18

FLOATING SHOULDER

“Floating shoulder” (FS) is an intensively debated issue in studies dealing with scapular fractures [2, 9–18, 21, 23–30, 32–34, 38–42, 44–47, 49, 50, 52–53]. The initially described combination of a clavicular fracture, or AC dislocation, with a fracture of the surgical neck of the scapula [16–24] has become, over time, a source of numerous mistakes and misunderstandings that persist in the literature until today [9].

HISTORY

The first combination of a clavicular fracture with a scapular fracture was published and illustrated by Vogt [51] in 1800 (**Fig. 18-1**).

Ganz and Noesberger [16], in 1975, described an unstable fracture of the surgical neck of the scapula, defining it as “*a fracture of the collum scapulae combined with a clavicular fracture, or acromioclavicular dislocation, and rupture of the coracoclavicular and coracoacromial ligaments*“, in which the glenoid fragment is displaced distally and medially by muscular pull and the weight of the extremity. The attached radiographs suggest that it was a fracture of the surgical neck, although it cannot be reliably determined. The authors recommended operative treatment of both injuries, i.e. the clavicle, or AC dislocation, and the scapular neck.

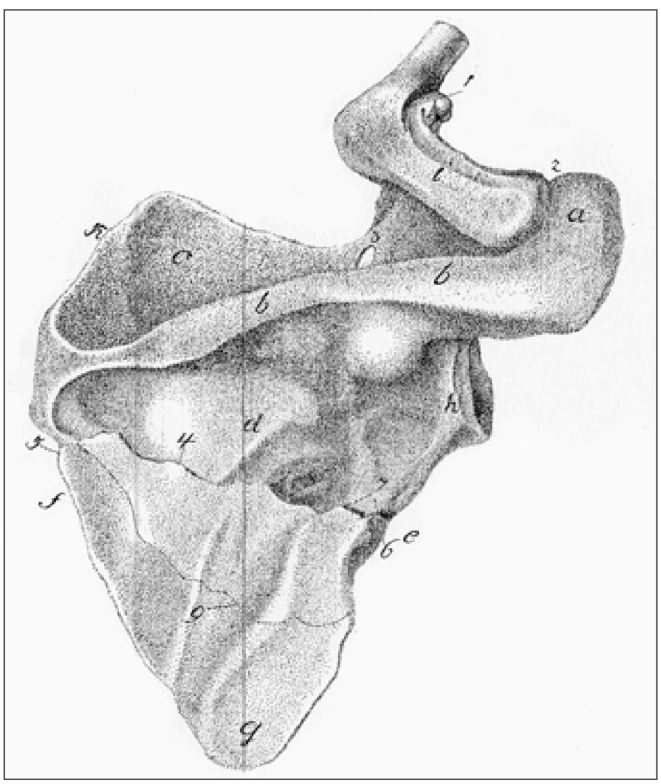

Fig. 18-1 Fracture of the infraspinous part of the scapular body, associated with a clavicular fracture, published by Vogt in 1800 [51].

Hardegger et al. [22], in 1984, discussed *stability of fractures of the surgical neck*. A necessary precondition for development of instability and displacement was, in their view, *a fracture of the clavicle and rupture of the coracoclavicular ligament*. The coracoacromial ligament was not mentioned, as is evident also in the accompanying figure (**Fig. 18-2**).

Herscovici et al. [24], in 1992, introduced the concept of the *floating shoulder* (FS) which included “*an ipsilateral midshaft clavicular fracture, a fracture of the surgical neck of the scapula and rupture of the coracoclavicular ligament*“. More specifically, it was a fracture of the surgical neck of the scapula associated with rupture of the coracoclavicular ligament and a clavicular fracture medial to the clavicular insertion of that ligament. The authors also reprinted Hardegger’s drawing. However, the radiographs show that it was an infraspinous fracture of the scapular body with an intact coracoclavicular ligament. In 7 operatively-treated patients, the authors performed only internal fixation of the clavicle with a plate, always with an excellent result.

Rikli et al. [45] in their study of 1995 used the term “*unstable shoulder girdle”*. According to their concept it included a combination of a scapular neck fracture (i.e., of the surgical neck as shown by the accompanying documentation) and a clavicular fracture, or AC (sometimes SC) dislocation. However, as for SC dislocation, they admitted that neither did they find such a case reported in the literature, nor did they encounter it in their series. Injury to the coracoclavicular ligament was not mentioned by them. The accompanying figures show injury to the ligament only in a case of AC dislocation, while in cases of a clavicular fracture the ligament was presented as intact. According to the authors, a clavicular fracture *may be extraarticular, or involve the glenoid fossa*. This study clearly documents the misunderstandings and confusion associated with FS definition from its very beginning.

Goss [18], in 1993, introduced the concept of the so-called *superior shoulder suspensory complex* (SSSC), which, however, completely ignored the existence of the coracoacromial ligament.

SSSC AND ITS ROLE IN FS

The superior shoulder suspensory complex (SSSC) was for the first time defined by Goss [18] in 1993, who later revised his initial concept [20, 21].

Goss [20, 21] described SSSC as an osseofibrous ring formed by the glenoid, the coracoid, coracoclavicular (CC) and coracoacromial (CA) ligaments, the lateral clavicle, the AC joint and the acromion (Fig. 18-3). This ring connects two osseous struts. *The superior strut* is formed by the middle third of the clavicle, the *inferior strut* by the lateral part of the scapular body and the medial part of the scapular neck. The whole complex is divided into three units:

- **the first unit** is formed by the clavicle, the AC joint and the acromion (*clavicular – acromioclavicular joint – acromial strut)*,
- **the second unit** is a junction of the glenoid, the coracoid and the acromion with the scapular body *(three-process – scapular body junction)*,
- **the third unit** is formed by the ligamentous junction of the clavicle and the coracoid through the coracoclavicular ligament *(the clavicular – coracoclavicular ligamentous – coracoid linkage,* or *C-4 linkage)*.

