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ORIGINAL STUDY

Surgical treatment of acromioclavicular dislocation associated with midshaft fracture of the ipsilateral clavicle

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Acromioclavicular dislocation combined with a midshaft clavicle fracture is a rare traumatic shoulder problem. Various treatment options have been described in literature. We describe a new technique using a hook plate and coracoclavicular sling to replace the ruptured coracoclavicular ligaments in combination with plate osteosynthesis of the clavicle fracture. Furthermore, we provide a short overview of the few cases described in literature and their treatment options.

Keywords : acromioclavicular ; dislocation ; clavicle ; fracture ; osteosynthesis.

INTRODUCTION

Acromioclavicular (AC) dislocation and clavicle fractures are among the most common traumatic shoulder problems. If AC dislocation is associated with a fracture of the clavicle, it will be most of the times of the lateral third. AC dislocation combined with a midshaft clavicle fracture is rare. We describe two cases of this unique injury and our treatment strategy. Furthermore, this report provides a short overview of the few cases described in literature.

Case 1

A 43-year-old male, who fell from a two meter high scaffold, presented to our emergency department. After clinical examination, shoulder radiographs (anteroposterior and scapular Y-view) were obtained and revealed an AC joint dislocation (Rockwood III) and a displaced midshaft clavicle fracture (Fig. 1). The combination of an unstable AC joint and dislocation of the ipsilateral clavicle fracture were the indication for surgery. Two weeks post-injury open reduction and internal fixation (ORIF) was performed. The operation was performed under general anaesthesia and antibiotic prophylaxis. The patient was positioned in the dorsal decubitus position with a wedge under the shoulder.

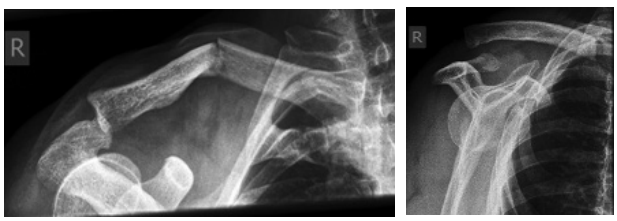

Fig. 1. — Anteroposterior view (a) and scapular Y-view (b) of the right shoulder. Note the displaced acromioclavicular joint and the mid-shaft clavicle fracture (Case 1).

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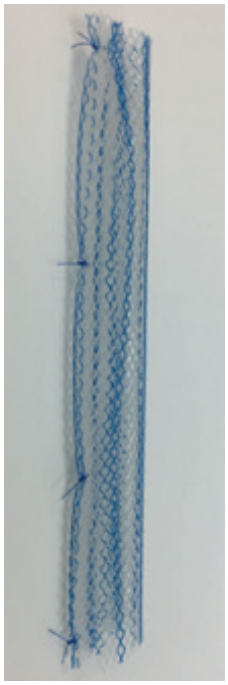

Fig. 2. — UltraPro composite mesh rolled up as a sling for reconstruction of the CC ligaments.

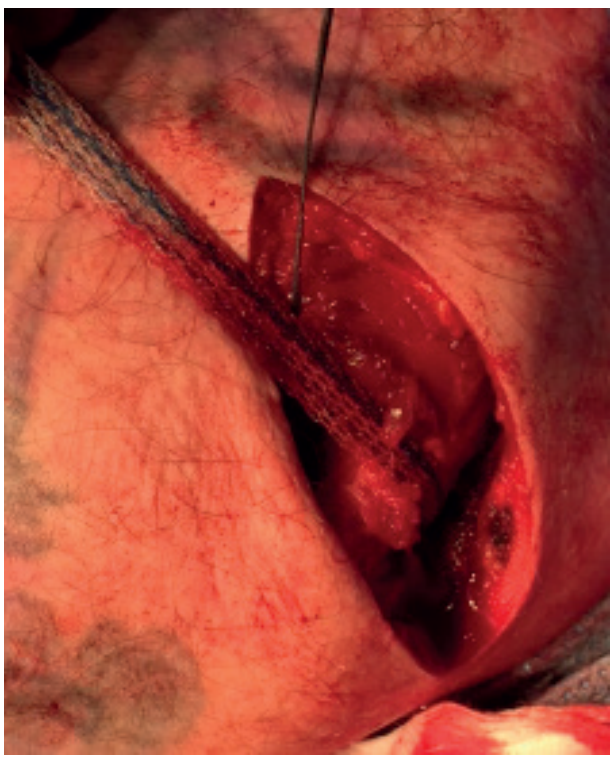

Fig. 3. — Intraoperative view of the AC joint; UltraPro composite mesh in sling fashion around the clavicle.

