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Anatomical reconstruction to treat acromion fractures following reverse shoulder arthroplasty

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Abstract

Purpose Scapular fractures after reverse shoulder arthroplasty (RSA) are often associated with substantial shoulder impairment. Patient outcomes following either conservative or operative treatment have not been favourable, and consensus is lacking on the best treatment approach. We describe a technique for anatomic reconstruction of fractured lateral and basal acromion in patients at higher risk for diminished function or those for which conservative treatment has already failed.

Methods Of the 95 patients who underwent RSA at our institution between December 2013 and December 2016, three had post-operative acromion fractures (type II). Two of these patients had secondary dislocation and one underwent conservative treatment that failed. In all three cases, the acromion was reconstructed using an open technique with plate and interfragmentary screw fixation.

Results After the acromial fracture and prior to reconstructive surgery, the shoulder function decreased substantially in all three cases. Following reconstruction, forward flexion improved from 53.0° to 127°, and abduction improved from 52.0 to 125°. The range of the Constant scores at the one year follow-up was 55-71, and the subjective shoulder value (SSV) was 50-90. One patient reached the same active range of motion (ROM) as her pre-fracture status, and the two other patients improved but did not regain the previous ROM level.

Conclusion Acromion fractures after RSA are serious complications that have the potential to cause severe shoulder function impairment. Our fixation technique for anatomic lateral and basal acromion reconstruction was used safely to treat three patients with poor shoulder function due to secondary dislocation or non-unions.

Keywords Reverse shoulder arthroplasty · Scapular fractures · Acromion insufficiency · Anatomic reconstruction · Shoulder function

Introduction

Modern reverse shoulder arthroplasty (RSA) methods, which have been developed based on the concept by Grammont and Baulot [1], are used to treat an increasingly broader spectrum of indications [2]. Rotator cuff arthropathy [3–5], irreparable rotator cuff tears [4–7], fracture sequelae [5, 8–11], failed total shoulder arthroplasty [4, 5], and chronic locked shoulder dislocations [12, 13] have been successfully treated with RSA. However, complications reportedly develop with varying frequency [14], with rates ranging from 19 to 68% [5, 7, 14–16].

A scapular fracture, one type of serious yet poorly understood complication following RSA, has been associated with changes in joint biomechanics [17, 18]. While it seems to occur infrequently, its severity has been underestimated [19]. Published incidence rates range from 0.9 to 7.2% [4, 7, 8, 20–30], and this type of complication often results in a more significant loss of function when compared to post-operative outcomes without complications [31].

Management of these fractures is challenging due to the severely diminished functional outcomes [25, 31–33] and the occurrence of non- or malunions [25, 26, 31, 32]. Moreover, evidence-based treatment recommendations for these fractures are lacking. According to the classification

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proposed by Crosby et al. [22], avulsion fractures anteriorly (type 1) can be successfully treated without surgery, whereas type 2 fractures (acromion base) often fail when treated conservatively. Scapular spine fractures are often successfully treated with open reduction and internal fixation [22, 34]. The main challenge in operative treatment is to maintain sufficient stabilization in a relatively thin bone layer that is often osteoporotic. Moreover, enough compression must be applied to the fracture fragment and distraction forces of the deltoid muscle have to be neutralized.

In this case series, we present anatomic reconstruction of fractured lateral and basal acromion using a simple fixation technique without compromising fibres of the deltoid muscle. We performed this technique on three patients after failed conservative treatment and secondary dislocated scapular fracture. The aim of this paper was to share our clinical experience with a surgical approach that may be useful in further defining the best management strategy for these challenging cases.

Material and methods

Patients

From December 2013 to December 2016, 95 patients were treated with RSA at our institution. Following surgery, two patients developed an acromion insufficiency fractures (13 and 40 weeks post-operatively) and one had an acromion fracture (8 weeks post-operatively) due to trauma. Patient characteristics are presented in Table 1. Written consent was obtained from all three patients to use their data in this report.

All RSA were done with patients in the beach chair position, under local (interscalene block) and general anesthesia. The operation was performed through the standard deltopectoral approach. Post-operatively, all patients were mobilized passively and actively without load for the first six weeks. Nocturnal sling immobilization was done during this time. Free active movements with load (pain adapted) were allowed for six to 12 weeks post-operatively.

