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SCAPULAR FRACTURES

MAXDORF

4

INJURY MECHANISMS

Scapular fractures have traditionally been considered to be caused, in a majority of cases, by high-energy trauma. The current experience, however, shows that they are caused by different mechanisms of varying violence [4]. Important determinants, in this respect, are age, associated illnesses, quality of bone stock, chronic stress, etc. Depending on the mechanism and the intensity of the violence, a number of scapular fractures are often associated with other injuries, involving not only the ipsilateral extremity, but also other parts of the body [1, 3, 8, 11, 13, 22, 27, 31, 38, 40–45, 49].

MECHANISM OF INJURY

Scapular fractures result from several basic injury mechanisms, either exogenous, or endogenous [4]. The scapula may directly impact, or be hit by, an object. Another mechanism is a direct impact of the humeral head onto the glenoid, or onto surrounding processes. The third cause is dislocation of the glenohumeral joint, and the fourth possibility, relatively rare, is a violent muscular contraction.

In addition to injuries to a "healthy" scapula, fractures affect also scapulae stigmatized by pre-existing pathology, or abnormal load patterns.

DIRECT BLOW TO THE SCAPULA

A direct blow to the scapula, during a traffic accident, a fall from a height, or the fall of a heavy object (e.g., a tree) onto the shoulder, are frequent causes of a scapular fracture [4, 28]. The fracture pattern depends on the energy and direction of the impact, size and shape of the object hitting the scapula, or being hit by the scapula. The range of injuries is relatively wide, including involvement of the acromion (Fig. 4-1) up to open complex fractures of the scapula (Fig. 4-2).

IMPACT OF THE HUMERAL HEAD ONTO THE SCAPULA

In this mechanism, external violence acts primarily onto the arm, more specifically onto the humerus. It may be, for instance, impact on the elbow transmitted to the humeral head. According to its position in the glenohumeral joint and the force vector at the time of injury, the humeral head impacts the adjacent parts of the scapula, i.e., the glenoid, the coracoid and/or the acromion, or the lateral scapular spine (Fig. 4-3).

With the arm in marked abduction, the humeral head is driven against the inferior area of the glenoid. As a result of such an impact, the distal glenoid may separate off, together with the adjacent lateral border of the scapular body (Fig. 4-4). With the arm abducted approximately horizontally, the humeral head hits the central part of the glenoid which may result in the split of the entire glenoid, or only separation of its anterior part. Sometimes the injury may also involve the coracoid (Fig. 4-5). With the arm in adduction, the subluxated humeral head hits the surrounding processes that form an osseoligamentous vault over it, causing fractures of the superior pole of the glenoid fossa, the coracoid, the acromion, the lateral scapular spine, the lateral clavicle, or AC dislocation (Fig. 4-6).

GLENOHUMERAL DISLOCATION

Glenohumeral dislocation may be associated with fracture-separation of a rim of the glenoid fossa. Anterior dislocation of the humeral head may result in separation of the anteroinferior rim of the glenoid (Fig. 4-7), posterior dislocation in separation of its posterior rim. The frequency of the two types of dislocation varies. Separation of the anterior rim is much more common and is occasionally combined with an injury to the coracoid, or fracture of the greater tubercle [9, 24]. Injuries to the posterior rim are rare.

Fig. 4-1 Fracture of the acromion resulting from a direct impact on the shoulder after a fall.

