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TRAUMA SURGERY

The traumatic acromion fracture: review of the literature, clinical examples and proposal of a treatment algorithm

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Abstract

Purpose Traumatic acromion fractures are rare and typically occur in patients with multiple fractures, which often delays diagnosis. Limited guidance exists on the treatment of these fractures. We present a review of the literature from the last 20 years and describe our experience in treating five patients—two conservatively and three with open reduction and internal fixations (ORIF).

Methods We used the U.S. National Library of Science database, MEDLINE®, to search for all pertinent publications from January 1999 to December 2017. Included were retrospective or prospective studies, including case series and case reports, describing treatment for traumatic acromion fractures and clinical and/or radiological outcomes. For our case reports, we present five patients with traumatic acromion fractures who were treated at our institution between 2013 and 2017.

Results Through our review of 14 publications, we found that current recommendations are often based on a limited number of cases. No gold standard to treat these fractures exists. Most authors recommend anatomic reconstruction, especially for dislocated fractures, persistent symptomatic non-unions or additional injuries to the superior shoulder suspensory complex. There is no clear trend in terms of the operative technique. With regard to our five clinical examples that were all initially treated conservatively, two were successful and three eventually required reconstruction with ORIF. Based on the findings of this review, we proposed a treatment algorithm for traumatic acromion fractures.

Conclusions A classification system providing clear guidance on treatment options is needed. Although the non-union rate with conservative treatment is relatively high, it is not always painful or limiting to shoulder function, especially in elderly or less active patients. Fixation seems to be a more suitable treatment option for active patients who are more likely to require revision of symptomatic non-unions.

Keywords Scapular fracture · Acromion fracture · Os acromiale · Anatomic reconstruction · Shoulder function · Treatment algorithm

Introduction

Acromion fractures, which represent approximately 8% of all scapula fractures [3, 34, 50], are rare and often occur in conjunction with other injuries of the shoulder girdle [1, 3, 19, 30]. Recent studies report fractures to the acromion as a postoperative complication following reverse shoulder arthroplasty (RSA), which has been on the rise in recent years [49]. Due to changes in biomechanics and the lengthening of the upper arm after RSA, the associated acromion fractures are often considered insufficiency fractures. Traumatic fractures are the other type of commonly occurring acromion fracture that results from direct trauma to the shoulder girdle. Similar to insufficiency fractures, the indication for operative treatment of traumatic fractures has not been well established. Some studies report good clinical outcomes in non-displaced or minimally displaced fractures that were treated conservatively [1, 3, 30, 38]. However, displaced fractures tend to result in non-unions with compromised shoulder function and chronic pain [3, 4, 14, 17, 30, 36].

Once surgical intervention to treat these fractures is indicated, the selection of a suitable fixation technique poses a

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challenge given the wide variety of options reported in the literature (e.g., tension band wiring, Kirschner wire fixation, screw and plate fixation techniques, etc.) [3, 7, 10, 19, 31, 36, 38, 41, 48]. One issue associated with open reduction and internal fixation (ORIF) is the extent of compromise to muscle fibers, particularly in the delta muscle. Moreover, the level of invasiveness of the ORIF has a varying effect on the amount of muscle fiber compromise. Tension band wiring and screw fixation often fail to address the multiplicity of force vectors of the delta fibers. Plate fixation, even when using locking plates, often provides insufficient stability in the lateral fragment, especially in osteoporotic bones [5, 23].

This review of the literature includes previously unpublished results of five cases of traumatic acromion fractures treated at our institution, two of which were treated conservatively and three that were treated with open reduction and internal fixation. The aim of our ORIF technique, which uses a simple plate fixation with an interfragmentary screw, was to combine the strength of tension band techniques with rigid plate fixation, without compromising fibers of the delta or trapezius muscles [25]. These cases are presented within the larger context of the current body of knowledge on this topic.

