesthesia. They were placed in a standard beach-chair position. The shoulder should be draped so that it will be accessible from all side and with the arm freely movable. We used either the modified anterior approach of Roberts or the supraclavicular approach. These approaches allow a very good visualization of the outer edge of the clavicle, the AC joint, the coracoid process, the coracoclavicular and CC ligaments (Fig. 1). After exposure of the coracoid process, the synthetic grafts were passed beneath the coracoid, posterior to the conjoined

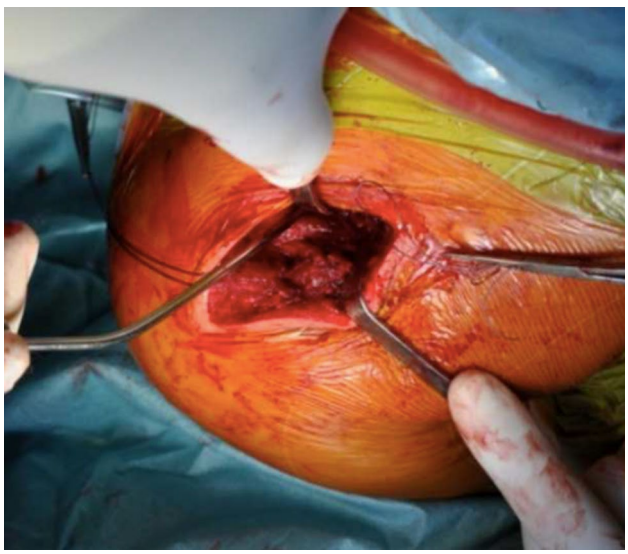

Fig. 1 Intraoperative photograph showing the modified anterior approach of Roberts performed on the AC joint of injured shoulder

tendon, with a sharply curved instrument (Deschamps Needle). We used two polyester tapes (4.8 mm × 45.7 cm, 3/16 in. × 18 in., sterilized using irradiation, MAQUET). Next after crossing each other (to increase stability), the ends of the graft were passed posterior and superior to the clavicle through a tunnel created with a Deschamps Needle. After reduction in the lateral clavicle, the two synthetic grafts CC loop were tightened and secured with a square knot, anterior, and lateral to the clavicle. A 3- to 4-mm end was left, and a non-absorbable suture was used to secure the free ends. We did not systematically remove the meniscus, unless it was torn. The CC ligaments were never sutured or reconstructed. The torn muscle attachments of the deltoid and the trapezius were carefully repaired. The AC reconstruction was supplemented by an AC joint fixation with two 1.8- or 2-mm KW (Fig. 2). These were removed after 4 weeks, under local anaesthesia.

Post-operatively, the shoulder was protected in a broad arm sling for 4 weeks. During that time, patients were allowed to remove the sling for personal hygiene, to perform active and passive exercises to maintain elbow's range of motion (ROM) only but weightlifting was absolutely forbidden. The patient could only perform passive exercises into pain-free range during the first 3 weeks; thereafter, the patient could start with active exercises. The patient was prohibited from performing stressful activities for the AC joint, such as reaching, pushing, and pulling. Muscle strengthening exercises were delayed up to 10–12 weeks.

Clinical and radiological evaluation

All patients underwent a complete physical examination and an X-ray scan just after the trauma. They all underwent surgery and were clinically as well as radiographically evaluated 1 month, 3 months, and 2 years post-operatively. The same doctor (but not the one who performed the surgery) performed the examinations during follow-up. Besides the clinical tests for shoulder diseases, assessment reports were collected for each patient. The Constant Score (CS) (which includes pain, function, ROM, and strength) and the Acromioclavicular Joint Instability Scoring System (ACJI) (which includes also daily life activities, cosmesis, and radiological assessment) were recorded [16].

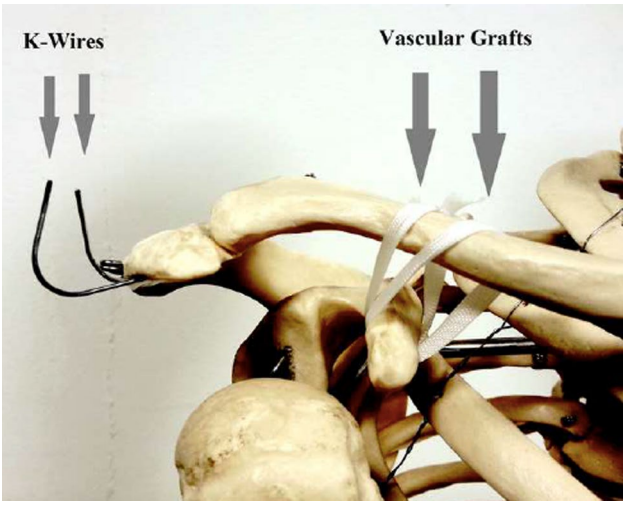

Fig. 2 Sawbones surgical model showing AC joint reparation with two temporary percutaneous KW and two polyester tapes