This complex maintains a normal stable relationship between the scapula and the axial skeleton; it allows limited motion via the AC and SC joints, and provides a firm attachment point for multiple ligaments and muscles.

Disruption of the osseofibrous ring at two sites, or at one site in combination with a fracture of one or both struts, produces a potentially unstable anatomical situation, i.e., "floating shoulder", which may result in delayed healing, nonunion, or malunion (Fig. 18-4).

This postulate of Goss had been adopted by a number of authors [15, 31, 37, 39, 41, 48]. His schemes became an integral part of multiple publications dealing with FS and an object of theorizing about potential variants of SSSC disruption [15, 30]. However, speculations on individual unstable injuries to the SSSC were not based on clinically verified cases or, on 3D CT reconstructions that would confirm their existence. A majority of authors, when describing their cases, only stated that they used the term FS for injuries with SSSC disruption at two or more levels [5, 31, 37, 39, 41, 48]. Due to the absence of an exact description of the injured SSSC structures, it was impossible to get a clear picture of the particular FS pathoanatomy. Only Cole et al. [11] mentioned that a double SSSC lesion may be considered to be FS if "*double disruption involves a fractured scapular neck and concomitant ipsilateral clavicular fracture*".

The effect of the SSSC on the stability and displacement of fractures is currently overestimated. Injuries to certain SSSC elements may affect stability and displacement of surgical neck fractures, but not stability and displacement of scapular body fractures.

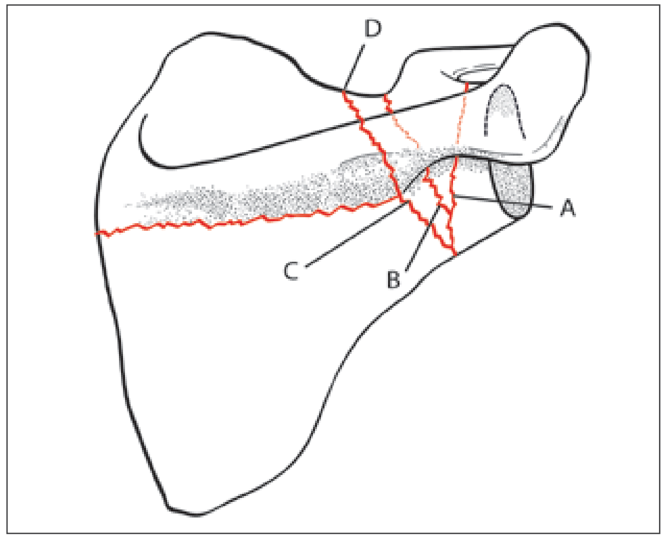

Fig. 18-5 Goss' classification of scapular neck fractures of 2017. **A** – anatomical neck fracture, **B** – surgical neck fracture, **C** – "fracture of inferior neck", **D** – transspinous fracture of the neck. Modified according to [21].

SCAPULAR NECK FRACTURE AND FS

Definition, classification and terminology of scapular neck fractures are essential for understanding the FS concept. Many authors describing FS use the general term *scapular, or glenoid, neck fractures* [13, 24, 32, 38, 40, 41, 45, 52]. Only Labler [30], Izadpanah [27] and Hashiguchi [23] specified this fracture as Ada and Miller Type IIA (surgical neck fracture). Gilde et al. [17] included also a transspinous fracture of the scapular neck and an infraspinous fracture of the scapular body in FS, as shown by their documentation (3D CT). Van Noort et al. [49, 50], Arts and Louette [2], Bartoníček et al. [6, 7] and Kani et al. [28] mentioned the role of anatomical neck fractures in FS.

The source of confusion and inconsistencies in the FS concept is primarily the so-called scapular neck fracture described by Ada and Miller [1], in 1991, as type II C. In 1994, Goss [19] included this type in his classification of scapular neck fractures and called it *"a fracture of the inferior neck"*. As has been already mentioned, this fracture is not a scapular neck fracture as it does not separate the glenoid from the scapular body but splits the infraspinous part of the scapular body into two parts. The glenoid remains firmly connected with the superior fragment of the body. A clavicular fracture, if any, is irrelevant in this respect. Despite this, due to misunderstandings and mistakes, any fracture of the scapular body with the fracture line passing through the subglenoid part of the lateral border of the scapular body began to be classified as a scapular neck fracture. Although, in 2017, Goss [21] revised his classification of scapular neck fractures by adding a transspinous fracture of the neck as type D, he left there "*a fracture of the inferior neck*" as type C (Fig. 18-5).

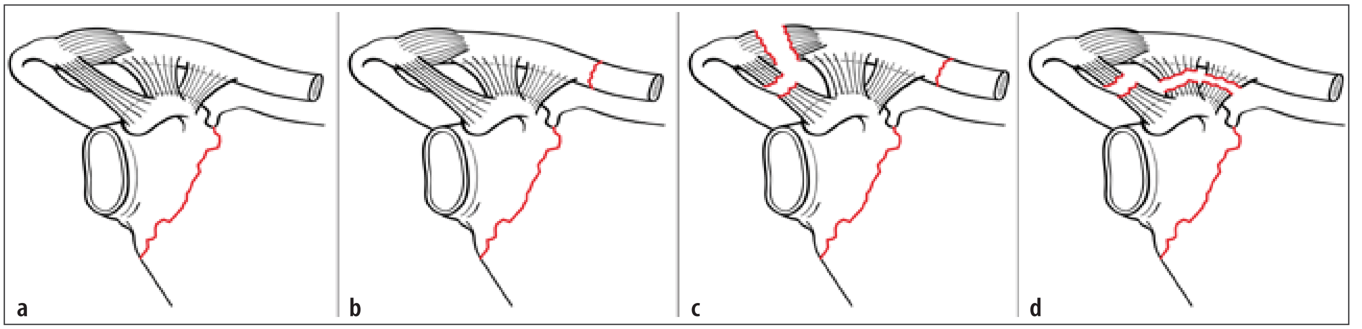

Fig. 18-6 Individual types of surgical neck fractures tested by Williams et al.: **a)** surgical neck fracture; **b)** surgical neck fracture combined with a clavicular shaft fracture medial to the insertion of the intact coracoclavicular ligament; **c)** surgical neck fracture combined with a clavicular shaft fracture medial to the insertion of the intact coracoclavicular ligament, rupture of the AC joint capsule and the coracoacromial ligament; **d)** surgical neck fracture combined with rupture of both coracoid ligaments. Only types c and d may be classified as a floating shoulder. Modified according to [52].