Materials and methods

Literature review

The U.S. National Library of Science database, MEDLINE®, was used to search for all relevant publications from January 1999 to August 2018. We limited our review to the last 20 years since older publications often present data on scapula fractures including the acromion, not solely acromion fractures. Inclusion criteria for this review were as follows: all published reports of original retrospective or prospective studies describing treatment for traumatic acromion fractures that included clinical and/or radiological outcomes. Since the number of studies was small, case series and single case reports were also included. Excluded from the review were reports about insufficiency fractures with or without prior reverse shoulder arthroplasty, the treatment of os acromiale and reports of pediatric fractures. Consequently, a relatively large number of reports that addressed general scapula fractures without detailed information about scapula process fractures were excluded.

Using two key terms—"acromion fracture" and "scapula fracture"—we identified 211 and 442 articles, respectively. All abstracts of these articles were screened by two of the authors. Full-length versions of potentially suitable articles were then assessed by the same reviewers. Of the 653 abstracts screened for inclusion, 14 articles fulfilled the criteria.

Clinical examples

Between January 2013 and December 2017, a total of 72 patients with a traumatic scapula fracture were treated conservatively or operatively at our institution. For the purposes of this report, we selected patients with traumatic fractures of the acromion or the base of the acromion, with or without concomitant scapula injuries. However, we excluded patients with previous shoulder surgery (e.g., ORIF to the scapula or reverse shoulder arthroplasty) or the presence of an os acromiale. Five cases met the inclusion criteria and are described in this report. Patient characteristics and outcomes are summarized in Table 1. Written consent for the use of medical records data was obtained from all patients.

Three patients who had a traumatic acromion fracture underwent anatomical reconstruction using an open technique with a modified cruciform pilon plate (Depuy Synthes, West Chester, PA, USA) and interfragmentary compression screw fixation. All patients were assessed at a minimum of 1 year postoperatively. At final follow-up, conventional radiographs (AP and Neer view) and the Constant Scores [11] were obtained for both shoulders. Abduction strength was assessed in the scapular plane using a handheld dynamometer with the arm at 90° abduction. In addition, the patients were asked to estimate their Subjective Shoulder Value as a percentage of a normal shoulder, which was documented preoperatively and at final follow-up [15]. All clinical outcomes at the12-month follow-up are given in Table 1. A more detailed description of this operative technique was published previously [25].

Results

Literature review

Imaging and classification

Scapula fractures were most often described in patients with multiple injuries and/or high energy traumas. Additional injuries to the shoulder girdle (i.e., lesions of the brachial plexus, vascular injuries, lesion of the suprascapular nerve, rotator cuff tears, glenohumeral dislocation), thorax and skull were also frequently reported [16, 30, 38]. In addition to a direct lateral blow to the shoulder, other fracture mechanisms identified in the literature were indirect forces to the deltoid muscle (avulsion fractures) or insufficiency fracture after RSA [26, 47]. The fact that acromion fractures are often accompanied by other injuries might explain why non-displaced fractures are frequently overseen in conventional radiographs and diagnoses are delayed [4, 24].

Table 1 Summary of characteristics and outcomes of five clinical examples

Parameter	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Gender	Male	Male	Female	Female	Male
Age (year)	72	75	55	83	54
Handedness	Right	Right	Right	Right	Right
Fracture side	Left	Left	Right	Left	Left
Fracture type [30]	II	II	IB	IB	II
Concomitant injury	Vertebral body fracture Th6	Serial rib fractures, pneumothorax	None	Epidural hematoma, facial bone fractures, stump chest trauma	None
Operative treatment	No	Yes	Yes	No	Yes
Conservative treatment prior to surgery [weeks]	–	25	68	–	27
Union	No	Yes	Yes	Yes	Yes
Plate removal	–	Yes	Yes	–	No
Complications	No	No	No	No	No
Results					
Length of follow-up (months)	12	20	21	13	12
Elevation/abduction (°)	150/140	160/160	150/140	160/150	165/160
SSV [15] (%)	95	95	80	100	95
CS [11]	83	90	87	78	86
CS [11] contralateral side	81	98	77	84	100