The three patients who had a post-operative 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. In one case, the initial fracture was not detected on the original CT scan, which resulted in a secondary dislocated acromion that could not be treated conservatively. The second patient was treated conservatively for six weeks with an abduction splint, but pain and function levels did not improve over time. The third patient already had a secondary dislocated fracture at the time of diagnosis. Rehabilitation after anatomic reconstruction included the use of an abduction splint for six weeks (Ppatient 1 and 2) and functional treatment immediately following surgery (patient 3).

All patients were postoperatively assessed at a minimum of one year. At the last follow-up visit, Constant scores [35] were measured 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 (100%), which was documented pre-operatively and at the final follow-up visit [36] (Fig. 1).

Table 1 Patient demographic and outcomes

	Patient 1	Patient 2	Patient 3
Gender	f	f	f
Age (year)	78	66	80
Handedness	Right	Right	Right
Surgical side	Right	Left	Right
Reason for RSA	Massive irreparable rotator cuff tear	Massive irreparable rotator cuff tear	Massive irreparable rotator cuff tear
Reason for fracture	Insufficiency fracture	Fall	Insufficiency fracture
Fracture type	Type II	Type II	Type II
Time-to-fracture after RSA (weeks)	13	40	8
Pre-RSA shoulder function (E/A) [°]	85/85	30/25	60/60
Post-fracture shoulder function (E/A) [°]	70/70	40/40	50/45
Union	Yes	Yes	Yes
Plate removal	No	No	Yes
Complications	No	No	No

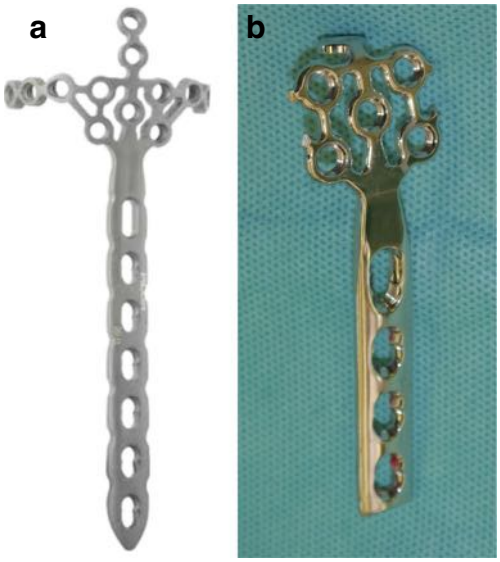

Fig. 1 Modification of the cruciform pilon plate. **a** Original plate. **b** Modification shortening the side arms, the most distal hole, and plate length

Operation technique

To expose the fractured scapula during surgery, patients were positioned laterally on the contralateral shoulder (see Fig. 2). Pre-operative antibiotics (cefazolin 2 g) were given according to the patient's weight. The operation was performed under general anesthesia with additional interscalene analgesia. A 10 cm incision was done along the scapular spine toward the middle third of the lateral border of the acromion. Neither the deltoid nor the trapezius muscle had to be detached or impaired. In order to insert the plate, sufficient exposure laterally on the acromion was needed. Open reduction and temporary fixation of the fracture with a Weber clamp were then performed. In the case of non-union, the fracture region was cleaned and roughed with a small sharp spoon. The osteosynthesis was performed with a 2.4/2.7 mm cruciform Pilon plate (Depuy Synthes, West Chester, PA, USA). To ensure anatomic alignment with the scapular spine and the acromion, the plate was bent approximately 20 to 30° and torqued approximately 15° in the neck region. The lateral plate arm could then be shortened and adapted to the acromial size. The distal hole must be bent 90° to the plate. At this point, the plate should be positioned and fixed with the interfragmentary compression screw, which should be inserted into the bent hole from the middle of the lateral aspect of the acromial border into the scapular spine. The screw ought to cross the fracture area and should be at least 35 mm in length. To compress the fracture fragment, a semi-threaded screw was used. The plate was then fixed with three cortical