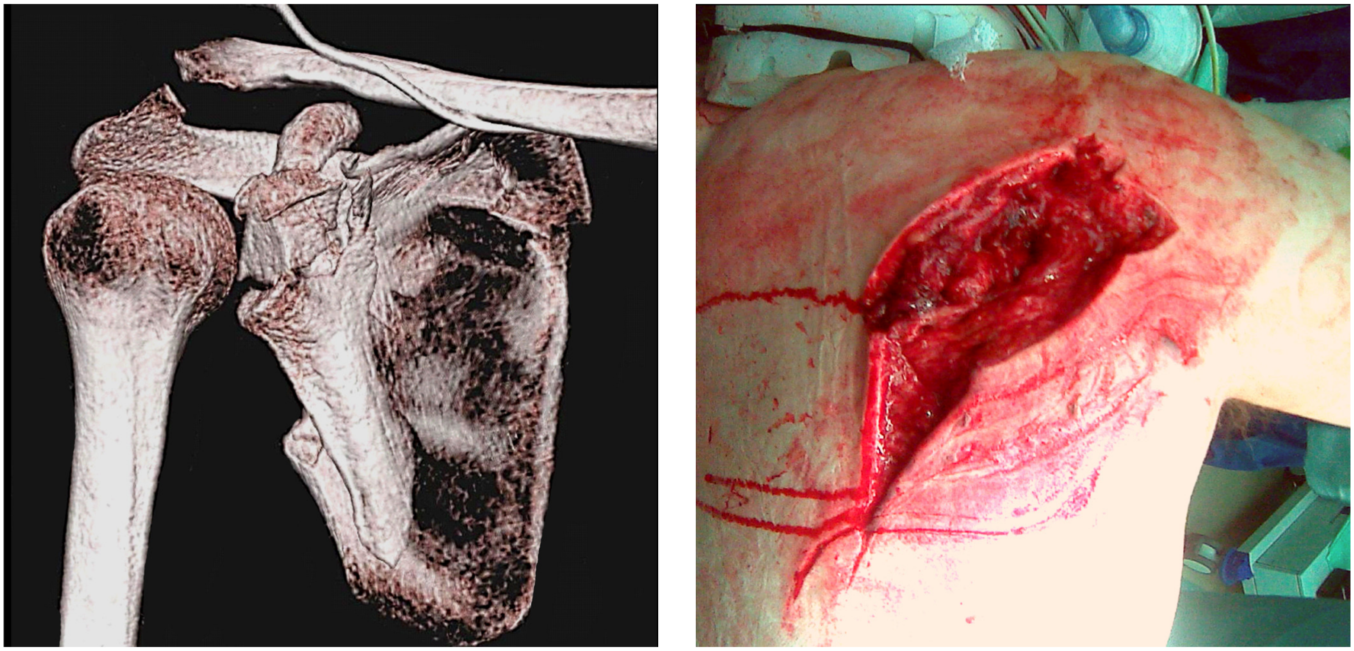

Fig. 4-2 Open complex intraarticular fracture caused by motor vehicle accident.

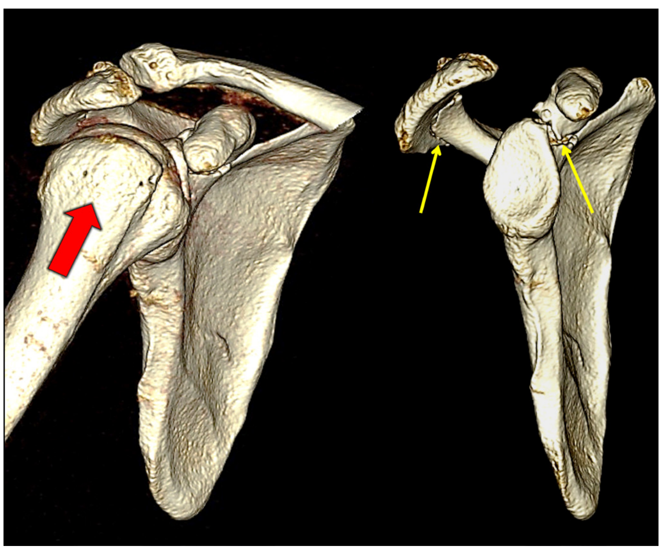

Fig. 4-3 Proximal displacement of the humeral head causing scapular process fractures. The arrows indicate fractures of the scapular spine and the coracoid.

