

# Fractures of the Scapula

## Zlomeniny lopatky

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### SUMMARY

The scapula connects the arm with the chest wall and is therefore of great importance for a free range of shoulder of motion. For a long-term scapular fractures had been treated predominantly conservative. However, clinical studies of the past decades revealed that some fracture patterns deserve operative treatment to prevent unfavorable functional outcome and chronic state of pain.

Scapular fractures are predominantly acquired during high-energy trauma and these patients' presents with a mean of 3.9 associated injuries in the emergency department. Injuries to the head, chest and ipsilateral upper extremity are most common. As some of these injuries are possibly life threatening they are treated first. Scapular fractures are only very seldom surgical emergencies. Therefore they are treated during the phase of convalescence in polytraumatized patients.

Decision-making should be based on a thoroughgoing diagnostics, including conventional x-rays and a CT-scan, especially in cases of glenoid neck or cavity fractures. All fracture patterns should be identified to their full extent and put into the context of the scapular suspensory complex.

The OTA lately presented a new and comprehensive system for classification of the scapular fractures. It is divided in two levels. Level one for the general orthopedic or trauma surgeon and Level two for the advanced upper Extremity or Shoulder surgeon. This classification scheme allows an easy access to understanding of the severity and prognostics of scapular fractures. As a general guideline surgery is indicated if a double disruption of the Scapula suspensory system, a relevant malposition or dysintegrity of the glenoid (articular surface) or a displacement of the lateral column is present.

### INTRODUCTION

Fractures of the scapula, almost without exception, occur during high-energy trauma. Therefore, they are frequently associated with severe injuries to the chest and skull. The latter define the first days of hospitalization in polytraumatized patients. Treatment of the scapula fracture itself should be initiated during the phase of convalescence.

Mostly a conservative treatment procedure is possible, however in about 10% operative treatment is indicated. Due to the complex anatomy of the scapula body and its processes and moreover the crucial importance for the connection of the upper limb to the chest wall decision-making and operative treatment belongs in the hands of an experienced orthopedic or trauma surgeon.

This review provides a comprehensive overview of the literature and therapeutic guidelines. Moreover, it presents the latest OTA classification system of scapular fractures and summarizes some crucial biomechanical concepts that will help the reader to comprehend decision-making.

### Relevant applied anatomy

The scapula consists of the flat shaped scapular body and four processes: the acromion, the coracoid process, the scapular spine and the glenoid process.

The superior, the medial and the lateral border of the scapula is thickened, as major muscles insert here. They should be used for placement of reduction clamps and osteosynthesis plates during operative treatment of scapula body fractures.

The acromion contributes to the acromioclavicular joint. An Os acromiale can be misdiagnosed as an acromial fracture and has to be carefully diagnosed. The scapular spine runs as a bony prominence from the medial margin to the acromion. It gives relevant contribution to the inserting muscles lever arm, due to its prominence (trapezoid, supraspinatus, infraspinatus and posterior deltoid muscle). The coracoid process initiates between the glenoid process and the anterior margin. As all important neurovascular structures run medial to the coracoid process it is called the "surgeon's light-house" during operative procedures. The coracoacromial, the conoid and the trapezoid ligament insert at the coracoid process. They participate in the Clavicular-CC-ligamentous-coracoid (C4)-linkage, which is the major suspension system of the scapula and the upper limb, respectively. The glenoid process lies between the scapular body and the glenoid cavity. The coracoid process arises from its superior aspect.

The stability of the glenoid process depends on the osseous connection to the scapular body and the suspension through the coracoid process and the CC-liga-

ments to the clavicle acromial joint strut (Figs 1+2). All fractures of the glenoid process associated with alteration of the later have to be considered as instable and desire operative fixation.

For operative decision making a pure anatomic approach to the bony scapula and its ligamentous adjuncts is of little benefit. Especially in cases of combined scapular fractures all structures should be evaluated with regards to role in maintaining an adequate scapular suspension (superior suspensory complex) and guarantee a free range of scapular motion.

#### *The superior suspensory complex*

The Superior suspensory complex is a bone-soft-tissue ring composed by the coracoid process, the glenoid process, the coracoclavicular ligaments, the distal clavicle, the acromioclavicular joint (ACJ) and the acromial process (8) (Fig. 1a). This ring lies between two bony struts: the superior strut, consisting of the middle clavicle and the inferior strut, consisting of the lateral body and spine (8) (Fig. 1b). The SSSC can be considered as the connection point of the upper extremity and the axial skeleton. Double disruptions of the SSSC deserve operative treatment (8) if displaced.