SSV Subjective Shoulder Value, *CS* Constant Score

Besides the AO Classification (Arbeitsgemeinschaft für Osteosynthese-Fragen), the most commonly used classifications were from Kuhn et al. [30], Ogawa and Naniwa [38] and Goss et al. [19]. The classification by Kuhn et al. described the fracture patterns in three categories: Type I fractures can be with or without a slight dislocation (Type IA avulsion, Type IB true fracture), Type II fractures are dislocated but without constraint in the subacromial space, and Type III fractures are dislocated and constrain the subacromial space. The majority of authors did not describe the direction of dislocation, but in most studies a lateral displacement of the fracture was reported, with or without element of rotation, especially in fractures with subacromial space impairment [27, 29, 51]. This might be due to the prominent muscle tonus of the deltoid, although biomechanical investigations to confirm this theory are lacking. Nevertheless, in addition to describing the most common dislocation direction to the lateral side, Kuhn et al. [30] described superior, anterosuperior and superolateral dislocated fractures. An impact of the degree and/or direction of dislocation could not be found in the available literature.

Treatment options

There is no gold standard to treat these types of fractures, and the current recommendations are often based on a limited number of cases. Most authors recommend anatomic reconstruction, especially for dislocated fractures, persistent symptomatic non-unions or additional injuries to the superior shoulder suspensory complex (SSSC) [22, 30, 50]. Recommendations for conservative treatment in patients with non-displaced or minimally displaced fractures have shown promising results. Nevertheless, complications develop in patients with conservatively treated fractures. Symptomatic non-union was one of the most frequently occurring complications following conservative treatment [1, 9, 30, 38]. Goss et al. [18] hypothesized that a fracture with an accompanying SSSC disruption may lead to an unstable shoulder, which leads to an increased likelihood of failure with conservative treatment. In addition to symptomatic non-unions, patients experience persistent pain, reduced function, rotator cuff tears secondary to displaced fracture and reduction of the subacromial space, acromioclavicular joint separation, humeral head subluxation and brachial plexus injury [17, 21, 30, 50].

A review of operatively treated fractures revealed a variety of fixation techniques including K-wire fixation, tension band wiring, screw fixation and plate fixation [5, 7, 23, 40, 44]. Unfortunately, most reports included a small number of patients, which was insufficient to adequately test the safety and efficacy of the techniques. Studies with the largest numbers of patients published within the last 20 years were from Brandsema et al. [9], Zhu et al. [51], Hill et al. [27] and Anavian et al. [3] (Table 2). The publication by Brandsema et al. [9] included 330 patients with extraarticular scapular fractures, 16 of which involved the

Table 2 Summary of studies in the literature review

Study	Year	Number of patients	Mean FU (months)	Type of treatment	Outcome	Complications	Evidence level
Alawad et al. [2]	2018	1	0.5	Screw fixation	Excellent outcome	–	V
Belien et al. [7]	2017	2	5	Locking plate, pre-bended	CS 90, DASH 6.82	None	IV
Cicekli et al. [10]	2017	1	3	Cannulated screw	CS 94, no pain	None	V
Brandsema et al. [9]	2016	16	–	2 Operatively, 14 conservatively ORIF (technique not described)	–	–	IV
Zhu et al. [51]	2016	9	3–15	Double-plate fixation	CS 91.9, DASH 6.35	1 Patient with stiff shoulder	IV
Mardy et al. [33]	2014	1	–	Screw fixation	Complete recovery	–	V
Hill et al. [27]	2014	13	12–72	Plate fixation	DASH 7.18, Flex 99%, Abd/ ER 101%, Strength 91–93%	1 Hardware removal	IV
Mehdi et al. [35]	2013	1	14	Pin fixation	Complete recovery	–	V
Kim et al. [29]	2010	34	28	Early Group: K-wire and cannulated screw. Late Group: plate fixation, cannulated screw with/without K-wire	Early Group: CS 92 Late Group: CS 81 (CS 86 with bone graft)	Early Group: none Late Group: 1 reoperation due to loss of abduction and extension	IV
Anavian et al. [3]	2009	13	12–42	Plate fixation	DASH 7	8 Hardware removal	IV
Schofer et al. [43]	2009	3	65	Conservative	–	–	IV
Russo et al. [41]	2007	1	12	K-wire, cannulated screw	Complete range of motion, no pain	Partial hardware removal	V
Gorczyca et al. [17]	2001	1	6	Plate fixation	Abduction 180°, ER 35°	–	V
Weber et al. [48]	2000	1	5	Tension band wiring	Full range of motion	–	V