The radiological evaluation was performed exclusively in the same institute and using the same criteria for all patients. Five views were executed: Zanca's bilateral view, Alexander view of the injured shoulder, routine bilateral anteroposterior (AP), axillary views and bilateral AP stress view. The AP view identifies the amount of vertical migration of the clavicle, whereas the axillary view evaluates anteroposterior displacement. The Zanca view (an AP with a 10°–15° cephalic tilt) provides improved visualization of the AC joint because it removes the scapula from the field. The AP stress view was performed with a 10 kg load in order to appraise the vertical stress that the AC joint must sustain and the increase in the coracoclavicular distance (CCd) during weight bearing [17–20]. CCd is assessed on AP standard views as the distance between the superior cortex of the coracoid process and the under surface of the clavicle where the CC ligaments insert. A normal CCd is between 11 and 13 mm, and there should be no greater than five mm difference between one side and the other [21]. These measurements were taken on both the injured and healthy shoulder. An increase in the CCd of more than 100% but less than 300% was used as criteria to define a grade V injury. If the increase in the distance was less than 100%, the dislocation was defined as grade III [22].

The CCd of both shoulders was measured pre-operatively, at 3-month and 2-year follow-up for every patient. At each follow-up, average of three CC measurements was determined. In addition, heterotopic ossification between the clavicle and the coracoid, clavicle osteolysis, and post-traumatic AC joint ostearthritis were evaluated at the last radiological follow-up. Heterotopic ossifications were graded into none, mild, moderate, and severe. Mild ossification appears as spots or small ossifications in the CC line, while moderate ossification is characterized by the presence of a complete bridge between the coracoid and the clavicle.

The hypothesis that patient's characteristics might influence post-operative outcomes was examined. We analysed specific characteristics including sport activity, job activities (workman or not; non-workman includes all patients who claimed to perform a job different from manual work including office employees, pensioners, and students), age, Rockwood classification and dominant or non-dominant shoulder

injured. We subsequently assessed the relationships between these characteristics and CCd modification.

Statistical analysis

Outcome variables normality of distribution was investigated using the Shapiro–Wilk test. Since data normality was ascertained for all variables (i.e. p value > 0.05), parametric tests were employed, and all data are presented as mean and range. All metric data were compared using the paired t test, and results were expressed in terms of mean difference with the corresponding 95% confidence interval (CI). All subgroups measurements were compared by means of the Wilcoxon signed rank test. Tests performed were two-sided with a level of significance $\alpha = 0.05$. Statistical analyses were performed using "R" version 3.2.1.

Results

Clinical results

Twenty-eight patients underwent surgery for acute AC joint dislocation from January 2009 till the end of September 2015. Twelve patients were excluded according to inclusion/exclusion criteria (four patients were lost at follow-up), and 16 (15 male, one female; mean age 46; range 19–65 years) reached the end of follow-up. The mean follow-up was 2.4 years after surgery (range 22–72 months). Thirteen (81%) patients suffered from an acute type V separation and three (19%) from an acute type III injury according to Rockwood classification [6]. No type IV separation was encountered during this period. Two of them were students, two were retired, and twelve were active workers (six office employees, five labourers, and one nurse). All were right-handed (the dominant upper limb was defined as the handedness). Nine of them (56%) injured the right AC joint, while seven (44%) injured the left one.

Twelve injuries (75%) occurred during sport practice, four (25%) as a downward blow accident on the shoulder during bicycle riding. The mean timing elapsed between trauma and surgery was 9.94 days (range 2–20). All patients underwent surgery within the recommended 3 weeks [23].

Two years after surgery, all patients (100%) reported the complete absence of pain. At last follow-up, the mean CS was 99.63 points (range 96–100). Two subjects obtained a lower score: One case presented a limitation of internal rotation, while a second case presented a moderate limitation in daily activity. The mean ACJI score was 96.19 (range 85–100) at the last follow-up.