The Superior suspensory complex can be divided into three functional partitions (Fig. 2).

1. The clavicular acromioclavicular joint acromial strut
2. C-4 linkage (Clavicle, CC-ligaments and the coracoid process)

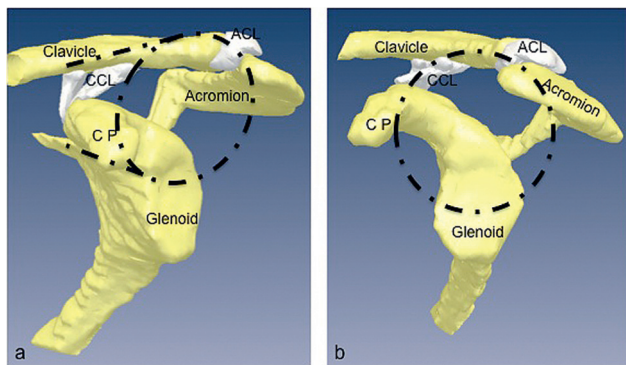


Fig. 1. The superior shoulder suspensory complex. A view on the bone - soft tissue ring, the superior and the inferior bone struts from ap direction; B view on the bone—soft tissue ring from lateral (CP-coracoid process, CCL- Coracoclavicular Ligaments, ACL-Acromioclavicular ligaments)

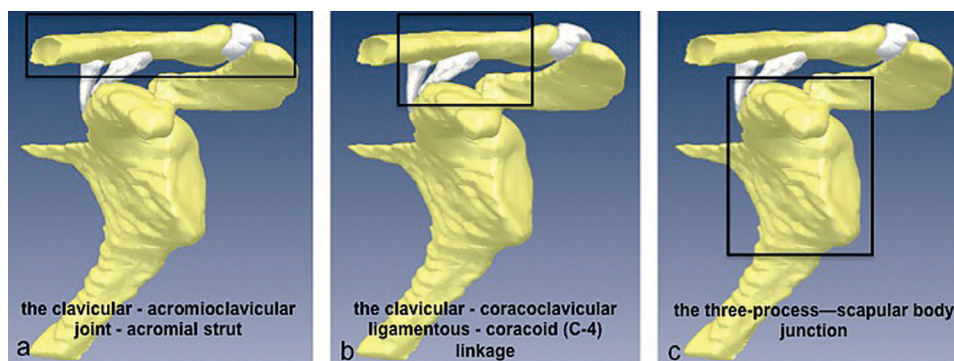


Fig. 2. The superior shoulder suspensory complex consists of three components: the clavicular—acromioclavicular joint—acromial strut (a), the clavicular—coracoclavicular ligamentous—coracoid (C-4) linkage (b) and the three-process—scapular body junction (c).

3. The three-process-scrapular body junction and last but not least the

NOTE:

Double disruptions of the SSSC are considered as instable and deserve open reduction and internal stabilization.

#### **Epidemiology, etiology and classification**

Scapular fractures are predominantly acquired during high-energy trauma and as a result they are associated with a broad variety of injuries(14, 19, 24). Each affected patient presents with a mean of 3.9 co-injuries (33). Amongst all, chest trauma is found to be the most common (rib fractures 38–45%, pulmonary contusion, pneumo- or haemothorax 15–50%) (19, 23). Injuries to the head are present in 20% (19). Fractures of the ipsilateral clavicle occur in 15–40% and of the ipsilateral humeral head in about 12%. The Patients morbidity highly depends on the severity of these associated injuries, especially on the presence of neurovascular injuries (2). The latter are present in about 10–12%. Lesions to the brachial plexus, the axillary artery or the subclavian vein occur (6, 10, 26, 34).

Scapular body fractures result from blunt or direct trauma. Forces have to be great, because of the great mobility and the thick surrounding deep and superficial muscle layers. Rowe et al described a recoil mechanism of the chest wall that provides additional protection (30). However, some cases of scapular body fractures after an electric shock or after epileptic seizures have been reported (4, 20, 32).