FS PATHOANATOMY

There is no uniform, generally-accepted definition of FS [9]. Initially, FS was defined in the studies as an unstable fracture of the surgical neck, characterized by loss of the osseo-ligamentous connection of the glenoid fragment with other parts of the scapula and the axial skeleton [16, 23]. The authors of a majority of the following studies considered FS to be any fracture of the scapular neck associated with a clavicular fracture. The importance of the CC and CA ligaments for stability of fractures of the surgical neck of the scapula was ignored.

Williams [52] correctly pointed out that a mid-shaft clavicular fracture and a fracture of the surgical neck alone cannot produce FS.

> *"In the presence of an ipsilateral fracture of clavicular shaft the glenoid has lost its attachment to the axial skeleton. However, it is still attached to the acromion by the coracoacromial ligament and, through the coracoclavicular ligament and distal clavicular fragment, by the acromioclavicular capsular ligaments."*

Thus, FS may develop only after rupture of the CC and CA ligaments. Paradoxically, Williams' drawings of various types of injuries to the suspensory apparatus of the surgical neck always show the glenoid fragment without displacement (**Fig. 18-6**). This may lead to a misunderstanding of displacement of the surgical neck of the scapula depending on injury to individual ligaments.

When analyzing the role of a clavicular fracture in the development of FS, it has to be taken into account that any fracture of the clavicle medial to the CC ligament, or complete AC or SC dislocation disrupt the osseo-ligamentous connection of the scapula to the axial skeleton. These injuries, however, are not classified as FS. If there occurs a concomitant fracture of the infraspinous part of the scapular body, the so-called *fracture of the inferior neck*, such a fracture has no impact on the stability of the glenoid. Regardless of this fact, a number of authors have classified this type of injury as FS.

Later studies have replaced the term clavicular fracture by a "*double, or triple, disruption of SSSC*", without specifying the injured structures and their particular impact on stability of the glenoid fragment(s) of the scapular body [5, 31, 37, 39, 41, 48]. This again is testimony to the increasing complexity and misunderstanding of the FS concept.

Some authors have also correctly classified as FS fractures of the anatomical neck, because in this injury the glenoid has lost any osseo-ligamentous connection with the other parts of the scapula, including the axial skeleton [2, 7, 28, 50].

Discussion on FS in the literature concentrates mainly on the osseo-ligamentous connection of the scapula with the axial skeleton, without taking into account the role of the scapulo-axial and the rotator cuff muscles [52]. Essential for stabilization of the scapula on the rib cage are the trapezius, serratus posterior, serratus anterior and levator scapulae muscles, which control the relationship of the scapula with the spine and the rib cage. An important stabilization role is also played by the trapezius, which attaches to the scapula at the scapular spine and acromion and across the AC joint as far as the lateral

Fig. 18-7 Extent of insertion of the trapezius onto the scapula and the clavicle. **1** – spinal part of the deltoid muscle; **2** – scapular spine; **3** – acromial part of the deltoid muscle; **4** – acromion; **5** – AC joint; **6** – the trapezius; **7** – clavicular part of the deltoid; **8** – clavicle.

Fig. 18-10 Injuries that cannot be classified as a floating shoulder: a) mid-shaft clavicular fracture disrupting the osseo-ligamentous connection between the intact scapula and the axial skeleton; b) infraspinous two-part fracture of the scapular body, the glenoid is part of the superior fragment of the scapular body and is connected with the intact clavicle; c) fracture of the clavicle combined with an infraspinous, two-part fracture of the scapular body – this injury cannot be classified as a floating shoulder, in terms of stability of the glenoid, it is the same injury as in figure a.

FS DEFINITION

Based on analysis of our own cases and the cases reported in the literature, we consider FS to be a type of injury in which ***the "floating" glenoid fragment has lost osseo-ligamentous connection with the scapular body and the axial skeleton.*** Most often they are totally unstable, displaced fractures of the surgical, or anatomical, neck of the scapula (Fig. 18-8). This opinion was shared also by Pasapula et al. [42] and Kani et al. [28]. These fractures may also include extraarticular, complex, scapular fractures with the glenoid fossa as a separate fragment, bearing no processes (Fig. 18-9). In all cases, the glenoid fragment has no osseo-ligamentous connection with the scapula or the axial skeleton, while indirect connection, by means of the humeral head, joint capsule and the rotator cuff muscles attached to it, remains preserved. A mid-shaft clavicular fracture in combination with a scapular body fracture has no impact on the stability of the glenoid (Fig. 18-10). Thus, reduction and internal fixation of the clavicle cannot improve the position of the glenoid in relation to the scapular body.

