SHOULDER

The Kite technique: a new all-arthroscopic technique for the treatment of acute acromioclavicular joint dislocation

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Abstract

Purpose Although many open techniques have been developed, no all-arthroscopic technique has been introduced to reduce acute acromioclavicular joint dislocation (ACJD) and augment both coracoclavicular (CC) ligaments. The Kite technique is the first all arthroscopic technique with this aim.

Methods Forty-one consecutive patients [35M–6F; median: 29.2 years (range 23–36)] with acute type III and V acromioclavicular joint dislocation were treated with the Kite technique: it consists of positioning three titanium buttons connected by heavy sutures in an 8-strand configuration between clavicle and coracoid to restore the anatomy of CC ligaments. Patients were followed up for a median of 35 months (range 30–43 months).

Results Median operation time was 70.6 min (range 58–82), with no cases of intra-operative complications. At the final follow-up, the median post-operative Constant Score and SST were 94.1 (range 89–98) and 11.6 (range 10–12), respectively. At the final follow-up reduction maintenance was present in 39 patients; in one patient, signs of acromioclavicular joint dislocation recurrence were present 3 months post-op. In another patient, medial suture ruptures occurred 4 months after surgery with type II acromioclavicular joint dislocation recurrence but with scarce symptoms and full recovery to sport activity. Clavicle osteolysis was observed in four patients. Cosmetics of the arm were judged as excellent in 39/41. All patients, except two, were satisfied with the final result.

Conclusions The kite technique is a safe and reproducible arthroscopic procedure to treat acute ACJD. In daily clinical practice, due to the excellent results and the low complication rate, this technique might be considered by surgeons when operative treatment of an acute acromioclavicular joint dislocation is planned.

Level of evidence IV.

Keywords Acromioclavicular dislocation · Arthroscopy · Three button technique · Acute AC dislocation · Kite system · Shoulder arthroscopy · Shoulder dislocation · Arthroscopic AC joint reduction

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Introduction

Acromioclavicular (AC) joint injuries represents 9% of all shoulder girdle injuries and are most often associated with direct blows to the shoulder or axially directed forces onto the ipsilateral extremity [1]. There is a consensus that type I and II injuries, according to Rockwood's classification [24], should be treated non-operatively, whereas the vast majority of acute type IV, V and VI injuries should be treated surgically. Considering type III injuries, in literature algorithms have suggested that scapula plays a role and that rapid progression in function excludes surgery as an option for quick recovery [2, 19, 26, 27]. If surgery is indicated, many techniques have been described, since Cooper's description of the first surgical fixation [8], having the goal to restore

anatomic reduction of the AC joint and to reconstruct the biomechanical forces of the coracoclavicular (CC) ligaments [3, 15, 16, 22]. Although many open techniques have been developed, no arthroscopic technique has been introduced to reduce acute ACJD and augment CC ligaments thus leading to satisfactory clinical and aesthetic outcomes. The Kite technique is an all arthroscopic technique with this aim; this procedure was performed in a series of patients with acute grade III and V ACJD evaluating both clinical and radiological outcomes after a minimum follow-up of 28 months.

Materials and methods

This study received the IRB approval (no. 12/2012) of the Celio Military Hospital of Rome. Forty-one consecutive patients with acute Rockwood grade III and V AC dislocation were treated in our Institution with the Kite technique. The diagnosis was obtained clinically and radiologically with a Zanca [31] and axillary views of both shoulders. The exclusion criteria was: concomitant lesions (evaluated by MRI); chronic type III and V ACJD (> 15 days); type IV and VI ACJD; vascular or nervous deficits, arthritis of the AC joint, fractures of the lateral clavicle or of the acromion, clinical sign of infection, concomitant glenohumeral instability, neurological pathologies. There were 35 males and 6 females with a mean age of 31.3 years (SD 3.5; range 23–51). The dominant limb was involved in 30 cases. The mechanism of injury consisted of a fall with a direct blow to the adducted shoulder when performing sports activities in 28 patients, motorcycle and bicycle accidents in six and seven patients, respectively. Type III and V were diagnosed in 33 and 8 patients, respectively.