Fractures of the glenoid neck are caused by blow over the anterior or posterior aspect of the shoulder, impaction of the humeral head against the glenoid process or after a fall on the outstretched arm. In rare cases they arise from a blow to the superior aspect of the shoulder complex (29). Fractures of the glenoid fossa result from a lateral impactation of the humeral head, when it is driven into the glenoid fossa (7). Fractures of the glenoid rim result from a strike of the humeral head against the anterior or posterior portion of the glenoid cavity. A direct blow or an indirect trauma after dislocation of the humeral head can cause a fracture of the coracoid process (28). Acromial fractures are caused by either direct trauma or during superior dislocation of the humeral head. Avulsions fractures of the acromion result from tensioning of the deltoid or trapezoid muscle (9, 12).

## Classification

The OTA proposed a comprehensive and easy to apply classification system with a two level approach to scapula fractures.

Level one is a classification system for the general trauma or orthopedic surgeon.

Level two is for shoulder specialists.

At level one the scapula is divided in three different groups (Fig. 3):

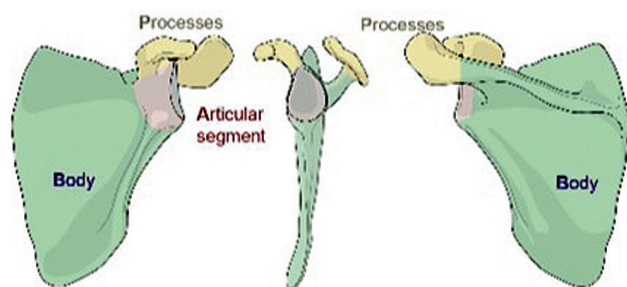


Fig. 3. Systematic overview of the OTA-classification system of Scapular Fractures- Scapular body fractures are coded B, articular fractures are coded F and process fractures are coded P.

1. The articular segment (Coded F)- including the glenoid fossa and the articular rim

2. The Processes (Coded P)- the coracoid process and the acromion

3. The Scapular Body (Coded B)

The articular segment is subdivided into three groups (F0, F1, F2). F0 fractures include all fractures of the articular segment that do not include the glenoid fossa or glenoid rim. F1 fractures are simple articular fractures with two major fragments. They are rim or split fractures of the glenoid fossa. Small fragments, less than 2 mm of size are not considered for classification. F2 fractures are multifragmentary fractures of the articular segment. For description of an involvement of the scapular body an additional qualifier is introduced (see below Tab. 1 and Fig. 4).

Scapular body fractures are coded with B. B1 fractures are simple fractures with 2 or less main fragments. B2 fractures are multifragmentary fractures and have more than 3 parts.

Process fractures are coded with a P. P1 defines fractures of the coracoid process and P 2 acromial fractures. P3 describes the combination of both fractures (Fig. 5).

## Clinical presentation and diagnostic procedure

Patients with scapula fractures complain local pain or tenderness. Usually they present in the emergency department with the ipsilateral arm adducted as with shoulder abduction tenderness and pain rises. Crepitus and local swelling can be local symptoms. However, because of the thick surrounding soft-tissue layer these symptoms can be missing. This might be the reason why in the pre-CT era scapula fractures were overlooked in up to 30% in polytraumatized patients.

Tab. 1. OTA classification scheme for scapular fractures

F =	Fx of articular segment
F0	Fracture of the articular segment, not through the fossa glenoidalis/glenoid rim
F1	Simple pattern with two articular fragments: rim or split fracture (Fracture involves the Glenoid Fossa) (Ignore small fragments up to about 2mm)
F2	Multifragmentary joint fracture (Fracture involves the Glenoid Fossa) (Three or more articular fragments)
Fx	.1 = without body involvement
	.2 = with simple body involvement
	.3 = with complex body involvement
B	Fx located within the Body
B1 =	Simple (Two or less body fracture exits)
B2 =	Complex body involvement (Three or more body fracture exits)
P	Process fracture
P1 =	Coracoid fracture (Separate fracture line not affecting the glenoid fossa nor any part of the body)
P2 =	Acromion fracture (Fracture line lateral to the plane of the glenoid fossa)
P3 =	Fracture of both coracoid and acromion