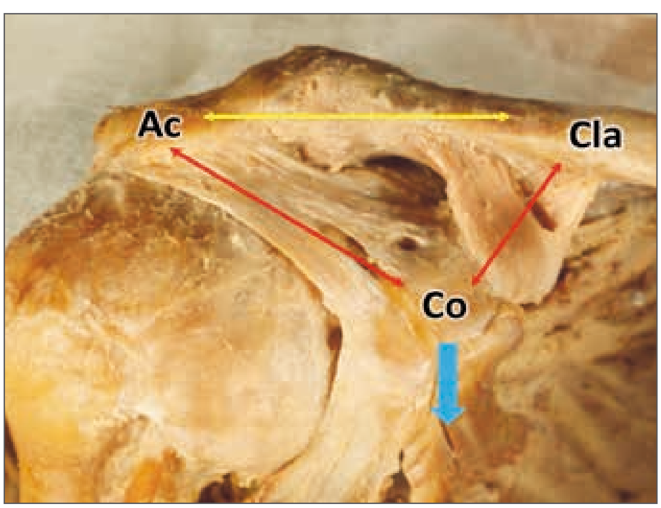

Fig. 18-11 Structure of the superior shoulder suspensory complex. The proximal level is formed by the lateral clavicle, AC joint and acromion (yellow arrow); the middle level by the coracoclavicular and coracoacromial ligaments (red arrows); and the distal level by the coracoid embedded by its base in the superior surface of the scapular neck (blue arrow). Ac – acromion, Cla – clavicle, Co – coracoid.

STRUCTURE OF SSSC

Suspensory structures of the glenoid are important in terms of FS only in surgical neck fractures. They may be divided into three vertical levels (Fig. 18-11).

- **The proximal level** is formed by the lateral clavicle, AC joint and the acromion.

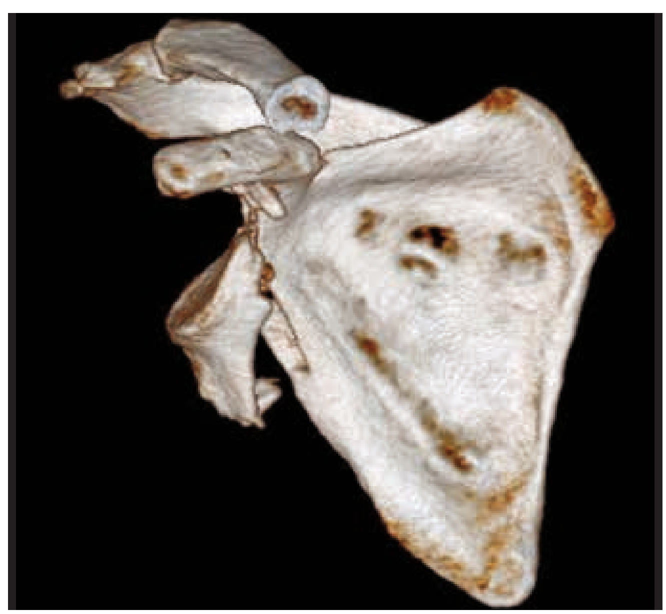

Fig. 18-12 Development of a floating shoulder in an anatomical neck fracture. The glenoid fragment has no osseo-ligamentous connection with the scapula, or with the axial skeleton.

19

SCAPULOTHORACIC DISSOCIATION

Scapulothoracic dissociation (STD) is a severe, high-energy traction injury that is associated with concomitant injuries to the shoulder girdle (SC joint, clavicle, AC joint, scapula), vascular injuries (subclavian, axillary, or brachial artery), injuries to the scapulo-axial muscles (trapezius, latissimus dorsi, rhomboid, levator scapulae muscles, etc.) and the brachial plexus (pre- or post-ganglionic injury), accompanied by massive soft tissue swelling [1, 4, 5, 16]. These injuries result in dissociation of the upper extremity from the axial skeleton (Fig. 19-1). The skin cover remains intact. That is the sole difference between STD and traumatic amputation of the upper extremity.

This devastating trauma is fortunately rare. The first case was described by Oreck et al. [11] in 1984. Zelle et al. [16] found 62 cases described in the English and German literature between 1984 and 2004, Lee et al. [9] identified 72 such patients reported in 1984-1996. One study presented also a bilateral injury [8]. Patient mortality averages around 11% [16].

PATHOANATOMY

STD results in disconnection of the osseo-ligamentous system of the scapula from the axial skeleton at various levels, separation of muscles of the scapulo-axial system, and injuries to major blood vessels of the upper extremity, the brachial plexus and the soft tissues in the region of the chest and the shoulder joint.