Fig. 4. — Anteroposterior view of the right shoulder two weeks postoperative (Case 1).

A straight infraclavicular incision was made towards the AC joint. The skin incision was deepened through the subcutaneous tissue and the platysma. The acromioclavicular and coracoclavicular (CC) ligaments were found to be completely ruptured and the clavicle was displaced posteriorly, representing a Rockwood type IV dislocation. The dislocated midshaft clavicle fracture was reduced with reduction forceps. To ensure proper stabilization of the AC joint, we decided to use a clavicle hook plate and a coracoclavicular sling to replace the ruptured CC ligaments. Two Mitek G2 QuickAnchors (DePuy Synthes, Johnson and Johnson, Amersfoort, the Netherlands) were placed in the coracoid process. An UltraPro® Monocryl Prolene composite mesh (Ethicon, Johnson and Johnson, Amersfoort, the Netherlands) was rolled up as a sling and placed around the clavicle (Fig. 2, 3). A precontoured 6-hole 3.5 LCP clavicle hook plate (DePuy Synthes, Jonhson and Johnson, Amersfoort, the Netherlands) was placed over the mesh, with its distal extension underneath the acromion and fixated to the lateral clavicle. To fixate the clavicle fracture, a 7-hole LCP superior clavicle plate (DePuy Synthes, Jonhson and Johnson, Amersfoort, the Netherlands) was used. The plates had an overlap of two screw holes. Finally the mesh was fixated tightly with the previously placed Mitek anchors. Postoperative X-rays showed adequate reduction and fixation of the AC joint and the clavicle (Fig. 4). Postoperatively a sling was applied for ten days and the patient was instructed to start pendulum exercises. After two weeks the patient was allowed to do gentle exercises up to shoulder level and after six weeks above shoulder level. Radiological follow-up took place after 2, 6,

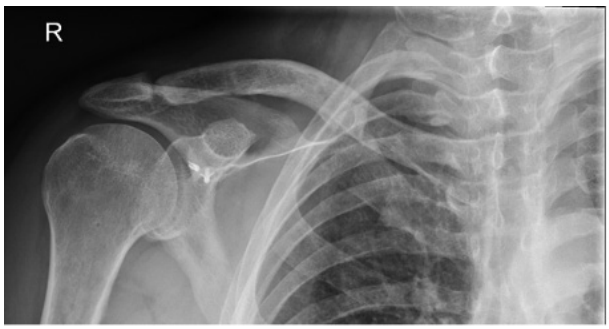

Fig. 5. — Anteroposterior view of the right shoulder after plate removal (Case 1).

12 and 24 weeks. The hook plate and clavicle plate were removed five months after the initial operation (Fig. 5). The patient was able to regain full range of motion but suffered from ongoing pain at the side of the AC joint. An MRI scan showed osteoarthritis of the AC joint and a lateral clavicular resection was performed.

Case 2

A 34-year-old male fell of his bicycle and landed on his right shoulder. He presented at our emergency department with marked tenderness at the mid-clavicle, as well as laterally towards the acromion. The neurovascular status of the right upper extremity was normal. Radiographs (anteroposterior view and scapular Y-view) showed a dislocated mid-shaft clavicle fracture and AC joint dislocation (Rockwood type III) (Fig. 6). The indication for surgery included the complete fracture displacement and ipsilateral unstable AC joint. On day five post-injury ORIF was performed. The initial approach was performed conform case one. The AC- and CC ligaments were found to be completely ruptured with the clavicle dislocated cranially, presenting a completely unstable AC joint. Furthermore a midshaft clavicle fracture was found with a floating segment of the lateral clavicle. Two Mitek G2 QuickAnchors were placed in the coracoid process and an UltraPro composite mesh was used as a coracoclavicular sling to reconstruct the CC ligaments. The mesh was tunneled through the lateral clavicle via a trans-osseous drill hole. A 4-hole 3.5 LCP clavicle hook plate was placed