Operative technique

Patients are placed in beach chair position under general anaesthesia and interscalene block. According to data by Rios et al. [23] the total clavicle length is measured and two independent points, representing 17% (trapezoid insertion) and 30% (conoid insertion) of the total clavicle length starting from the lateral margin of the clavicle are marked with a sterile pen. In the same way, all the arthroscopic portals are marked. Before starting with arthroscopy, the AC dislocation is manually and temporarily reduced and fixed with a K-wire under fluoroscopy visualisation. Initial diagnostic glenohumeral joint arthroscopy is performed with a 30° arthroscope through the standard posterior portal. The arthroscope is then switched to the lateral portal (L) in the subacromial space to provide working access to the coracoid surface. A 3.5 mm radiofrequency ablation device is then introduced into the subacromial space, passing through the antero-medial inferior (AMI) portal, in the mid-space

between the anterior edge of the acromion and the tip of the coracoid process. The AC joint is visualised, and the disc is removed, if damaged. By using the ablation device, the coracoid surface is prepared to visualise the lateral, inferior and superior edge (anteriorly to the insertion of the CC ligaments), the base and the tip. A dedicated drill guide is introduced with the tip positioned at the inferior surface of the coracoid neck. The optimal placement of the tip for the conoid tunnel should be at the base of the coracoid process.

A K-wire, equipped with an automatic drill stop to prevent iatrogenic neurovascular injury, is drilled through the clavicle and the coracoid under arthroscopic visualization and fluoroscopic control; the K-wire is left in place and a 4.5 mm bony tunnel is drilled through the clavicle and the coracoid. The 4.5 mm cannulated drill bit is maintained while the K-wire and the guiding tool are removed. A shuttle relay is slowly passed through the cannulated drill, starting from the top of the clavicle and pulled out from the AMI portal, with a suture (#5 FiberWire) inside the eyelet. The eyelet of the shuttle is retrieved from the shoulder through an antero-medial superior (AMS) (Fig. 1a–d). The carried suture is then released from the shuttle eyelet and secured. By pulling down the distal end of the shuttle, the button is then passed vertically into the hole of coracoid neck and flipped. The medial clavicular button is then connected to the #5 FiberWire suture previously carried only through the clavicle (Fig. 2a–d). By using the drill guide again under arthroscopic and fluoroscopy visualisation, the second tunnel is drilled. A similar shuttle relay is inserted through the cannulated drill and retrieved from the AMS portal. The end of the carrier suture of the lateral clavicular button is secured into the eyelet and then, by pulling up the shuttle relay, the buttons are shuttled vertically to the top of the clavicle and pulled up until they are visible, then lifted over the skin on the clavicle surface. The sutures of the two clavicular buttons are then tightened and the buttons flipped under fluoroscopic visualization. Finally, the K-wire positioned at the beginning of the surgery is removed (Figs. 3a–d, 4).

The Kite technique is summarized in Video 1 in ESM.