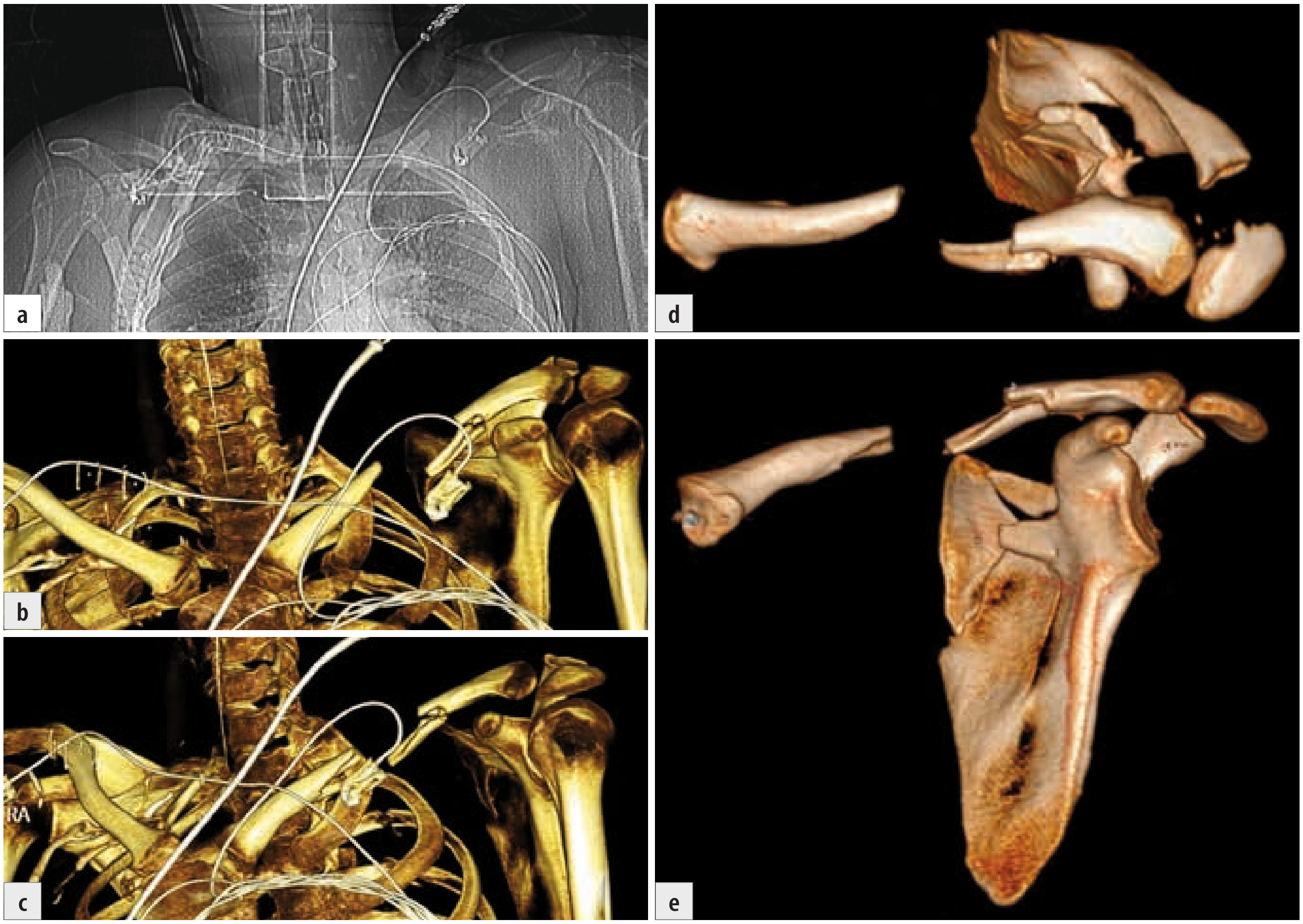

Fig. 19-1 CT image of the scapulothoracic dissociation: a) topogram showing a widened space between the chest and the left scapula; b+c) 3D CT reconstructions of an injured shoulder girdle showing separation of the scapula from the axial skeleton; d+e) 3D CT reconstruction of a fractured clavicle and scapula (Courtesy Petr Obruba, MD).

Angiography: Conventional arteriography, or CT or MRI angiography may be used to examine the condition of the blood vessels. Currently, CT angiography is preferred, and it can be performed as part of the whole-body examination. Angiography shows not only blood vessel patency, but also any bleeding, and the state of the collateral circulation.

CLASSIFICATIONS

Of all the proposed classifications, the most frequently used today is that developed by Zelle et al., [16] as a modification of the original Damschen's classification [2]. Zelle et al. [16] distinguish between four types of injury:

- **type 1** – isolated musculoskeletal injury alone,
- **type 2A** – musculoskeletal injury with vascular injury,
- **type 2B** – musculoskeletal injury with incomplete neurological impairment,
- **type 3** – musculoskeletal injury with incomplete neurological impairment of the upper extremity and vascular injury,
- **type 4** – musculoskeletal injury with complete neurological impairment.

This classification reflects prognosis for the final outcome of the treatment, which is obviously the worst in patients with type 4.

TREATMENT

Today there is no universal algorithm for acute treatment of these severe, rare and variable injuries. Essentially, it is necessary to restore the osseo-ligamentous connection of the scapula to the axial skeleton, to reconstruct the blood supply to the injured extremity and to minimize the functional deficit caused by neurological lesion. However, the patient's general condition and appropriate timing of the procedure must always be respected. The urgency of any procedure is determined primarily by the severity of the vascular injury. A major determinant of the final functional outcome is the severity of the injury to the brachial plexus.

Osseo-ligamentous stabilization: This procedure must be performed in any case, as a stable skeletal re-connection of the separated extremity is a basic prerequisite for healing of the soft tissues, including muscles; in cases of major blood vessel injury, stabilization protects any accompanying vascular reconstruction and prevents progression of injuries to the brachial plexus.

In clavicular fractures, we use plate fixation, using a standard technique (see Chapter 17) (Fig. 19-3). AC dislocation requires reduction of the joint and its stable fixation [10]. A hook plate, proposed by some authors [5] in combination with a coracoclavicular screw, is not, in our view, adequate to resist distraction forces. In such cases, we prefer a wire loop with a coracoclavicular screw. Stabilization of the SC joint is difficult. In addition to reduction and suture of the joint capsule, it is necessary to reconstruct the costoclavicular ligament with the use of a tendinous graft pulled through a tunnel made in the sternum and the medial clavicle [5].

Vascular reconstruction: The experience shows that the results of angiographic examination are decisive for any indication of vascular reconstruction. In the study by Sampson et al. [12], angiography revealed arterial occlusion in all their 11 patients, but always without extravasation of contrast media. Subsequently, 6 of these 11 patients underwent vascular reconstruction using a venous graft. None of the remaining 5 patients showed signs of arterial insufficiency, even after a longer time interval after the injury.