## F = Fx of articular segment

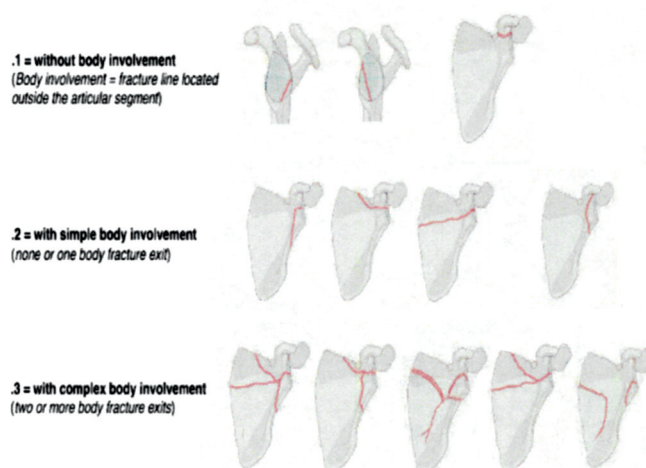


Fig. 4. F0 fractures include all fractures of the articular segment, F1 fractures are simple articular fractures with two major fragments and F2 fractures are multifragmentary fractures of the articular segment.

Scapula fractures can be identified to its full extent on plain radiographs. For correct identification of all fractures components the four processes have to be displayed correctly. Furthermore, the corresponding joints as the acromioclavicular joint, the scapulothoracic articulation and the glenohumeral joint have to be evaluated. Alteration to the superior suspensory complex and its components (the C4 linkage, the acromioclavicular joint acromial strut and three-process-scapula body junction) should be excluded actively. If there is doubt about an injury of the AC-joint or a rupture of the coracoclavicular ligaments a weighted x-ray should be performed.



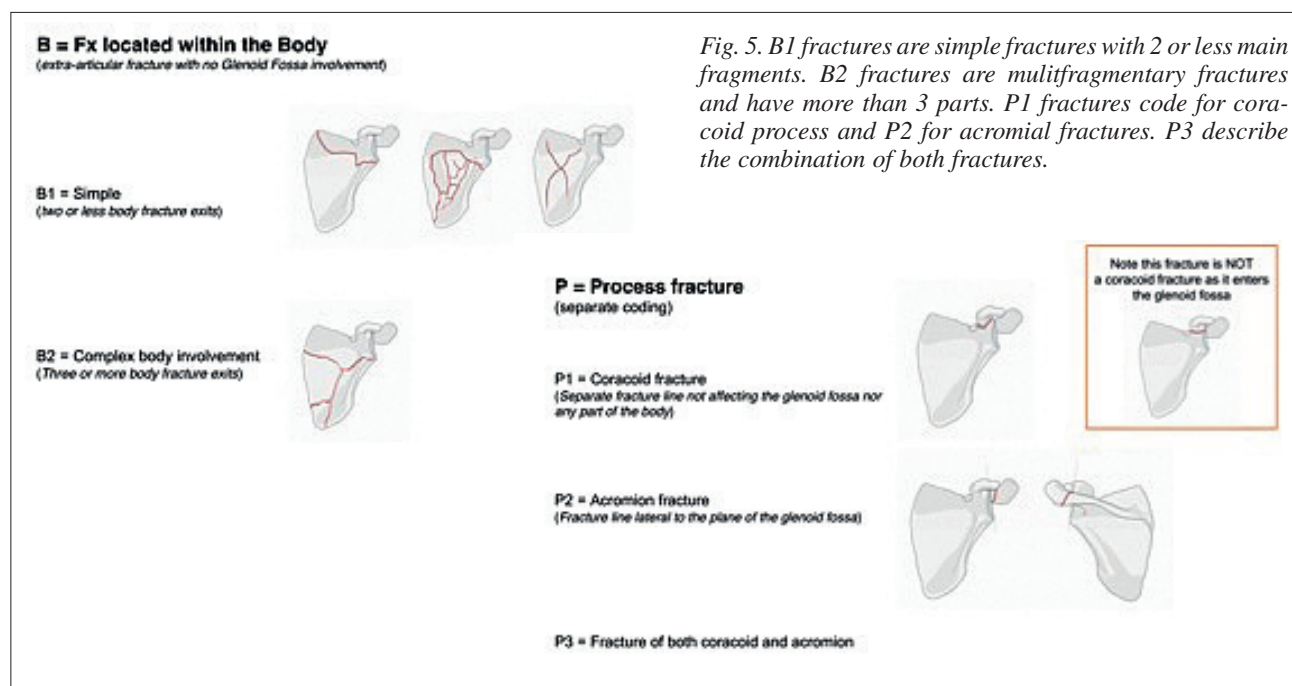


Fig. 5. B1 fractures are simple fractures with 2 or less main fragments. B2 fractures are multifragmentary fractures and have more than 3 parts. P1 fractures code for coracoid process and P2 for acromial fractures. P3 describe the combination of both fractures.