Postoperative care

After surgery the arm was positioned in a sling for 2 weeks. Active mobilization of the elbow and 30° passive and active abduction and forward elevation of the arm is started on the first post-operative day. After sling removal, passive and assisted-active shoulder range of motion were allowed up to 90° of flexion and abduction for the third and fourth post-operative weeks; until 120° for the fifth and sixth post-operative weeks; until 160° for the seventh and 8 post-op weeks. Full activity resumed from 3 months onward. Contact sports or motorcycling were discouraged for 6 months after surgery.
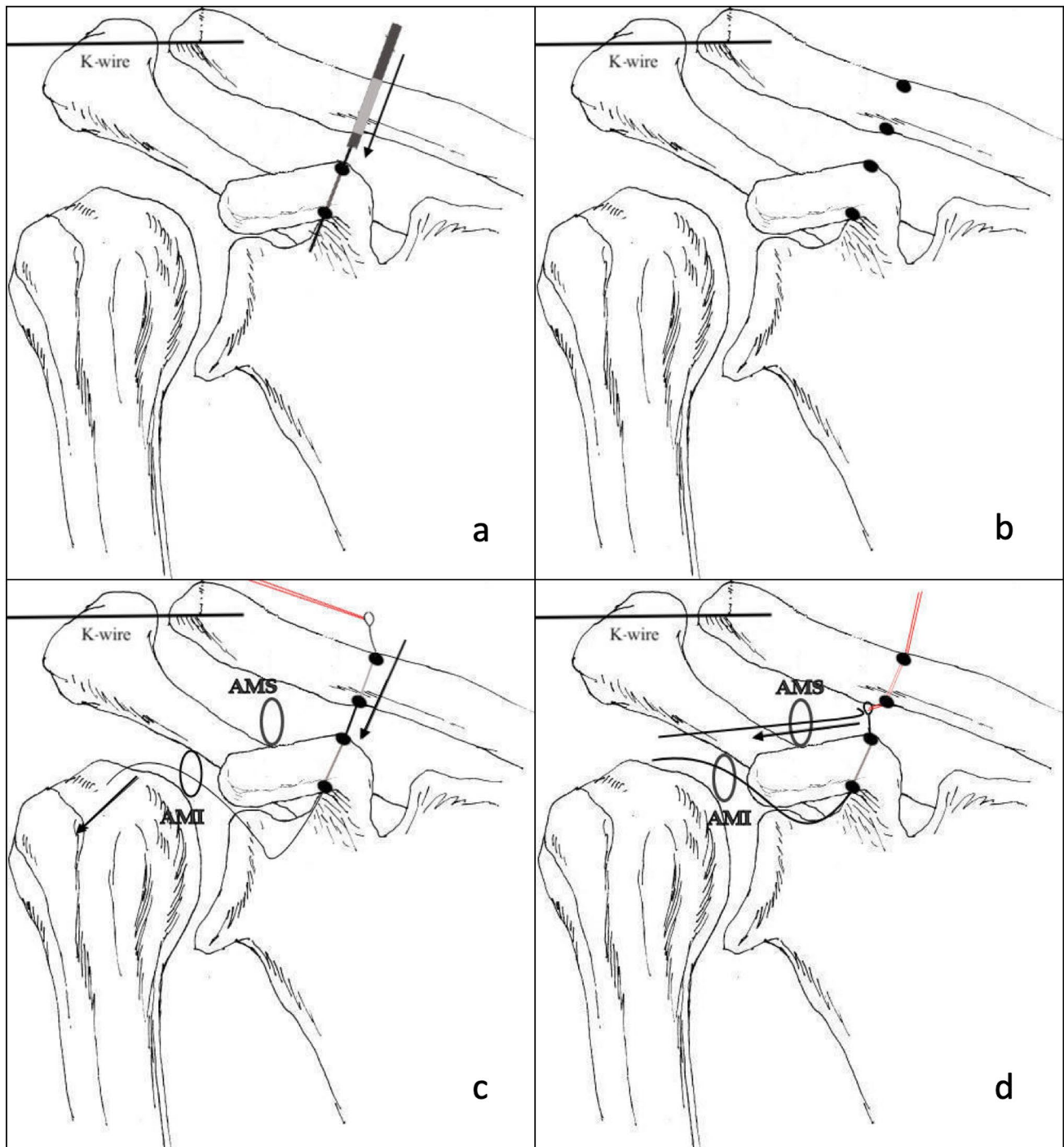
Fig. 1 the AC dislocation is temporarily reduced and fixed with a K-wire under fluoroscopy visualisation; a 4.5 mm bony tunnel is drilled through the clavicle and the coracoid (**a**, **b**); a shuttle relay is slowly passed through the cannulated drill, starting from the top of the clavicle and pulled out from the AMI portal, with a suture (#5 FiberWire) inside the eyelet (**c**); the eyelet of the shuttle is retrieved from the shoulder through an antero-medial superior (AMS) (**d**)