Choo et al. [5] therefore recommend angiography to detect vascular lesions, to assess the collateral circulation and to rule out active arterial bleeding. The choice of any further procedure,

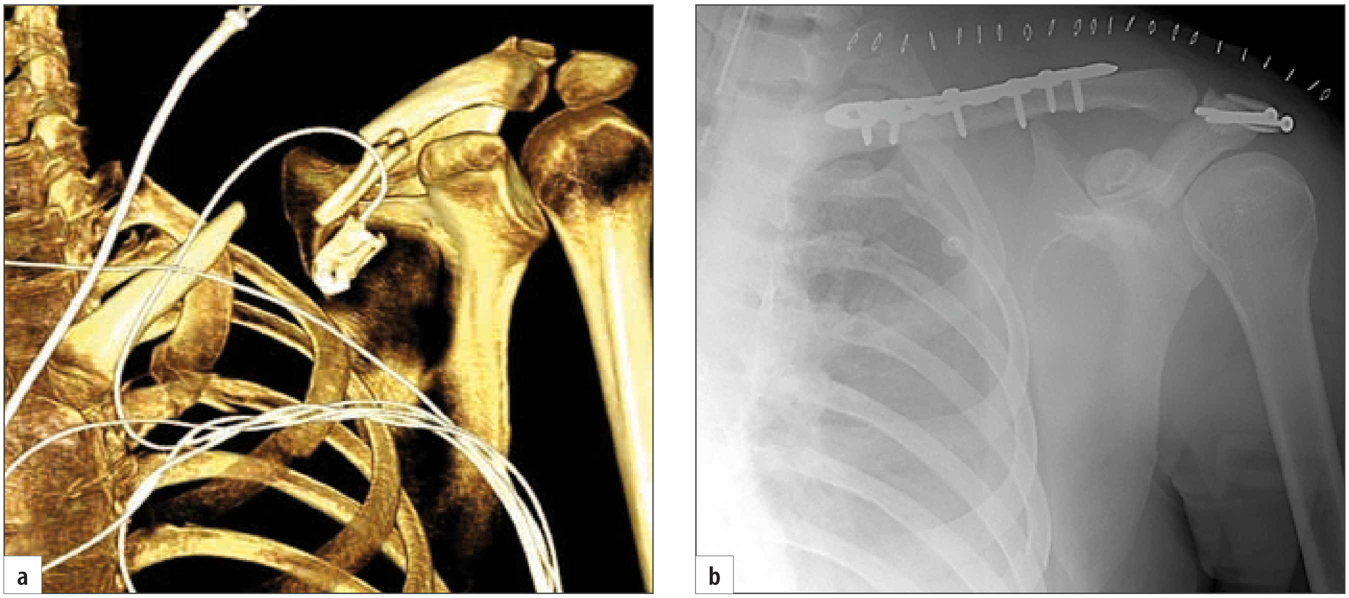

Fig. 19-3 Treatment of osseo-ligamentous dissociation: **a)** 3D CT reconstruction of an injured shoulder girdle; **b)** postoperative radiograph after plate fixation of the clavicle and lag screw fixation of the acromion (Courtesy Petr Obruba, MD).

20

COMPLICATIONS IN SCAPULAR FRACTURES

Scapular fractures in adult patients are associated with a number of complications, some of which may considerably influence the final outcome of the treatment. Their clinical manifestations are almost the same and include pain, weakness and limitation of the motion in the shoulder joint.

The development and severity of complications are determined by multiple factors. The first of these are the trauma energy and mechanism of the injury, that are decisive for the scapular fracture pattern, soft-tissue lesions, as well as for injuries to the shoulder girdle, and other structures and organs, as the case may be.

Another factor is the patients' personality, i.e., their general state of health, age, bone quality, the shoulder condition prior to injury, motivation and willingness to cooperate.

The third factor is the treatment method and its implementation. Of decisive importance in this respect is the knowledge, experience and also, in cases of operative treatment, the skills and experience of the treating surgeon. Scapular fractures still remain underestimated, inadequately examined and treated, although recently the situation has started to improve slightly.

CLASSIFICATION OF COMPLICATIONS

Complications accompanying scapular fractures may be divided from various viewpoints, i.e., the time of their development, their severity or the method of treatment.

Complications may develop during the injury, or at a different time interval thereafter, either during or after the treatment. Many complications are associated with the treatment method, others are independent of it. A specific group includes complications that develop during the operative treatment. Complications also vary in their severity.

COMPLICATIONS DEVELOPED DURING THE INJURY

The incidence of these complications is dependent mainly on the intensity of the trauma energy, the injury mechanism and the fracture pattern:

- injury to the suprascapular nerve,
- injury to the brachial plexus,
- injuries to the surrounding blood vessels,
- intrathoracic penetration of scapular fragments,
- open fracture,
- compartment syndrome,
- injury to the glenoid labrum,
- injury to the rotator cuff,
- injury to the shoulder girdle.

COMPLICATIONS RELATED TO OPERATIVE TREATMENT

In terms of the time of their development, these complications may be divided into intraoperative and early and late postoperative ones.

Intraoperative complications

Some intraoperative complications are related to the operative method (arthroscopy versus open reduction and internal fixation) used, or the surgical approach (the Judet versus deltopectoral approach):

- injury to the suprascapular nerve,
- injury to the circumflex scapular artery,
- non-anatomical reduction,
- intraarticular penetration of screws,
- injury to the axillary nerve and artery.

Early postoperative complications

They appear in course of the first weeks after operation during healing of the surgical wound, most frequently in the form of:

- hematoma in the wound,
- superficial infection,
- deep infection.

Late postoperative complications

A majority of these complications are associated with the course of healing of the surgically treated extremity. The most frequent of them include:

- failure of internal fixation,
- breakage of the implant,
- non-union,
- painful prominence of implants,
- subacromial impingement,
- cosmetic problems associated with the scar,
- late infection.