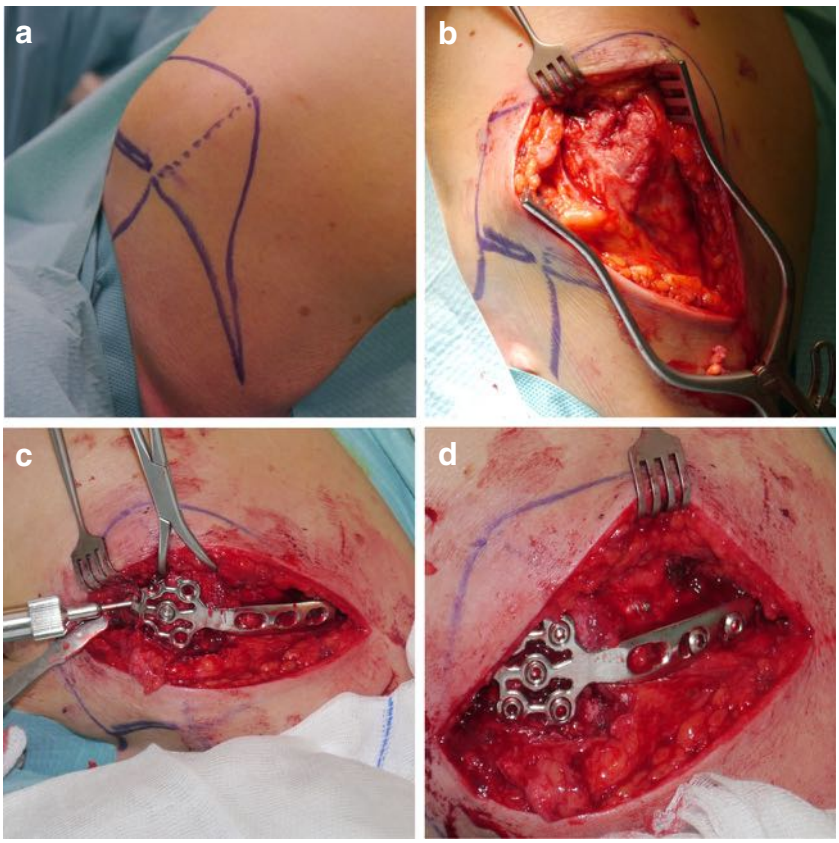

Fig. 2 Operative technique of anatomic reconstruction of the acromion. **a** Patient is positioned on the contralateral side with free movable arm. **b** Exposition of the acromion and scapular spine without detachment of the deltoid muscle. **c** Placement of the interfragmentary compression screw into the scapular spine. **d** Final situs

screws into the scapular spine and locking screws distally into the acromion (see Fig. 2).

Case reports

Patient 1

A 78-year old woman underwent reverse shoulder arthroplasty (Delta Xtend, DePuy Synthes, Warsaw, IN, USA) to treat chronic massive irreparable rotator cuff tear of the right shoulder. The patient's medical history included surgery to treat breast cancer several years prior; however, no subsequent treatment or medication was needed. Results from the first two clinical and radiological visits (6 weeks, 3 months) following the RSA indicated improved functioning. At the three month visit, the patient had an active abduction of 110°, forward flexion of 140°, external rotation of 20°, and internal rotation to L4. Thirteen weeks after RSA, the patient was hospitalized due to increasing pain (7-10 on pain scale) and diminishing function. She reportedly fell twice, although there was no evidence of injury to the right shoulder. A CT scan did not detect a fracture, component loosening, or joint puncture. Moreover, there was no low-grade infection or scapular insufficiency fracture. However, shoulder function and pain did not improve after six months of physiotherapy. At that point, the patient was diagnosed with a secondary dislocated acromion fracture with poor function in daily living. Open reduction and internal fixation was done six months after primary surgery. Post-operatively, the shoulder was immobilized in a 60°-abduction splint with only passive movements for 6 weeks (Fig. 3).

Patient 2

A 66-year old female patient presented with painful chronic massive rotator cuff tear of the left shoulder. After failed conservative treatment, the patient underwent surgery for RSA (Delta Xtend, DePuy Synthes, Warsaw, IN, USA). At the time of the six month follow-up visit, the patient had adequate active range of motion with abduction 110°, flexion 150°, external rotation 70°, and internal rotation to L2.