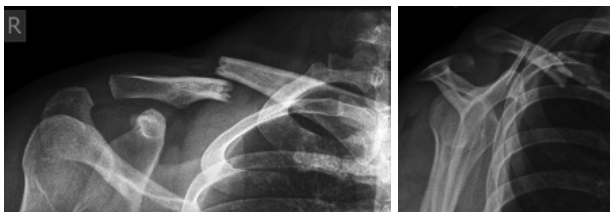

Fig. 6. — Anteroposterior view (a) and scapular Y-view (b) of the right shoulder. Note the widening of the acromioclavicular joint and the completely dislocated mid-shaft clavicle fracture (Case 2).

Fig. 7. — Anteroposterior view of the right shoulder two weeks postoperative (Case 2).

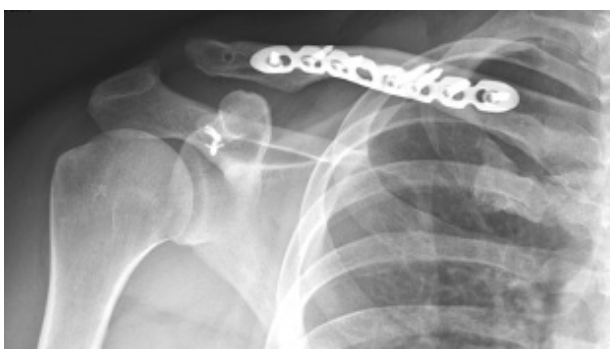

Fig. 8. — Anteroposterior view of the right shoulder after hook plate removal (Case 2).

over the mesh with its distal extension underneath the acromion and fixated to the lateral clavicle. After fixating the mesh tightly with the Mitek anchors, adequate stabilization of the AC joint was obtained. The clavicle fracture was fixated with an 8-hole 3.5 LCP anterior clavicle plate (DePuy Synthes, Jonhson and Johnson, Amersfoort, the

Netherlands) with conventional and locking screws, to ensure adequate compression at the fracture site. Postoperative X-rays showed adequate reduction of the AC joint and clavicle (Fig. 7). Postoperative management and follow-up were performed as previously described. After 7 months the hook plate was removed (Fig. 8). Patient regained full range of motion without pain.

DISCUSSION

AC joint dislocation and clavicle fractures are among the most common traumatic shoulder problems. Both injuries most often occur in young men, during sports or in a traffic accident. The typical mechanism is a direct blow or fall onto the shoulder with the arm in adduction. As a result the acromion can displace caudally with respect to the clavicle, increasing the load on either the clavicle or the AC and CC ligaments, which sprain and then may rupture *(2)*. Based on this mechanism Tossy et al. *(16)* described an injury classification system (type I-III) that reflects the progression. It was extended later by Rockwood by another three types (type IV-VI) *(12)*. Clavicle fractures are usually classified based on the anatomic location of the fracture, the middle third of the clavicle (type I) or the lateral (type II) and medial (type III) thirds, as described by Allman *(1)*.