Tab. 2. Radiographic evaluation of the Scapula „Trauma series“

Radiologic view	Check for
True anteroposterior (AP)	Glenoid Scapula neck Scapula body, medial part Margo medialis Spina scapula
Lateral view	Scapula body
True axillary	Acromion, AC-joint Coracoid process Glenoid, anterior and posterior border

A standardized trauma series of the scapula should include a true anteroposterior (AP), a lateral view and a true axillary view of the glenohumeral joint (Tab. 2).

CT-scans did not improve the classification of scapula neck fractures following the study of McAdams and coworkers (22). However, the authors believe that CT-scans can help to identify associated injuries and moreover CT-scans should be performed in all cases of multifragmentary fractures of the scapula body or glenoid cavity. 3D reformatting can further help understanding the fractures type and is an crucial information reconstruction of these scans can help operative planning and should be carried out regularly.

### Indication for surgery and operative procedure

As scapula fractures are often associated with severe injuries to the chest or head operative treatment has to be well coordinated if a multidisciplinary approach is needed. Except of some cases reported in the literature with thoracic penetration or major displacement of the fracture fragments (5, 11) operative treatment can be performed during the phase of reconvalescence in polytraumatized patients.

There are quiet a few studies published focusing on indicationing and treatment of each part of the scapula such as the acromion, the glenoid the scapular body or the coracoid process.

However, it is possible to formulate some general surgical directives.

#### A general surgical directive:

#### Surgery is always recommended if

- 1.a double disruption of the Scapula suspensory system (SSSC; incl. C4-linkage)
- 2.a relevant malposition or dysintegrty of the glenoid (articular surface)
- 3.a lateral column displacement is present.

### Scapular body fractures

Scapular body fractures regularly present alarming in conventional roentgenography. However, operative procedures are on occasion indicated as the surrounding soft tissue-layer prevents further dislocation (15). Moreover, the scapulothoracic articulation can largely compensate deformation of the scapula body. Nordquist and Co-workers reported less favorable outcome in patients with dislocation of the fragments greater than 1 cm (25). However, the authors cannot recommend this as a general guideline. We believe that operative treatment should be considered more on a case based decision. Open reduction should always be performed if any alteration of the lateral column or an alteration of the SSSC is present.

In a metaanalyse of 520 cases Zlowodzki (39) and co workers reported that 99% of all scapula body fractures are being treated non-operatively and 86% achieved good to excellent functional outcome. 99% of the operated patients achieved good to excellent functional results. These results indicated that operative treatment should be carried out if indication is in question.

If indicated a posterior approach has to be performed. The extend of exposure depends on the fracture locali-

zation. A limited window technique should be always favored and can be performed in fractures of the lateral border, the acromial spine and the vertebral border. When there are more than three exit points of the fracture lines an extensive exposure might be necessary to gain full control. Small reduction clamps can be used for fracture reduction, as no specific reduction tools exist. The bony scapular ring can best be used for instrument osteosynthesis placement. 2.7 and 3.5 mm dynamic reduction plates can be used for definitive reduction.

### Glenoid Neck fractures

Complete fractures of the scapular neck can be divided into fractures of the anatomic and the surgical neck. Fractures of the anatomic neck are rare (3, 11) but inherently unstable, because the glenoid fragment completely lost its suspension. A lateral and distal dislocation of the glenoid can be found in most cases. These fractures types always deserve operative treatment.

Minor displaced fractures of the surgical neck, with a displacement less than 1cm and dysangulation less than 40° can be treated conservatively (1, 24,38). In case of significant displacement, the glenoid fragment shows medialization and head-long overturning (36). This can lead to rotator cuff dysfunction with subsequent pain and impaired arm abduction. CT-scans are especially important in these fractures types to identify the injury to its full extend.