During the six months after RSA, she also had several lumbar facet joint infiltrations to treat multiple segmental arthritis and spinal stenosis. Forty weeks after RSA, the patient fell on her left shoulder and a non-displaced acromial fracture was detected. It is unlikely that a pre-existing insufficiency fracture was overseen at this point. Physiotherapy was ceased and her shoulder was immobilized in a 60°-abduction splint for six weeks. However, the patient continued to experience pain and limited shoulder function, which led to the decision to perform anatomical reconstruction. Post-operatively, her shoulder was immobilized again in a 60°-abduction splint with only passive movements for six weeks.

Patient 3

An 80-year-old female underwent RSA (Delta Xtend, DePuy Synthes, Warsaw, IN, USA) to treat chronic massive irreparable rotator cuff tear with arthritis (Hamada II) in the right shoulder. Although the patient had atrial fibrillation and hypertension, she was still physically active.

She was taking rivaroxoban 20 mg to treat her cardiac condition and pain medication for the shoulder. At the time

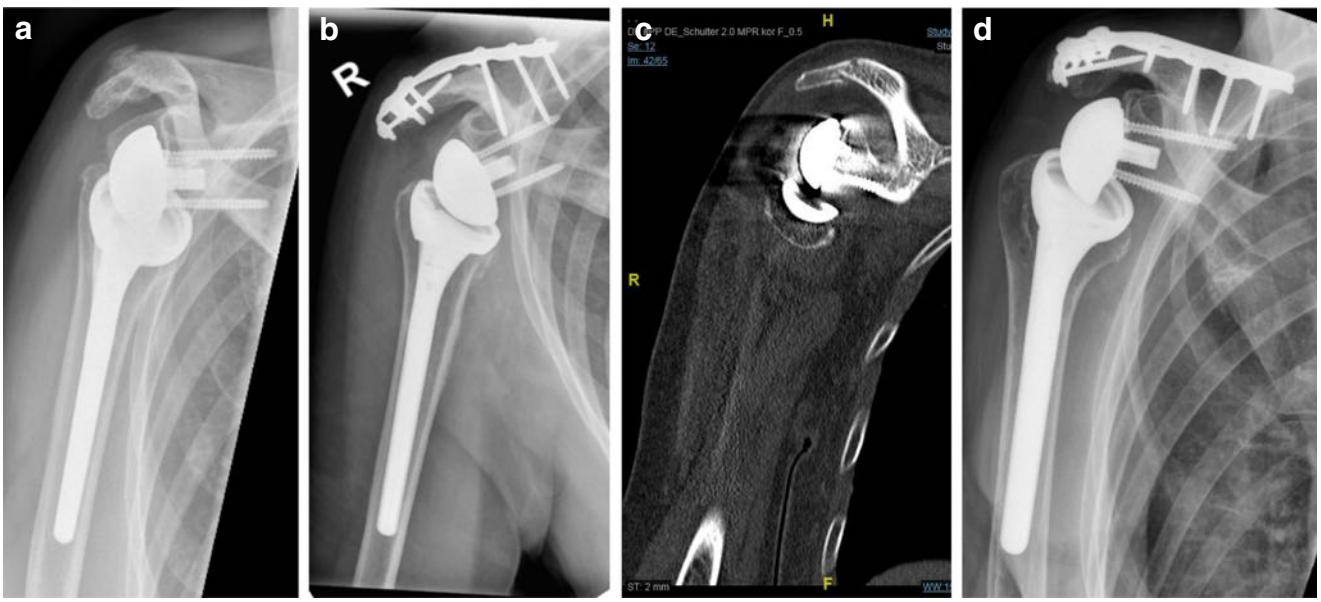

Fig. 3 Radiological example of patient 1 and 3. Secondary dislocated acromion fracture (type II **a** and **c**). Postoperative radiograph (**b** and **d**) after anatomical reconstruction

of six week follow-up visit, the patient had virtually unlimited active motion (abduction 150°, forward flexion 160°, external rotation 30°, internal rotation to L2) and was reportedly pain-free. However, eight weeks post-operatively she complained of loss of function and increasing pain during daily activity. Results from the CT scan showed that she had a moderate dislocated acromion fracture with clinically poor active abduction and forward flexion (see Table 2). Due to the laterally depressed acromion and her initially favourable clinical progress, the decision was taken to move directly to anatomical reconstruction without attempting conservative treatment. Instead of immobilization in an abduction splint, the patient was mobilized actively and passively without load for 6 weeks.