FU follow-up, *CS* Constant-Murley Shoulder Outcome Score, *DASH* Disabilities of the Arm, Shoulder and Hand Score

acromion process. Fourteen patients were treated conservatively, while two patients underwent an ORIF. Zhu et al. [51] reported on a technique of double-plating in 9 patients, 8 of which had favorable results. Hill et al. [27] presented a series of 13 patients, all but one were treated operatively by various plate fixations. The outcomes were reported to be good to excellent. In the cases present here, there were no reports of non-union, however, one patient underwent implant removal due to local irritation. Anavian et al. [3] published results from 26 patients with scapular process fractures, 13 of which had acromion fractures. All acromion fractures were treated operatively using plating, with or without an additional cortical lag screw. As described in the series by Hill et al. [27], there was no non-union, but 3 implant removals were necessary due to irrigation of soft tissue. In conclusion, most manuscripts published in the last 20 years indicate a preference for operative treatment and plate fixation while other techniques were described in case reports or small case series.

Due to anatomical challenges, peripheral lateral or anterior fractures are more difficult to treat. Goss et al. [19], as well as authors of some case reports, recommend tension band wiring for such fractures. K-wire fixation does not allow for sufficient compression or stable fixation. Tension band wiring provides a good fracture compression, which is the primary advantage of this technique. Given the anatomical structure of the delta muscle, it causes multiple force vectors on the acromion. A simple tension band wiring does not provide sufficient rigidity to resist these forces, which may be one of the main reasons for implant failure [6]. In general, plate fixation is more rigid but achieving sufficient fracture compression is more difficult, which is an important disadvantage of the technique. Furthermore, implant removal is more often described after plating techniques than tension band wiring due to plate thickness and local irrigation.

Aftercare

According to the literature, patients should use a sling for 6 weeks but with immediate postoperative passive and assisted active motion, free active motion is allowed after 4–6 weeks while muscle strengthening exercises were started after 2–3 months [3, 28]. When deciding on a conservative course of treatment, factors such as the length of immobilization, initiation of active motion and the type of orthosis recommendations are not given in the literature. As such, most case series address surgical treatment and postoperative aftercare. Kuhn et al. [30] recommended a simple sling for 2 weeks in cases of a Type IA fracture. In most Type IB and II fractures, a sling used from 4 to 12 weeks. Based on our clinical experience, use of a sling for 6 weeks is usually sufficient and passive mobilization can be started after 3 weeks. Sling removal and active motion is possible 6 weeks after trauma. Whether an abduction splint can more effectively prevent fractures from secondary dislocation has not been reported in the literature.

Treatment algorithm

Establishment of treatment guidelines has been difficult due to the lack of clinical studies with a higher patient volume and evidence level. Absolute and relative indications are not clearly defined. Nevertheless, some recently published recommendations are useful. Open fractures of the acromion are extremely rare and may be the only absolute indication for surgery—if not simply to close the soft tissue but to perform additional open reduction and internal fixation [2, 33]. Based on the classification scheme proposed by Kuhn et al. [30], operative treatment should be used for patients with Type III fractures and symptomatic non-unions in Type II fractures. Whereas operative treatment of all dislocated fractures was proposed by Baur et al. [6]. Particularly in fractures with compromised subacromial space, anatomic restoration may prevent muscular dysfunction and scapular dyskinesia [27]. Kim et al. [29] compared early and delayed fixation in a retrospective series of 34 patients, and found a significantly better Constant Score and daily activity score in the early fixation group.