Outcome assessment

Patients were assessed clinically and radiologically (Zanca and axillary views) the day after surgery and then after 12 weeks, 3 and 6 months, 1, 2, 3 and 4 (if possible) years post-operatively. At the final follow-up the function of the shoulder was evaluated with the Constant–Murley Score
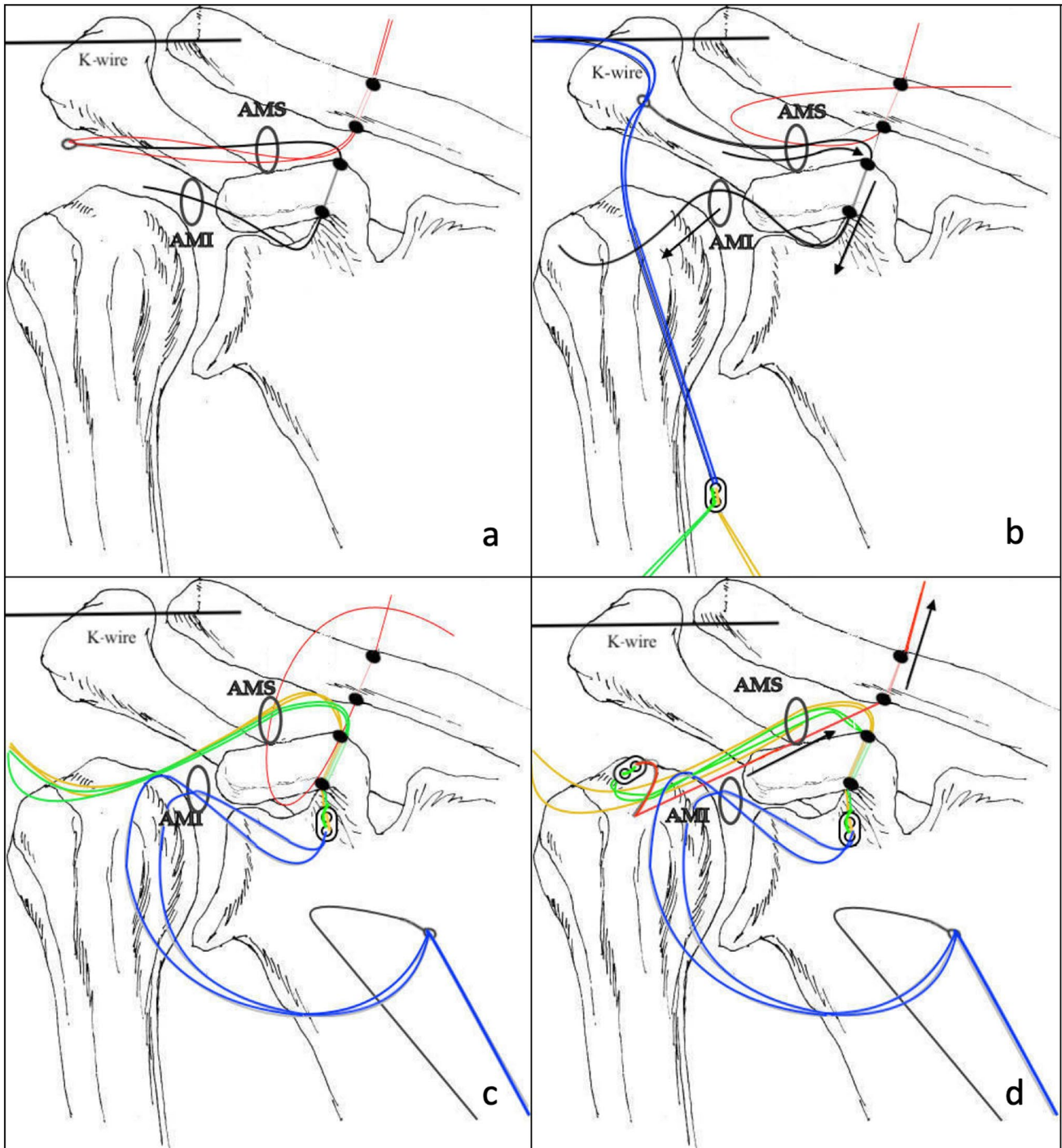
Fig. 2 a–d The carried suture is then released from the shuttle eyelet and secured. By pulling down the distal end of the shuttle, the button is then passed vertically into the hole of coracoid neck and flipped. The medial clavicular button is then connected to the #5 FiberWire suture previously carried only through the clavicle

[7] and the Simple Shoulder Test (SST) [18]. Finally, patients were asked about their satisfaction with the results.