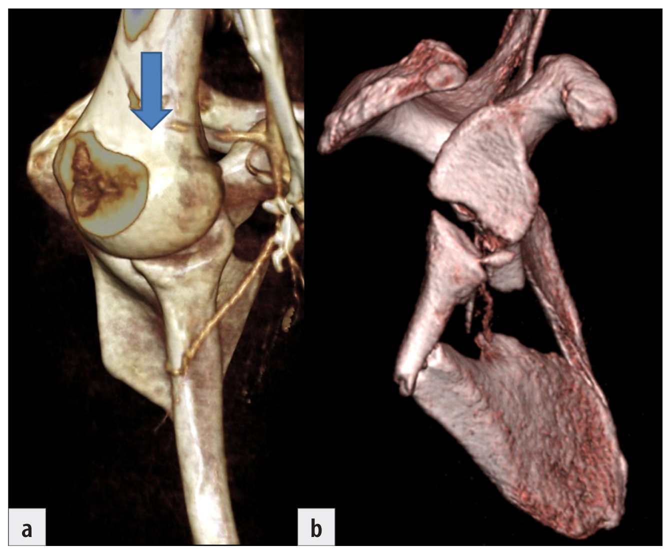

Fig. 4-4 Glenoid fracture with the arm in marked abduction: **a)** the humeral head is driven against the inferior area of the glenoid; **b)** as a result of such an impact, the inferior glenoid separates off, together with the adjacent infraspinous part of the scapular body.

MUSCLE CONTRACTIONS

Avulsion injuries caused by muscle contractions are often overemphasized in the literature [2, 5, 20, 21, 23, 32, 34, 46, 51]. A detailed analysis has shown that most such so-called avulsion injuries, particularly coracoid or acromion fractures, could not be caused by this mechanism, but rather by direct violence.

A violent muscle contraction, causing a scapular fracture, occurs mostly as a result of electrical injury, or epileptic seizure; rarely as a result of hypocalcemia, or an uncoordinated sudden movement [10, 16, 19, 26, 39, 50, 53]. Typical of this mechanism are compression fractures of the scapular body, often bilateral, and, less frequently, fractures of the glenoid, or avulsion of the inferior angle of the scapula (Fig. 4-8). A case of bilateral coracoid fracture also has been reported, associated with a bilateral anterior dislocation of the glenohumeral joint and bilateral fracture of the greater tubercle, caused by a hypoglycemic seizure [9].