Based on the literature and our experience treating acromion fractures, we drafted a treatment algorithm (Fig. 1) using the classification system proposed by Kuhn et al. [30]. A critical factor when selecting a suitable treatment strategy is to identify the patient's demand level (high or low), which is largely determined using the patient's age and activity level. However, patients who are physically active, employed, and living independently are typically assigned to the high demand group, regardless of their age.

Clinical examples

The authors' experience treating five patients with acromion fracture with a minimum follow-up of 1 year is summarized in Table 1. All of the patients were initially treated conservatively, either because they refused surgery or due to concomitant injuries. Of the five patients, three were treated operatively and two had successful outcomes with conservative treatment alone. One conservatively treated patient developed an asymptomatic non-union. Three of these cases are illustrated in Figs. 2 and 3.

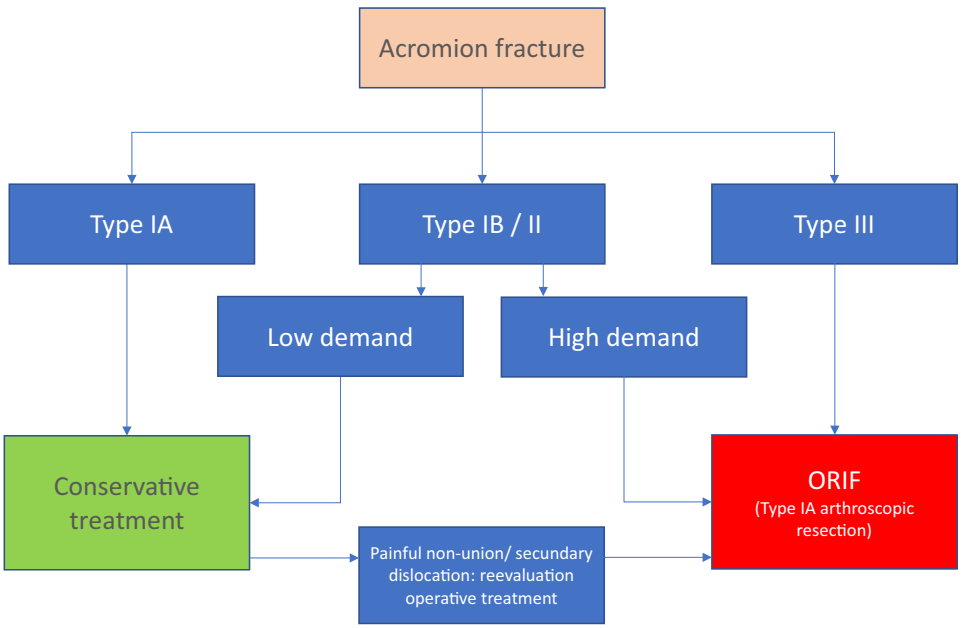

Fig. 1 Proposed treatment algorithm for acromion fractures. The classification is based on the original system created by Kuhn et al. [30]