Discussion

The incidence rate (3.2%) of scapular fractures after RSA in patients treated at our institution was consistent with published rates of 0.9 to 7.2% [4, 7, 8, 20–30]. In all three patients, shoulder function substantially decreased after the fracture, which was also found in previous publications [26]. However, in contrast to other reports, pain scores increased in our case series [26, 27]. All three patients experienced improved shoulder function and decreased pain following anatomical reconstruction of the acromion. Only patient 3 returned to the initial pre-fracture function after RSA, though.

In two of our patients, secondary dislocation of the acromion occurred—one was detected after a missed diagnosis on the CT scan (patient 1) and the other was already present at the time of diagnosis (patient 3). Reduced tension of the deltoid fibers leads to a large reduction in shoulder function that is not likely to improve with conservative treatment. Patient 2 did not respond to temporarily stopping physiotherapy and immobilization with an abduction splint. No callus was detected intra-operatively, and the lateral fragment was mobile. Early diagnosis of the fracture before dislocation is critical since it is correlated with poorer outcomes [34]. Favorable results with non-surgical management for patients with lateral acromial fractures have been reported [8, 22, 26, 27, 33]. However, management of the acromion base is challenging and often associated with poor clinical outcomes since a larger portion of muscle fibre is impaired, as compared with cases of peripheral fractures.

Previously published techniques to treat acromion fractures, such as tension band wiring or dual locking plate fixations, have not been accepted as standard treatment procedures [27, 28, 37]. It is likely that there is a high rate of failure using tension band techniques because the force vectors generated by the deltoid muscle run in multiple directions. Plate fixations are more rigid and the deltoid origin often has to be partially detached [37], which leads to additional impairment of shoulder function. Furthermore, such fractures often occur in elderly patients with osteoporotic bone quality and/or reduced thickness of the acromion due to previous acetabularisation.

The technique described in this report combines the strengths of tension band techniques with plate fixation. The cranially-placed plate connects the lateral fragment to the rest of the scapula and is fixed with three screws to the scapular spine. The screws typically bind well, even in osteoporotic bones. Bridging the fracture with a plate provides a more rigid fixation than just the two pins used in the tension band technique. The laterally-placed locking screws neutralize the deltoid muscle forces in multiple directions. The most difficult step of the technique is correct placement of the interfragmentary screw. The cortical screw should be inserted from the lateral aspect of the acromion through the most laterally-placed bent hole, which crosses the fracture area into the scapular spine. It should extend at least 35 mm in length, depending on the exact fracture location. By connecting the plate with the interfragmentary screw, the reconstruction acts as tension band wiring, switching tension forces into compression forces. This is likely the reason that active motion without load after reconstruction is possible in patients with good bone quality (patient 3).

Most studies conclude that scapular fractures following RSA result in inferior outcomes [25–27, 34]. However, there are also reports indicating that not all acromion fractures lead to poor shoulder function [22, 24, 25]. A clearly defined, evidence-based strategy for treating scapular fractures after RSA is needed.

In conclusion, this case series report describes a technique for anatomical reconstruction of scapular fractures that can be used to treat patients with secondary dislocated lateral acromion and acromion pedicle fractures, or to treat patients with failed conservative treatment of such fractures. This technique should not be considered a general method to be used for all scapular fractures following RSA, though. It is critical that patients are carefully assessed to determine if further surgery would be beneficial given their circumstances. In the future, this technique could be optimized by using anatomic plates that can be easily applied and permit early active motion or shortened immobilization time to prevent stiffness. Early

Table 2 Final follow-up (≥12 months) after anatomical reconstruction

	Patient 1	Patient 2	Patient 3
Elevation / abduction [°]	140/135	90/90	150/150
SSV [1] (%)	70	50	90
CS [2]	55	56	71
CS [2] contralateral side	79	92	81

SSV = subjective shoulder value, CS = Constant score

detection and diagnosis are essential for preventing secondary dislocation of the acromion, which is associated with poorer functional outcomes. Conservative treatment should still be the method of choice, whenever feasible.

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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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