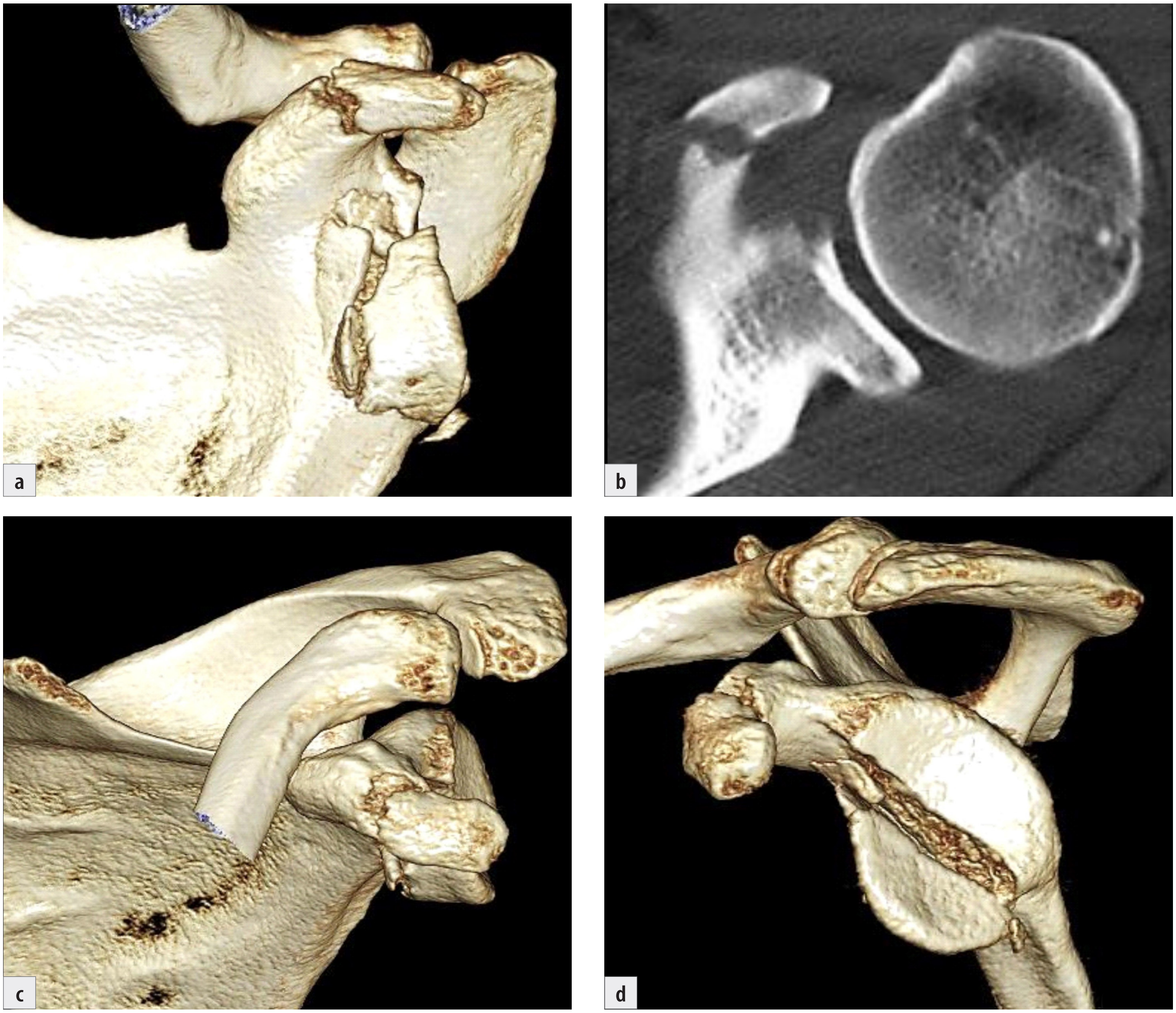

Fig. 4-5 Glenoid fracture with the arm abducted horizontally. The humeral head is driven against the central part of the glenoid, its impact results in avulsion of the anterior rim of the glenoid and coracoid process: **a)** anterior view; **b)** CT transverse scan; **c)** superior-anterior view; **d)** lateral view.

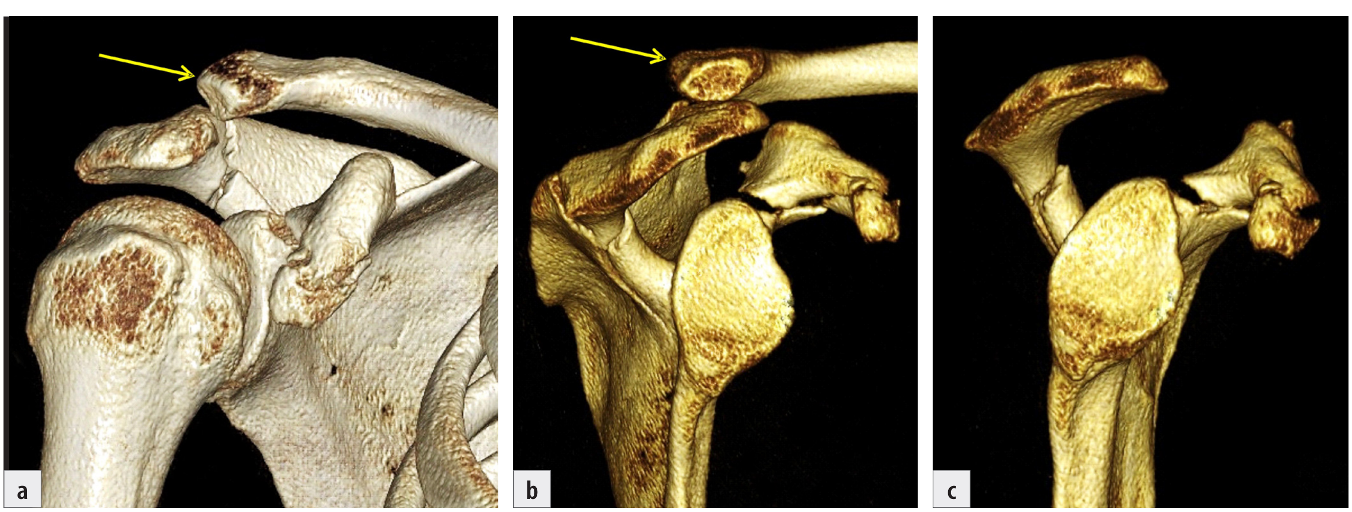

Fig. 4-6 Process fracture with the arm in adduction, the humeral head is driven proximally and hits the surrounding processes: **a)** comminuted fracture of the coracoid, fracture of the lateral scapular spine and AC dislocation; **b)** subtraction of the humeral head; **c)** subtraction of the humeral head and the clavicle.