Statistical analysis

Calculation of sample size was done using G*Power 3.1.9.4 software (Heinrich-Heine-University, Dusseldorf, Germany). According to the analysis, at least 30 patients would
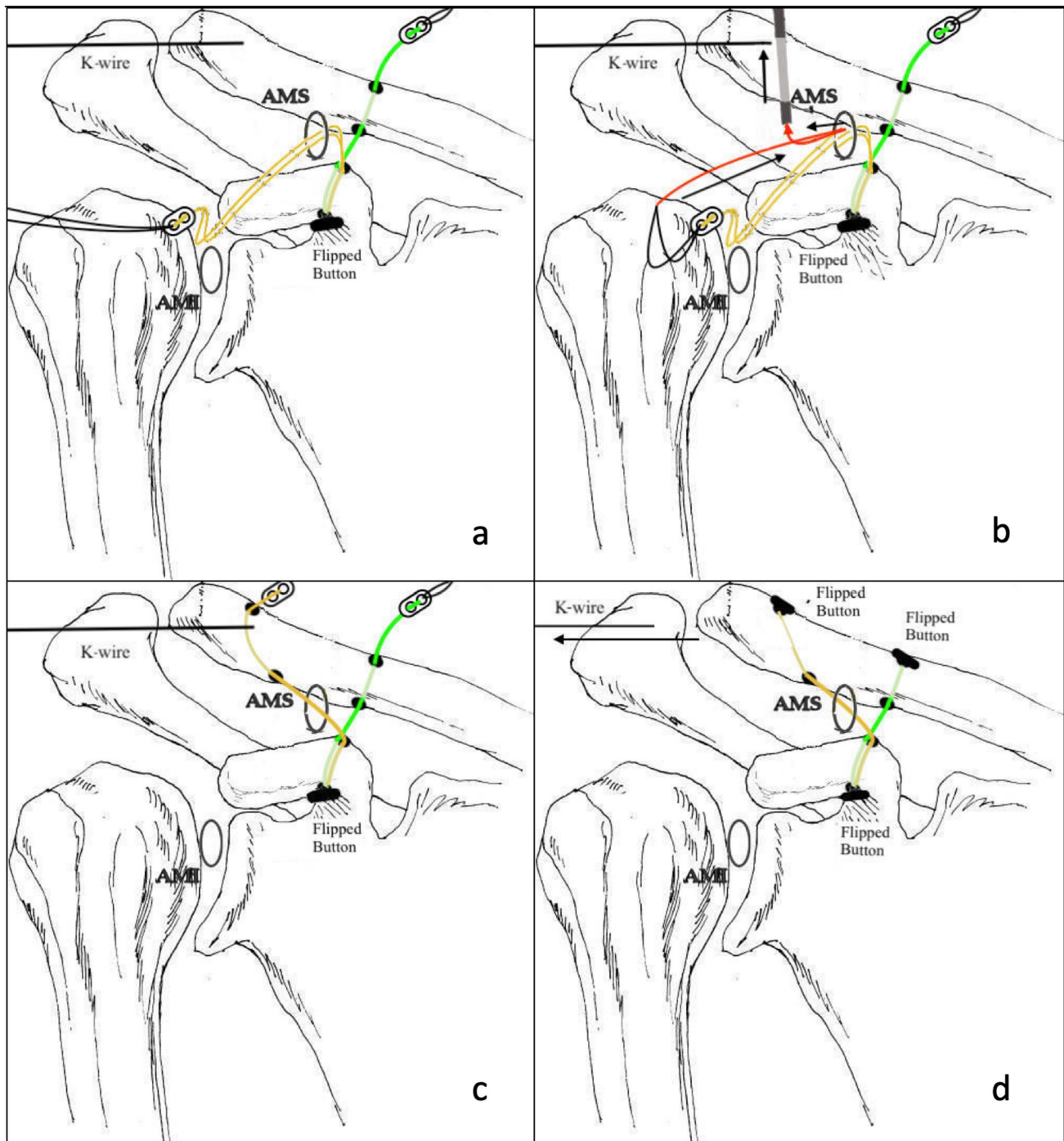
Fig. 3 a–d The second tunnel is drilled; a shuttle relay is inserted through the cannulated drill and retrieved from the AMS portal. The end of the carrier suture of the lateral clavicular button is secured into the eyelet and then, by pulling up the shuttle relay, the buttons are shuttled vertically to the top of the clavicle and then lifted over the skin on the clavicle surface. The sutures of the two clavicular buttons are then tightened and the buttons flipped under fluoroscopic visualization. Finally, the k-wire is removed