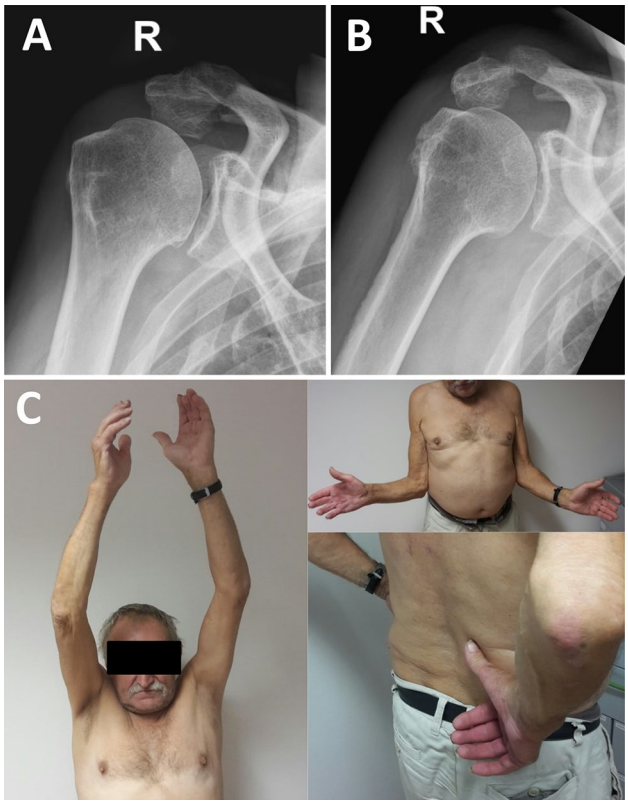

Fig. 2 Patient 1 who refused operative treatment: **a** post-trauma X-ray, **b** follow-up X-ray after 3 months, **c** clinical result after 3 months

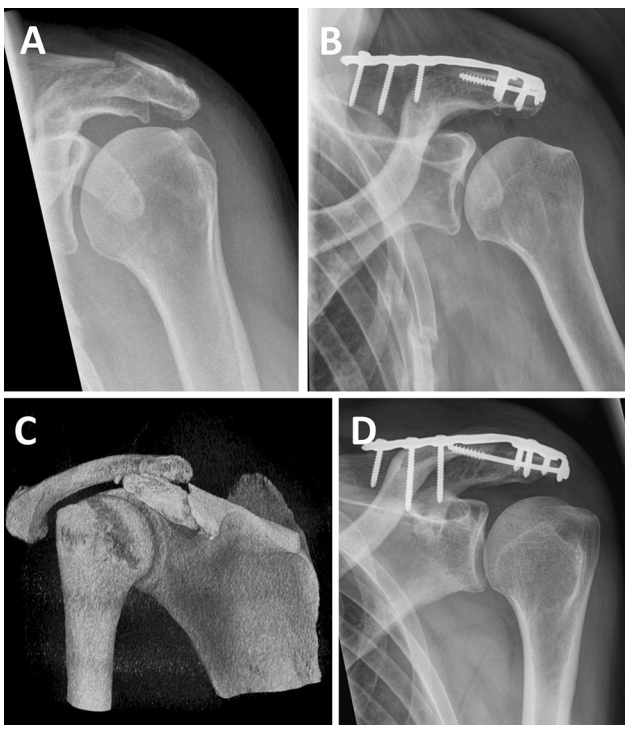

Fig. 3 Pre- and postoperative radiographs of patient 2 (**a, b**) and patient 5 (**c, d**)

In three of the above-mentioned patients, a modified 2.7/3.5-LCP cruciform pilon plate (Depuy Synthes, West Chester, PA, USA) in combination with an interfragmentary compression screw inserted into the lateral plate hole was used [25]. In theory, the plate is designed to provide sufficient rigidity to neutralize the multiple force vectors of the deltoid muscle, and fracture compression is provided by the interfragmentary compression screw, but this plate was not specifically designed for acromion fractures. The combination of plate and compression screw acts as a tension band wiring and leads to an increased fracture compression by activating the delta muscle [20, 25]. Consequently, early active mobilization is possible.

Discussion

Fractures of the acromion process and base are rare and account for 7–10% of the scapula fractures [3, 4, 38], which represents approximately 1% of all fractures [1, 22]. The common causes of these fractures are (1) direct lateral impact due to a fall, car accident, sports injury, or (2) indirect force to the deltoid muscle [3]. However, reports can be found in the medical literature of less common stress fractures without a history of trauma [13, 32, 45, 47]. Traumatic acromion fractures typically occur in conjunction with more severe injuries. Consequently, diagnosis is often delayed or overlooked during initial assessments [4, 24].