Fig. 4-7 Fracture of the anterior rim of the glenoid in anterior dislocation of the humeral head: **a)** post-injury radiograph; **b)** post-reduction radiograph; **c)** 3D CT reconstruction after reduction.

OTHER INJURY MECHANISMS

Penetrating injuries to the scapula resulting from gunshot, or stab, wounds, quite frequent in the past, are rare nowadays. However, the number of fractures of a scapula pathologically altered by, e.g., a bone cyst (**Fig. 4-9**), an intraosseous ganglion, osteodystrophy, metastases, is increasing (**Fig. 4-10**) [29, 33, 36]. Stress fractures, resulting from various causes and involving individual parts of the scapula have more often been reported [6, 7, 17, 25, 35, 36, 47, 48]. Elderly patients with rotator cuff insufficiency and a consequent proximal migration of the humeral head may sustain stress fractures of the acromion, or of the lateral scapular spine [14, 37]. Stress fractures are reported also after bisphosphonate therapy [18]. An acromial fracture has been encountered after arthroscopic, subacromial decompression [30]. A unique case of a scapular fracture was described after chronic cough attacks [12].

INTENSITY OF TRAUMA ENERGY

Thanks to its robust muscular envelope, its mobility and its location on the elastic chest wall, the scapula is well-cushioned against injury. This explains the relatively low frequency of injuries to the scapula among the total number of all fractures. The intensity of trauma energy resulting in scapular fractures varies considerably in individual cases. Three basic groups of injuries may be identified in these terms; high-, medium- and low-energy trauma.

HIGH-ENERGY TRAUMA

This group comprises injuries sustained during traffic accidents, fall from a great height, or by the fall of a heavy object onto the patient. A great majority of them are scapular fractures in polytrauma patients [1, 3, 8, 11, 13, 22, 27, 31, 38, 40–45, 49], with a correspondingly wide range of associated injuries to individual organ systems, i.e., chest, head, spine,

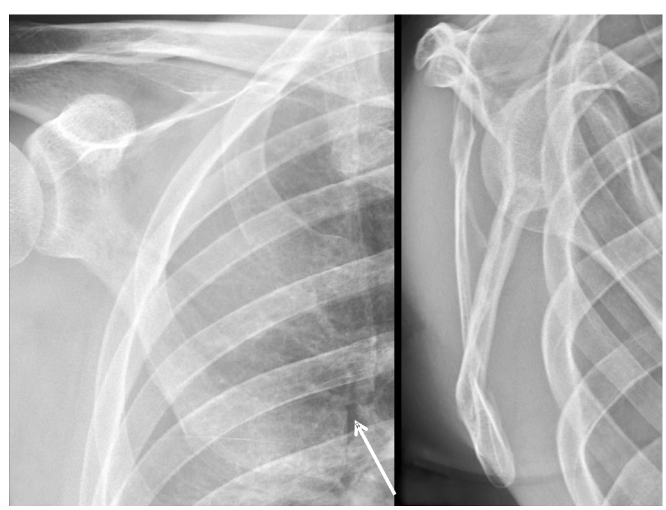

Fig. 4-8 Fracture of the inferior angle of the scapula resulting from muscle contraction. The white arrow shows the fracture.