be required, assuming a 2-tailed α value $= 0.05$ (sensitivity: 95%), and a β value of 0.95 (with a study power of 95%).

The Fisher's exact test was used to compare the proportions and the Student T test for average values. P values < 0.05 were deemed to be statistically significant.

Results

Median operation time was 70.6 min (range 58–82), with no cases of intra-operative complications. The median follow up was 35 months (range 30–43 months). The median

Fig. 4 AP zanca view of the left shoulder: the Kite technique has been performed

time between the injury and surgery was 9.5 days (range 4–13 days).

The median pre-operative Constant Score and SST were 40.1 points (range 38–45) and 4.0 (range 3–5), respectively. At the final follow-up, the median post-operative Constant Score and SST were 94.1 (range 89–98) and 11.6 (range 10–12), respectively; on the uninjured side, the CS and SST were 95 (range 90–100) and 12 (range 11–12), respectively. No statistical differences were found between the two shoulders (*P* < 0.005).

All patients had a total recovery with no pain and resumption of full activities, except for two.

1. In a 33 years male bodybuilder with type V ACJD clinical and radiological signs of grade III ACJD recurrence were found 3 months after surgery during bodybuilding activity (Fig. 5). A hardware removal and an open stabilization according to Mazzocca's technique was performed.
2. In a 27 years male with type V ACJD clinical and radiographical signs of grade II AC joint dislocation were found 4 months post-op due to medial suture failure

Fig. 5 AP radiographical view of a right shoulder: failure of the Kite system in a 33 years male bodybuilder 3 months after surgery

(Fig. 6); patient referred low intensity pain (VAS: 2/10) when performing overhead sport activity.

Radiographical signs of medial suture failure were present in an additional four patients (three with type III ACJD, and one with type V ACJD); no clinical signs of ACJD recurrence were observed and none of the patients referred symptoms.

No clavicular and/or coracoid fractures occurred. Signs of clavicular osteolysis were observed in four patients; none of the patients referred symptoms; in all four patients, osteolysis started around 6 months after surgery (range 5–7) and stopped around 14 months post-operative (range 12–15).

Cosmetics of the arm was judged as excellent in 39/41 cases, as moderate in 1/41 and fair in 1/41.

Discussion

The present study demonstrates that the Kite technique for the treatment of acute acromioclavicular joint dislocation was associated to excellent clinical, cosmetic and radiographical outcomes with a low complication rate.

The goal of surgical treatment of AC joint injuries is anatomical reduction and restoration of AC normal kinematics. No consensus is present regarding the best option for treating ACJD; currently, there are four main surgical options [4–6, 9, 12, 13, 16, 17, 20, 25, 30]: (1) primary AC joint fixation

Fig. 6 AP radiographical view of a right shoulder: medial suture failure of the Kite system. Recurrence of a type II ACJD in a patient with preoperative type V ACJD

(with pins, sutures wires, plates and hook plates) with or without ligament repair or reconstruction; (2) primary repair of the CC ligaments with or without AC fixation or ligament reconstruction; (3) CC ligament repair with or without distal clavicle excision, or coracoacromial ligament transfer; (4) muscle transfer with or without distal clavicle excision. The vast majority of procedures require open approaches with specific risks and complications: adequate access to the coracoid needs partial deltoid detachment and extensive soft tissue dissection. Furthermore, patients require an excellent aesthetic result. For these reasons, arthroscopic procedures are becoming more interesting [4, 25]: the greater visualization of the coracoid base, the minimal soft tissue dissection and the smaller incisions while allowing for safe implant passage are certain benefits.