AC dislocation associated with a fracture in the lateral third of the clavicle can be sub classified by Neer.*(10)* This combination of injuries is frequently reported in literature. However, AC dislocation combined with a midshaft clavicle fracture is rare. Only 10 reports (14 cases) have been described in the literature (table I). Surgical management in these cases was performed with several techniques. The earliest report that we could access was authored by Lancourt et al. *(7)* in 1990. He described a case of a horseback rider who sustained the combination injury to her midshaft clavicle and AC joint. ORIF of the AC joint was performed with two Steinmann pins, which were subsequently removed after eight weeks. A three year follow-up reported a good outcome of painless, full range of shoulder motion. In 1992 four cases of this combined injury were reported by Wurtz et al. *(20)*. One of the patients was diagnosed with a Rockwood II dislocation and was treated conservatively with early start of exercises. The other three patients, all with Rockwood IV dislocation, were treated surgically with either a CC cancellous bone screw (two patients) or AC transfixation Steinmann pins (one patient). After six to eight weeks the fixation devices were removed operatively in all three patients. After one year all four cases had a good clinical final outcome. Heinz et al. *(5)* reported in 1995 a case of a conservatively managed midshaft clavicle fracture combined with a Rockwood III dislocation. A two year follow up reported a good clinical outcome, although radiographs showed a wide AC separation with superior displacement of the healed clavicle that was greater than the width of the clavicle. In 2002 Juhn et al. *(6)* reported a case of an ice hockey player with a Rockwood VI dislocation and a greenstick midshaft clavicle fracture. Since the patient already presented good range of motion from day one, conservative treatment was chosen. After 14 weeks the patient felt he had returned to preinjury status. In 2004 Wisniewski et al. *(19)* described a case of a patient with a Rockwood IV dislocation combined with an undisplaced clavicle fracture and intact CC ligaments. ORIF with Kirschner wires was performed to stabilize the AC joint. A ten year follow-up reported a painless, full range of shoulder motion. In 2009 Yeh et al. *(21)* reported a case of a horseback rider with a Rockwood IV dislocation and a minimally displaced mid-shaft fracture. ORIF with a clavicle plate was performed and a semitendinosus allograft was used to reconstruct the AC and CC ligaments. This is the first case that described a treatment technique for CC ligaments reconstruction in this combined injury. One year follow-up showed a painless full active and passive range of motion. Two years later, Psarakis et al. *(11)* used a comparable technique for the reconstruction of the CC ligaments in a patient with a Rockwood V dislocation. He used a TightRope fixation device to achieve stabilization of the AC joint. The clavicle fracture was treated with a precontoured locking plate. Eighteen months postoperatively the patient showed a painless full range of motion. Shortly after, Wijdicks et al. *(18)* described two cases of the combined injury. A Rockwood type III with

Table I. — Summary of case reports in literature

Rockwood classification	Clavicle fracture	Injury activity	Sex/age (years)	Fixation method	Follow up (months)	Outcome	References
Type II	NA	Fall from horse	F, 33	Conservative treatment	12	Painless, FROM, normal function	Wurtz, 1990 [20]
Type III	Displaced midclavicle fracture	Fall from bicycle	M, 34	Conservative treatment	24	Clavicle deformity, normal function and strength	Heinz, 1995 [5]
	Displaced midclavicle fracture	Fall from motocross bike	M, 44	Clavicle plate + hook plate + suturing CC ligament	13	Painless, FROM, normal function NB.hook plate removed after 4 months because of impaired forward flexion	Wijdicks, 2012 [18]
	Displaced midclavicle fracture	Motor vehicle accident	M, 50	Clavicle plate + hook plate	23	Painless, FROM	Beytemür, 2013 [3]
	Displaced midclavicle fracture	Car accident	M, 40	Reconstruction clavicle plate + two coraco-clavicular bone screws	12	Painless, FROM	Solooki, 2014 [14]
Type IV	NA	Fall from bicycle	M, 36	Coracoclavicular bone screw	36	Asymptomatic, FROM	Wurtz, 1990 [20]
	NA	Motor vehicle accident	M, 23	Coracoclavicular bone screw	24	Painless, FROM, normal function	Wurtz, 1990 [20]
	NA	Fall from horse	F, 19	Two Steinmann pins	36	Aysmptomatic, FROM	Wurtz, 1990 [20]
	Undisplaced midclavicle fracture	Fall from bicycle	M, 32	Two Kirschner wires	120	Painless, FROM, normal function NB. K-wires removed after 4 months	Wisniewski, 2004 [19]
	Displaced midclavicle fracture	Fall from horse	F, 46	Clavicle plate + AC/CC ligament reconstruction with allograft	36	Painless, FROM, good strength	Yeh, 2009 [21]
	Displaced midclavicle fracture	ATV rollover	M, 36	Clavicle plate + hook plate	6	Painless, FROM, normal function NB. hook plate removed after 6 months because of impaired flexion/abduction	Wijdicks, 2012 [18]
Type V	Displaced midclavicle fracture	Car accident	M, 38	Clavicle plate + CC ligament reconstruction with tightrope fixationsystem	18	Painless, FROM	Psarakis, 2011 [11]
Type VI	Greenstick midclavicle fracture	Struck the boards during ice hockey	M, 21	Conservative treatment	10	Free of shoulder/ clavicle symptoms	Juhn, 2002 [6]
Unknown	NA	NA	F, 19	Steinmann pins	NA	Successful outcome	Lancourt, 1990 [7]