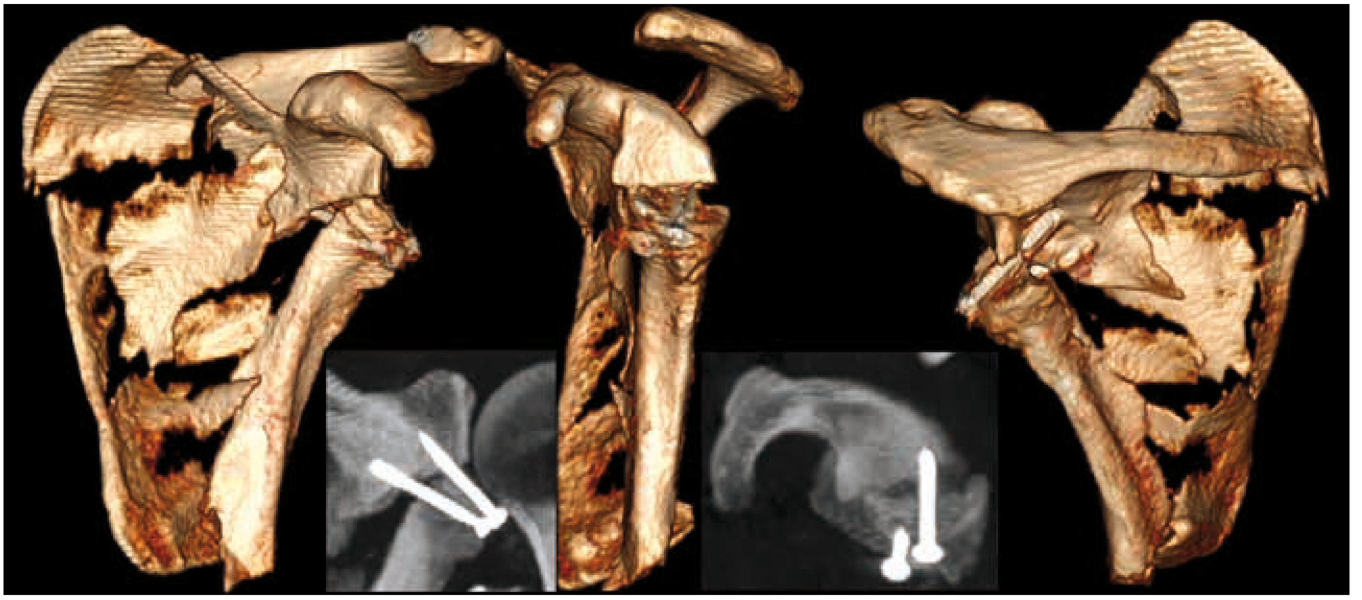

Fig. 20-4 Postoperative CT scan of a non-anatomical reduction of an intraarticular complex fracture. This whole case is presented in Chapter 22.

INTRAARTICULAR INSERTION OF SCREWS

Penetration of screws into the articular cavity is an uncommon, but severe complication [7, 13]. It occurs more often in extraarticular than in intraarticular fractures. In cases of glenoid fractures, the joint capsule is open and the articular surface can be thoroughly inspected by palpation. By contrast, in extraarticular fractures treated by internal fixation of the lateral pillar, when the joint capsule is intact, palpation or visual control of screw positions is impossible. Therefore, it is essential to palpate exactly the position of the joint line during operation and then use this as a guide to determine the direction of screw insertion.

Cole et al. [13] had to remove intraarticularly-inserted screws in 2 of 84 operatively-treated extraarticular fractures. Rais et al. [56] had to deliberately insert a screw intraarticularly to obtain stability of internal fixation of a fracture of the anterior glenoid.

We have encountered this complication only in 1 case of the above-mentioned malreduction of a scapular surgical neck fracture. One of the screws passed closely subchondrally, with a minimal prominence into the joint. The patient refused removal of the screw [7].

HEMATOMA IN THE SURGICAL WOUND

This complication is typically associated with the Judet approach, particularly when the infraspinatus was mobilized. It may be prevented by careful hemostasis and wound drainage. Any hematoma must be evacuated. Hardegger et al. [24] encountered 2 cases requiring hematoma evacuation in 37 operations. We had to treat 3 cases of hematoma in the surgical wound after the Judet approach.

SUPERFICIAL INFECTION IN THE SURGICAL WOUND

Problems with Staphylococcus aureus were reported by Hardegger et al. [24] in 2 cases that healed after surgical drainage. Schandelmaier et al. [61] recorded 1 case of superficial infection in 22 operatively-treated glenoid fractures, managed by antibiotics.

Our series included 2 cases of superficial discharge from the surgical wound after the Judet approach, treated with repeated changing of wound dressings and antibiotic therapy.

DEEP INFECTION IN THE SURGICAL WOUND

This is one of the most severe complications of the operative treatment of scapular fractures. There may be a number of causes, such as high-energy trauma leading to contusion of the shoulder joint soft tissues, including compromised skin integrity; general patient's condition (diabetes mellitus, hepatopathy etc.), extended surgical approach and prolonged operative time [8, 62].

Such cases require radical debridement of the surgical wound, removal or exchange of the implant, if unstable, wound drainage and intravenous antibiotic therapy, as determined by microbiological examination of excised tissue.

Schmidt et al. [62] described 3 cases of infection requiring revision and 2 of them even an early removal of the plate. In their view, the cause was an extensive contusion of soft tissues during the primary injury.

Schandelmaier et al. [61] reported 1 case of deep infection after a glenoid fracture, in which one of the plates broke. After revision and implant removal, the infection resolved, but the functional outcome was poor. The same authors [61] described a deep infection, appearing 12 months after internal fixation of the glenoid, caused by Proteus vulgaris. Seybold's case was described above [60].