The CC ligaments are the primary structures resisting the dislocation forces on the AC joint in the superoinferior direction [20]. The trapezoid ligament is the primary restraint during posterior displacement and provided $55.8\% \pm 20.0\%$ of the resisting force [15, 23]. In addition, in the AC joint compression, the trapezoid ligament served as the primary restraint [22]; this ligament attaches to the coracoid process starting from the entire lateral body of the process with a large implant base. The conoid ligament covers a limited region of the postero-medial margin of the coracoid [14].

Based on previous observations, when surgical treatment is planned, the CC ligaments should not be considered as one structure; a single CC ligament repair in acute ACJD can only restrain the clavicle in one direction, from superior to inferior leading to a non-anatomical reconstruction. Unfortunately, no arthroscopic procedure aiming to restore the correct anatomy of the CC ligaments after high grade ACJD has been developed.

Salzmann et al. [25] introduced an arthroscopic assisted technique for restoration of ACJD by using two isolated tight rope systems with four buttons. After a 58-month period, the same group [29] reported eight radiographic failures (under-correction, posterior displacement, or both) and four over-corrections of the CC distance among the 30 treated patients. Furthermore, this technique may be associated with high risks of fracture of the coracoid process due to the drilling of two 4.5 mm tunnels. Recently, Thangaraju et al. [28] documented the high rate of clavicle and coracoid process fractures after arthroscopically assisted ACJ stabilization during the early post-operative period.

These considerations led us to introduce a stronger construct for ACJD composed of three buttons resulting in an anatomical construct similar to a kite held by two threads. After a minimum follow-up of 30 months, excellent results were obtained in our cohort of patients with grade III and IV ACJD leading us to believe that the kite technique is a safe, reproducible procedure to augment both CC ligaments with the advantages of the minor invasiveness of the arthroscopy. The reduction of the ACJD was obtained and maintained during the follow-up in the vast majority of our group (39/41); all except for two returned at the preinjury level of sports activity 6 months after surgery. Only one case of recurrence occurred 3 months after surgery in a male bodybuilder during bodybuilding activity.

No clinical and radiographical signs of horizontal instability, except for the two patients in which surgery failed, were present; this is due to the fact that the Kite technique leads to an anatomical healing of both CC ligaments and a consequent anatomical reduction of the AC joint allowing also the superior AC ligament to heal in the post-operative period.

The three buttons composing the system represent another advantage of this technique. In fact, radiological signs of medial suture ruptures were observed in five patients; in only one case a minimal loss of reduction, with low intensity pain reported by the patient was observed while the other three patients had no clinical signs of dislocation due to the integrity of the lateral suture.

In our group, no clavicular and/or coracoid process fractures occurred. This is due to—the low diameter of the two clavicular holes;—the correct anatomical position in

the clavicular surface—the unique coracoid process hole. However, in four patients signs of clavicular osteolysis were present; in all cases, the width of the bone tunnels slowly increased from 6 to 14 months after surgery. No further progression was registered during the follow-up period.

The study has some limitations—no control group or comparison with other treatment for type III and V ACJD was present—the treatment of deltotrapezoid fascia was not performed in acute type V ACJD, as is usually done when treating these injuries in open surgery.

In daily clinical practice, due to the excellent outcomes and the low complication rate, this technique might be considered by surgeons when operative treatment of an acute acromioclavicular joint dislocation is planned.

Conclusions

Based on the successful clinical and radiological outcomes, the Kite technique has thus far proven to be a safe all arthroscopic technique for treatment of acute type III or V AC joint dislocation.

Compliance with ethical standards

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