The glenoid neck can be best reached through a posterior approach. Van Noort and Obrebsky (19, 27) described modifications of the classic posterior approach for operative treatment of the glenoid. The interval between the teres minor and the infraspinatus muscle is used for exposure of the lateral scapular border and the posteroinferior aspect of the glenoid neck. In some case of difficult to control superior fracture components an extension of the posterior approach to superior aspect of the shoulder can be performed. 2.7 and 3.5 mm malleable reconstruction plates can be used for stabilization. Additionally lag screws or K-Wires can be placed.

### Glenoid cavity fractures

There exist 6 Types of glenoid cavity fractures (13, 14) the majority can be treated nonoperatively. In Type 1 frac-

tures operative treatment is recommend in cases of persistent humeroglenoidal instability or if an intraarticular gap greater than 5 mm is present (16). Persisting instability can be assumed in fractures displaced greater than 1 cm and if the anterior or posterior rim components are greater than one fourth of the cavity. Yamamoto and coworkers 37suggested that operative treatment should be carried out in all cases when the anterior rim fragment is greater than 20% of the glenoid length. Secondary luxation can happen unnoticed and therefore operative treatment should be indicated generously.

In Type 2, 4 and 5 fractures an operative treatment should be carried out if an intraarticular gap greater than 5 mm or persistent subluxation of the humeral head is present. Type 3 fractures exit medial to the coracoid process. Open reduction is indicated in case of additional rupture of the coracoclavicular ligaments or if an intraarticular gap greater than 5 mm is present.

Type 6 fractures are treated mainly conservatively. Surgery is only randomly indicated because secondary congruency is often maintained. Moreover surgery maintains the danger of a secondary disruption of the remaining soft-tissue support.

Type 1 fractures are addressed via an anterior approach or arthroscopically (31). Interfragmentary compression screws or polypins are used, if the fracture component is large enough (Fig. 6). Type 1 b fractures are approached via a posterior approach. In case of a comminuted anterior or posterior fragment and persistent instability of the humeral head a tricortical bone graft can be implanted.

A posterior approach is used for reduction of a Type 2 fracture. Depending on the fragment size canulated screws or reconstruction plates should be used for internal reduction. Type 3 fractures can be addressed via an anterior, posterior or an arthroscopic approach. Canulated screws are used for internal fixation (Fig. 7). In case of an additional injury to the superior suspensory complex additional open reduction and internal fixation has to be performed if significant dislocation is present. For the operative treatment of Type 4 fractures an anterosuperior or a combined anterior and posterior approach can be chosen. Type 5a fractures should be treated as Type 2 fractures and Type 5b and c fractures as Type 3 fractures.



Fig. 6. The 36-year-old male suffered an Ideberg 1 Glenoid fracture with anterior luxation of the humeral head (a-c). After open fragment reduction and polypin fixation of the Glenoid fragment bony healing and stable conditions were achieved.

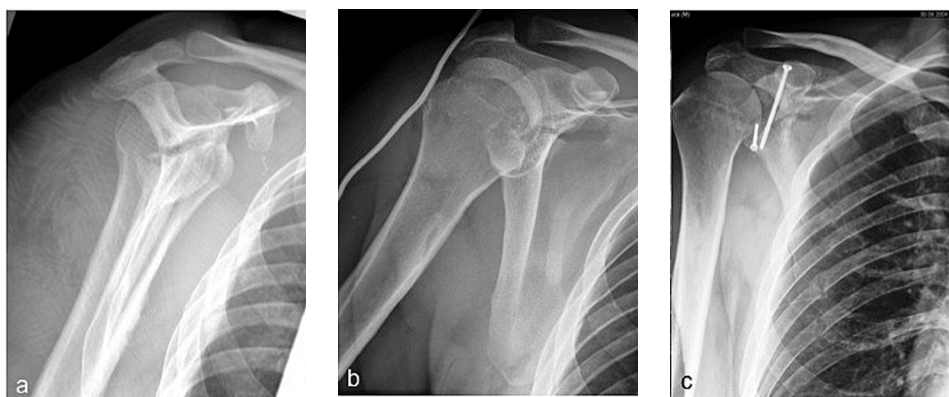


Fig. 7. The 32-year-old male suffered an Ideberg 3 Glenoid fracture. Open reduction and internal fixation using 2.7 mm screws was performed.