We recorded 2 cases of deep postoperative infection. The first case was a 56-year-old patient, with alcoholic hepatopathy, who fell from 1.5 meters and sustained a fracture of the entire glenoid and the infraspinous part of the scapular body, treated

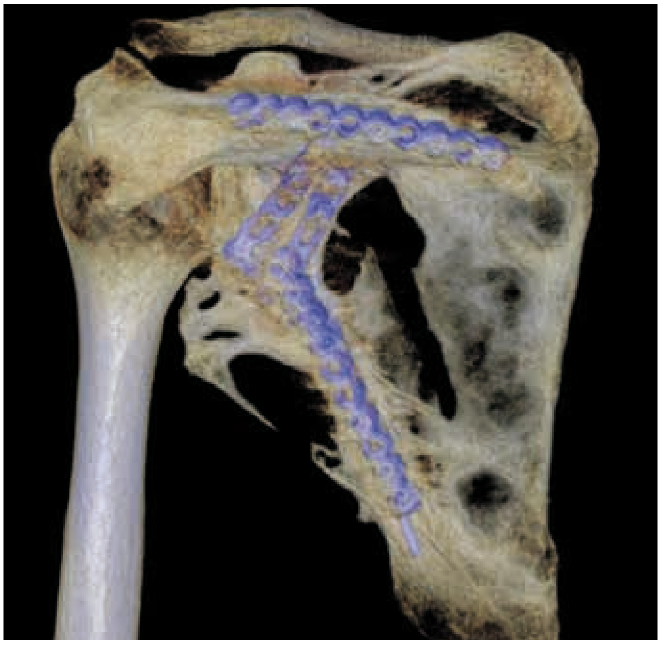

Fig. 20-6 Postoperative heterotopic ossification in a complex extraarticular fracture of the scapula. This whole case is presented in Chapter 22.

We found, in a number of operated on fractures of the scapular body, or glenoid, marked, but asymptomatic, heterotopic ossifications in the subglenoid part of the lateral border of the scapula (Fig. 20-6). In all these cases we had observed, during the primary operation, markedly damaged muscular attachments in this region (the teres minor, the long head of triceps brachii).

LOOSENING, OR BREAKAGE, OF THE IMPLANT

These complications may result from an inappropriate implant, its improper application, or early loading of the extremity after the operation. The solution depends on the process of healing of the fracture and position of fragments. Sometimes just radiological follow-up is sufficient, whereas other cases may require reoperation [9, 24, 39, 61].

Anavian et al. [2] reported loosening of a screw from a plate on the acromion. Schmidt et al. [62] found a broken plate in a patient two months after the operation, but without fragment displacement. We encountered a similar complication in an active 70-year-old man [9], who had sustained a fracture of the glenoid and the infraspinous part of the scapular body, treated with plate fixation. The plate placed on the lateral pillar broke 6 weeks postoperatively because the patient had started exercises with a 20kg (!!!) dumbbell as early as the 3rd week after operation. The fracture healed in an anatomical position, with an excellent functional result (Fig. 16-16).

A specific "complication" is considered to be a late breakage of the plate in a healed fracture, obviously due to a long-term material fatigue. Schandelmaier et al. [61] reported a case of breakage of a semi-tubular plate 17 years after healing of a glenoid fracture. In our series we found breakage of such a plate at follow-up 16 years after operation of a 3-part infraspinous fracture of the scapular body. It had healed in an anatomical position, with an excellent functional outcome (Fig. 20-7).

NON-UNIONS OF THE SCAPULA

Reports in the literature describe non-union involving different parts of the scapula, i.e., the body, neck, the lateral scapular spine, acromion, coracoid process and glenoid [1, 4, 11, 15, 16, 18, 19, 22, 31, 33, 34, 37, 40, 53, 58, 66, 75]. Non-unions are to be seen largely after non-operative treatment, and only exceptionally after operation. As a rule, they are associated with pain, limitation of the range of motion and weakness in the shoulder joint.

Non-unions of the lateral scapular spine are frequent. The causes include, for instance, pull of the deltoid resulting in fragment displacement, a thick cortex and a small contact surface of the two fragments. Angulated non-unions of the lateral spine may compromise the subacromial space and cause impingement syndrome. A scapular spine non-union was the reason for the first internal fixation of the scapula in 1884 performed by Mayo Robson [45]. Currently, non-unions are treated in a similar way, only by means of more sophisticated implants (lag screws, plates) [4, 12, 15, 58].

Non-unions of the acromion are less frequent. They cause pain and may reduce the subacromial space. They should be distinguished from the os acromiale. Depending on the fragment size they are treated with internal fixation, or excision. Internal fixation may be performed with the use of lag screws, tension band wiring, T-plate, locking plate for the lateral clavicle, or a "mesh" plate [16, 28, 40, 53].

Non-unions of the coracoid involve primarily its distal beak, and less often its base [33, 65]. The reported cases were treated, in case of a larger fragment, by internal fixation with a lag screw and bone grafting (coracoid beak), or with a small plate (the coracoid base); small fragments were excised [33].

Non-unions of the scapular body and neck have been reported by a number of authors [18, 22, 31, 34, 43, 49]. They commonly involved the infraspinous part of the scapular body; only in the Charlton's case [31] was it a complex extraarticular

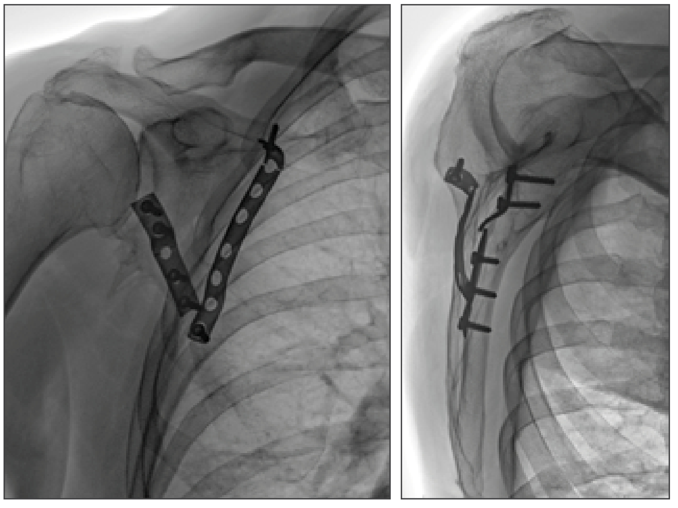

Fig. 20-7 Late fatigue-breakage of the implant, 16 years after internal fixation of an infraspinous fracture of the scapular body, with clearly-visible subglenoid heterotopic ossification.