Radiological results

Pre-operatively, the mean injured shoulder CCd was 30.33 mm (range 23.1–37.6); at 3-month follow-up, the mean CCd was 16.52 mm (range 8.3–31.1) (Fig. 3). The mean difference in CCd before surgery and at 3-month follow-up was 13.81 mm (range 3–24.8); the surgical reduction for type III AC dislocation (3 patients) was 13.96 (range 9.7–16.1) mm, while for type V it was estimated a surgical reduction of 15.15 (range 7–24.2) mm. The CCd of the healthy shoulder (mean 15.08; range 8.3–20.2 mm) did not differ significantly ($p = 0.1308$) from the operated shoulder at 3-month and 2-year follow-up (mean 16.52; range 8.3–31.1 mm). Furthermore, no significant difference ($p = 0.8063$) was found between the CCd at 3-month and 2-year follow-up.

Post-traumatic AC joint osteoarthritis was found in the radiological evaluation of one patient (6.25%); he had a degree of ossification, with reinforcement of radiographic opacity at the AC joint level. In three patients, signs of mild heterotopic ossification along the CC line were found. None

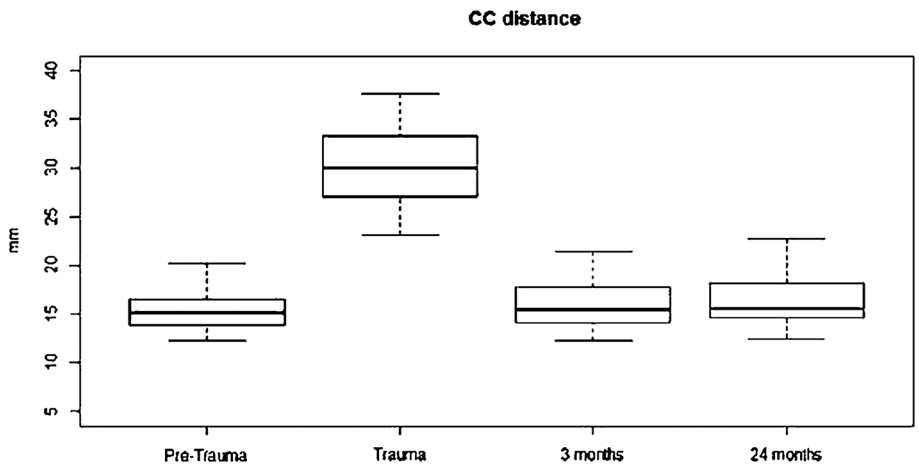

Fig. 3 Box plots showing the coracoclavicular distance of healthy contralateral shoulder (pre-trauma box plot) and injured shoulder at trauma, at 3-month and 2-year follow-up

showed signs of osteolysis at the radiological evaluation of the operated shoulder.

Influence of patient's characteristic on CCd modification

The group was split into subgroups according to patients with specific characteristics to verify a possible influence on CCd modification during F-U.

In the sporty group ($n=12$, 75%), a significant difference ($p=0.0090$) was revealed between the 3-month CCd (mean 17.31 mm) and the 2-year CCd (mean 17.56 mm). There was no statically significant difference ($p=0.371$) between the 3-month CCd (mean 14.12; range 12.3–15.4) and 2-year CCd (mean 14.25; range 12.5–15.4) in the "non-sporty" group ($n=4$, 25%, −0.1250; CI 95% −2.613 to 2.363).

No statistically significant difference was discovered ($p=1$) in the "no workman" group ($n=11$, 69%) between the CC distance at 3 months (mean 18.88 mm) and the CC distance at 2 years (mean 19.16 mm; −0.280; CI 95% −11.501 to 10.942). This group population was composed by students, retirees, and office employees. A statistically significant difference ($p=0.0058$) was revealed in the "workman" group ($n=5$, 31%) between the CC distance measured at 3 months (mean 15.44; range 8.3–20) and at 2 years (mean 15.63; range 8.3–20.1; −0.191; CI 95% −2.892 to 2.510).

No significant differences were observed between 3-month CCd and 2-year CCd considering subgroups according to Rockwood classification, or dominant upper limb and age.

Discussion

Our study shows that patients affected by acute ACJ dislocation and treated by anatomic AC reconstruction using polyester tapes and temporary KW ideally recovered and returned to completely normal daily activities. Moreover, all patients reported the complete absence of pain.

Our data show that the CC distance of the reconstructed shoulder is similar to that of the healthy at the 3-month follow-up.

Furthermore, there was no limitation of range of motion, nor increase in pain, nor sensation of instability. Aesthetically, there was no observable increase in the AC contour nor asymmetry between the two shoulders post-operatively, and in follow-ups.

Despite the generally positive trend of these patients, there was a significant difference between patients who overused the injured shoulder and patients who avoided functional overload of the shoulder post-operatively. Consequently, each of these subgroups was examined 3 months and two after surgery and 2 years after surgery; patients who undergo a higher stress on the injured shoulder show a greater CC distance, compared with patients not undertaking undue joint stress, at 2-year follow-up.