No gold standard or widely accepted treatment recommendations are available in the medical literature. Some studies report favorable results without performing ORIF [43]. However, according to the literature of the past 20 years, most authors suggest ORIF for those patients with a symptomatic non-union, displaced fractures or fractures associated with other lesions of the superior shoulder suspensory complex [3, 19, 27, 30, 38]. For many working adults, a conservative approach is too risky in terms of long-term disability and missed work days, particularly when this approach fails. Due to the infrequency of this fracture type, most studies lack a high enough sample size to draw plausible conclusions about the characteristics that will likely lead to failed conservative treatment. A recent study comparing the clinical outcomes of early and delayed ORIF of acromion fractures showed that patients with early fixation recovered quickly and fully, whereas 85.7% of the patients with delayed surgery were not able to return to their preoperative activity level [29]. This indicates that early treatment with ORIF, especially in younger patients, is more favorable than conservative treatment followed by delayed surgery.

An additional issue that makes establishment of treatment recommendations more complicated is the array of classification systems [19, 29, 30] that lack clear treatment management strategies. Suggested surgical techniques and

conservative treatment, as well as preferred fixation techniques, vary widely in the literature. Some authors recommend early treatment with ORIF to prevent chronic, painful non-union and to protect the rotator cuff tendons from impingement, as well as surgical excision if the bony fragment is smaller than a half an inch [22, 37, 39]. However, excision of longer fragments may result in deltoid dysfunction [46]. The primary objectives of ORIF are anatomical repositioning of the lateral fragment to restore the physiological width of the subacromial space, to establish a rigid fixation to neutralize the deltoid muscle forces, and to provide sufficient compression on the fracture for proper bone healing. The types of internal fixation to treat acromial fractures or symptomatic os acromiale most commonly recommended in the literature include the use of K-wires with tension band wiring, cannulated screws with or without additional tension wiring, as well as plate fixation [7, 8, 12, 40, 42, 44, 46]. Tension bands and K-wires do not provide the most rigid fixation and often lead to reduction failure, implant irritation and migration [5, 23]. The screw fixation offers more stability and a higher rate of fracture union, but screw insertion can be difficult because of the thin bone layer of the acromion. Plates provide more rigidity to the fracture area but are often associated with partial detachment of the deltoid muscle.

Three clinical examples in this report had severe concomitant injuries (Patients 1, 2 and 4) that required treatment and an accurate diagnosis was delayed in one patient (Patient 3). Eventually, all patients responded well to either conservative or operative treatment. The two conservatively treated patients (Patients 1 and 4) were entirely pain-free and able to carry out daily activities without limitations. The operatively managed fractures were also initially treated conservatively, but without success. In two cases, surgery was performed once the presence of a non-union was evident. The fracture in Patient 3 was not detected during early assessments and was subsequently misclassified as impingement syndrome. Ultimately, a diagnostic injection with local anesthesia into the non-union provided an accurate diagnosis.

The technique used in these clinical examples was also successful in treating patients with insufficiency fractures that were complications of a previously performed reverse shoulder arthroplasty [25]. The technique combines the strengths of tension band techniques with plate fixation, it restores sufficient rigidity to neutralize the deltoid muscle forces pulling in various directions, and it provides enough compression on the fracture area to permit proper healing. Most published studies included patients with symptomatic os acromiale, not patients with acute fractures of the acromion. In this report, we focused on patients with fractures. Nevertheless, the described fixation technique might also be successful when treating patients with os acromiale. To avoid local irrigation and implant removal, one possible solution would be an anatomic plate that accounts for the thin soft tissue layer.

Conclusion

In conclusion, reliable parameters that indicate when surgery at an early stage would be most beneficial are lacking. Likewise, a classification system providing clear guidance on treatment options is needed. Patient characteristics, such as activity level, might be particularly relevant when selecting a treatment strategy. Early ORIF may be the most sensible way to treat working adults who need to avoid long absences from work. Elderly patients often experience acceptable shoulder function, even in cases of painless non-union. Therefore, a conservative approach might be the most suitable treatment option.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individuals described in this case series.

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