### Acromion fractures

Fractures of the acromion can be treated conservatively in cases of minor or superior displacement of the fragment. In cases of inferior or major displacement open reduction is indicated. Presence of an Os acromiale might complicate diagnostics and in doubtful cases a CT-scan should be performed. More recent works propose a more aggressive indication for operative treatment in young and highly active patients, especially when they are in need of crutches (17). Distal disruptions can be treated using tendon graft reconstruction. Proximal fractures should be reduced using a plate fixation, i.e. a radial plate fixation (18).

### Coracoid fractures

Coracoid fractures can be divided into the coracoid base, the interligamentous area and the coracoid tip. Fractures of the coracoid base can be regularly treated conservatively, only in cases of a significant displacement an operative treatment is indicated. Fractures to the coracoid tip or the interligamentous area can be treated conservatively as well. In young patients performing high manual labor open reduction and open reduction and internal fixation is recommended (29).

The coracoid process is approached via an anterior deltoid split or arthroscopically. Compression screws are used for refixation of the coracoid process (Fig. 8).



Fig. 8. The 19-year-old female suffered a combined fracture of the coracoid process, an Ideberg 3 glenoid fracture and an acromioclavicular joint disruption Typ Rockwood 3. Closed reduction using an arthroscopic approach was performed using two 2.7mm screws.





Fig. 9. The 32-year-old male suffered a floating shoulder injury with a Type B clavicle shaft fracture (OTA) and a scapular neck fracture with relevant medial dislocation of the glenoid neck (a+b). After open reduction and plate osteosynthesis of the clavicle alteration of the lateral column and a disorientation of the glenoid remained (c). Therefore, open reduction and plate osteosynthesis of the scapula was carried out along the lateral border and the scapula spine (d-e).

In case of comminuted fractures the conjoint tendon should be sutured to the remaining process.

### Combined glenoid neck and clavicle fractures

Great forces are needed to cause a combined fracture of the glenoid neck and the ipsilateral clavicle shaft. They can occur with or without a disruption of the coracoclavicular ligaments. In case of a coracoclavicular ligament the glenoid fragment has to be considered as instable and operative treatment is always indicated. If the CCL remained intact operative treatment of the glenoid fragment is indicated whenever significant displacement ( $>1\text{cm}$ ) or significant dysangulation ( $>40^\circ$ ) is present. Clavicle osteosynthesis should be performed if significant osteosynthesis or shortening of the clavicle is present (21). Reduction of the clavicle might lead to fracture reposition of the glenoid fragment. However, reorientation of the glenoid is crucial to achieve good functional outcome (35). Open reduction of the clavicle and the scapula should be performed if both fractures show significant dislocation (Fig. 9).

### Rehabilitation

Re-achievement of a good range of motion is the major goal of rehabilitation.

Continuous passive motion during the early phase should be carried out in all patients. For six postoperative weeks only easy activities of daily living should be allowed. Before bony consolidation has occurred lifting of weights should be avoided. Patients with brachial plexopathy need special therapy and should be treated interdisciplinary as they might benefit from nerve grafting or brachial plexus exploration.

### Complications

Implant failure (7.1%) and postoperative Wound infection (4.2%) were the most common postoperative complication following the study of Lantry et al (19). In his series injuries to neural structures appeared in 2.4% and posttraumatic arthritis developed in 1.9%.

Fracture	Indication for Surgery
Isolated body fracture	Alteration to the lateral column Dissociated Scapular Suspensory System
Surgical glenoid neck	Displacement greater than 1cm Angular displacement greater than $40^\circ$ in coronal or sagittal plane
Anatomic glenoid neck	All fractures of the anatomic neck have to be considered as inherently instable and should be treated operatively
Glenoid cavity (Types 1,2,4,5)	All fractures associated with a persisting instability of the glenohumeral joint All fractures with an intra-articular displacement greater than 5 mm
Type 3 Glenoid Cavity	All fractures with associated rupture of the SSSC All fractures with an intra-articular displacement greater than 5 mm (16) All fractures with nerve palsy of the suprascapular nerve
Acromial fractures	All fractures with inferior or major displacement All fractures with accompanied ACJ disruptions grade 3 (Rockwood) or higher.
Coracoid tip/interligament area	In athletes or patients performing high manual labor
Coracoid base	When significantly dislocated or symptomatic

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