A Cochrane review was performed on the topic of non-operative versus operative treatment for type III injuries. Insufficient evidence from randomized controlled trials in the current literature precludes any meaningful conclusion or definitive recommendation for treatment [7]. The trials surveyed were dated, and none of the recent techniques were used. The 17–28% of patients receiving non-operative treatment in type III had disability with pain, weakness, fatigue, impingement, and ACJ instability [24]. By comparison, we currently found excellent outcomes especially in selected type III AC dislocation. It has been possible to provide a better outcome for these patients; for example, the CC distance remained unchanged at 3 months and 2 years post-operatively. This group of patients was probably helped by the integrity of AC joint structures, which give greater stability, like the delto-trapezial fascia; by contrast, other patients who had a grade V injury showed a slight increase in the CC distance during the follow-up. A prosthetic device, such as the TightRope device (Arthrex, Naples, FL), can be placed as a synthetic CC ligament reconstruction. Its use is described without temporary KW, but it is an expansive device and it is not free of complications (anteroposterior instability, osteolysis, recurrence of dislocation) [25]. With our surgical technique, we decide to reinforce graft reconstruction with KW for 4 weeks. We think that an early stabilization of the AC joint with K-wires releases tension from the grafts and gives a more stable construct to help AC ligament and capsular healing process.

Radiographic anteroposterior instability has been observed in up to 43% of patients. Venjakob and colleagues presented the longest term follow-up of 23 patients using fixation with two suture-button devices, and at 58 months post-operatively, 96% remained very satisfied or satisfied with the procedure outcome with an average Constant Score of 91.5, despite eight radiographic failures [26]. Similar techniques are described using LockDown devices with both similar good outcomes and disadvantages as the TightRope device. In our study, the use of polyester tapes and temporary KW in AC joint reduction presented very good results with no post-operative complications and no requirement for expansive devices as in other techniques. Only two patients in our study presented slight posterior instability. On the contrary, when double TightRope systems (V-shaped or parallel drill hole) are used, the prevalence of dynamic posterior instability is still high particularly in type V AC injuries [25]. Tissue ingrowth into a braided polyester scaffold-type ligament is generally accepted to occur in animals and humans. Histological studies have shown how polyester and similar devices act as scaffolds for connective tissue which forms an investing fibrous pseudoligament [27]. Moreover, it is

important to underline that this "open" technique, compared to arthroscopy, does not require specific equipment and is economical.

None of our patients showed signs of osteolysis at the radiological evaluation of the operated shoulder; only a radio-opacity increase was observed along the CC line in three patients indicating a successful connection between the ends of injured CC ligaments. The observed ossification at the site where the CC ligaments stood before injury is likely an indirect sign of tissue ingrowth. CC ossification and AC joint degeneration are related to ACJ motion and stabilization [27]. The rate of CC ossification described in different studies in early surgery is the same as in delayed surgery. CC ossifications will increase the stiffness of surgical reconstruction and are positively correlated with a normal AC joint motion [28].

ACJ dislocation is considered to be chronic after at least 6 weeks from initial injury [29]. The average time from injury to surgery is less than 3 weeks in early surgery and more than 3 weeks in delayed surgery in most recent studies [23]. The interesting use of an off label vascular graft with temporary KW was recently described, and it showed good results in both acute and chronic AC dislocations [30]. In this study, we describe excellent results only in acute AC joint dislocation; subacute and chronic AC injury should be treated with different techniques (reconstruction with allograft or autograft).

A limit of our study is the retrospective design; further prospective studies are required to confirm our findings. Moreover, the relatively limited sample size of our population could be considered a limit in our study; however, patients were completely evaluated with clinical and radiological outcomes. Finally, in our retrospective study, the lack of a nonsurgical group or a surgical control group with another technique could be considered another important limitation considering recent interesting results with other techniques.

Conclusion

Based on data analysed and literature comparison, we consider the technique with polyester tapes and temporary KW an excellent method for reparation of high-grade acute dislocation. Our findings indicate that this surgical procedure is effective in repairing acute type III and type V AC dislocations, especially when the timing of the surgery and the post-operative recommendations are observed.

Compliance with ethical standards

Conflict of interest Marco Bigoni, Massimiliano Piatti, Nicolò Zanchi, Massimo Gorla, Diego Gaddi, Luca Rigamonti, Robert J. Omeljaniuk, Giovanni Zatti, and Marco Turati declare that they have no conflict of interest.

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