Abbreviations : NA, not announced ; FROM, full range of motion ; AC, acromioclavicular ; CC, coracoclavicular.

a displaced midshaft clavicle fracture that was treated with a precontoured superior clavicle plate, a reconstruction plate, a hook plate and suturing of the native CC ligaments. After four months the hook plate was removed to improve forward flexion and prevent the occurrence of acromial osteolysis. Thirteen months follow-up reported good clinical results. The second case was a patient with a Rockwood type IV dislocation combined with a displaced midshaft clavicle fracture. ORIF was performed with an anterolateral plate and a hook plate. After six months the hook plate was removed and clinical and radiographical examination reported final good results. Beytemür et al. *(3)* reported a case of a Rockwood III AC dislocation combined with a displaced midshaft clavicle fracture that was managed surgically with a clavicle plate and a hook plate. The hook plate was not removed. After 23 months, degenerative findings and widening of the AC joint were seen on the radiographs, although clinical examination was normal.

In 2014 Solooki et al. *(14)* published another combination injury treated with a reconstruction plate and two cancellous screws, leading to good clinical result.

In our cases, we fixed the clavicle with a locking plate and used an UltraPro composite mesh as coracoclaviculair sling in combination with a hook plate to achieve stability of the clavicle to the acromion. Traditionally, for most isolated clavicle fractures nonsurgical treatment has been advised *(10,13)*. However, recent studies that reported higher non-union rates and functional deficits after conservative management of displaced midshaft clavicle fractures, are challenging this traditional belief *(8,17)*. One of the relative indications for surgical management of midshaft clavicle fractures may include polytrauma situations. After reviewing the few cases in literature, we see a tendency over the last decade toward surgical treatment of this combined injury with plate fixation *(3,11,18,21)*. The goal of fixation of the AC dislocation is to re-establish the CC distance to allow the native ligaments to heal and restore the stability of the AC joint. Therefore, current treatment recommendations favour surgical management in Rockwood type IV-VI dislocation *(9,15)*. Management of Rockwood type III dislocation should be individualized to the patient's physical demanding and sport activities *(9,15)*. In case of Rockwood type III-VI dislocation combined with a displaced midshaft clavicle fracture, surgical treatment of both might be advocated. Reduction of the AC joint can be performed with a number of treatment options with all different risks and benefits, ranging from K-wires, CC bone screws and a hook plate to ligament reconstruction with tendon grafts, a tight rope or the modified Weaver-Dunn technique. Although several studies suggest that satisfactory outcomes can be achieved with each technique, there is still a lack of high-quality evidence, making it difficult to draw firm conclusions regarding the best treatment option in these controversial cases *(9)*. We used a hook plate and supplementary fixation with an UltraPro composite mesh to reduce the AC joint. The hook plate has been shown to have a favourable outcome as it offers a high primary stability and enables early rotational mobility of the shoulder *(15)*. However, complications such as pain owing to impingement or acromion osteolysis and the need for plate removal, have to be taken into consideration. The UltraPro mesh can either be placed in sling fashion around the clavicle or tunneled through the lateral clavicle via a trans-osseous drill hole and fixated to the coracoid process. There is no advantage of either of these modifications, therefore decision is up to surgeon's preference. The UltraPro mesh is thought to accelerate formation of collagen by activating a profound tissue reaction, as described in hernia repair surgery *(4)*. This might enable earlier removal of the hook plate, preventing migration of the plate through the acromion. Since the mesh is placed in both techniques underneath the hook plate, the mesh can stay in situ when the hook plate is removed.

CONCLUSION

We reported two cases of an AC joint dislocation combined with an ipsilateral midshaft clavicle fracture. In the authors opinion, the combination of both bony and ligament repair is advocated in these combined injuries. Over the last decades we see a tendency towards surgical treatment of this combined injury in literature. Several treatment

options are described with all different risks and benefits. Specific treatment of these injuries should be individualized based on the dislocation pattern, fracture characteristics and patients and surgeons preferences.

Compliance with ethical standards

Ethical approval : This article does not contain any studies with human participants or animals performed by anyof the authors. Data was obtained in retrospect and this study did not interfere with treatment per protocol.

Informed consent : Informed consent was obtained from all individual participants included in the study.

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