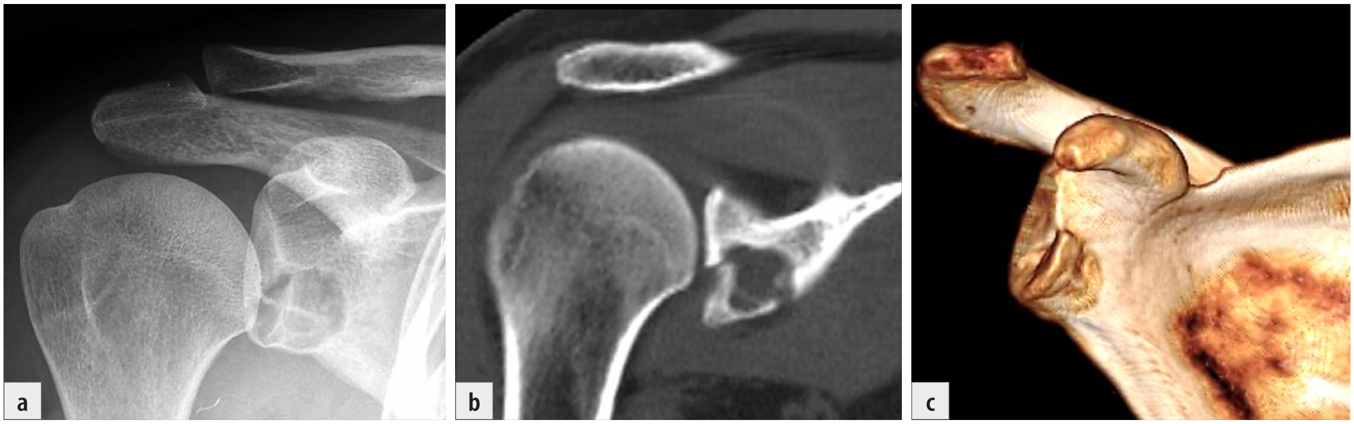

Fig. 4-9 Pathological fracture of the glenoid in a bone cyst: **a)** radiograph; **b)** 2D CT reconstruction; **c)** 3D CT reconstruction.

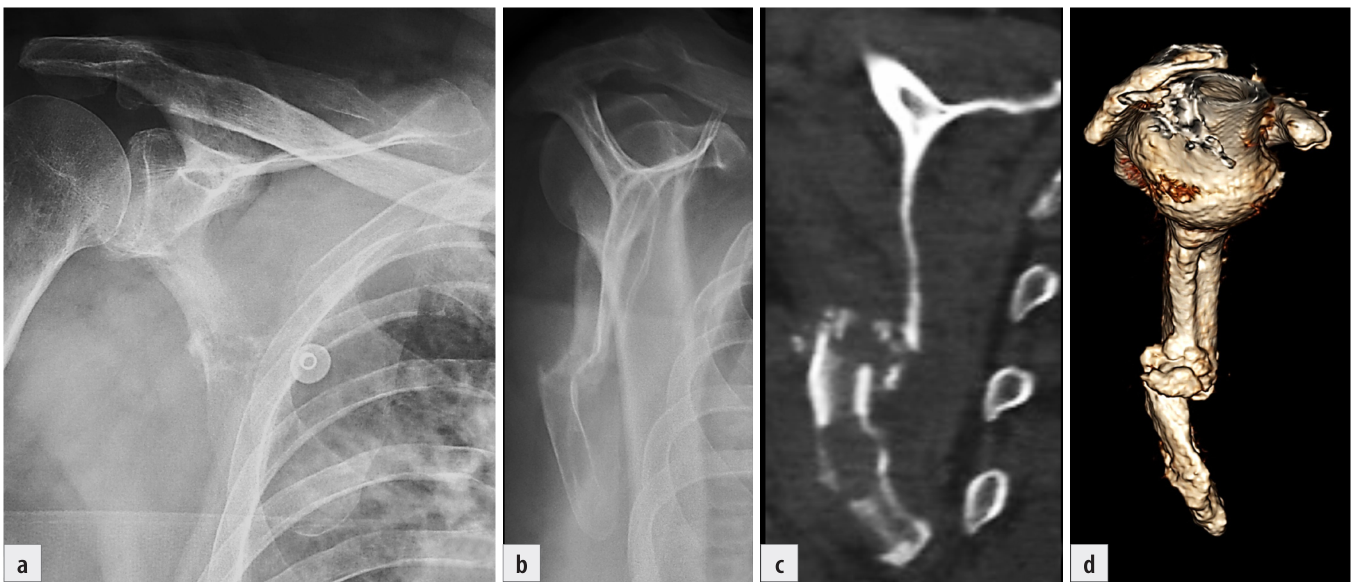

Fig. 4-10 Pathological fracture in the metastasis of the kidney tumor: **a)** anteroposterior radiograph; **b)** lateral radiograph; **c)** 2D CT reconstruction; **d)** 3D CT reconstruction.

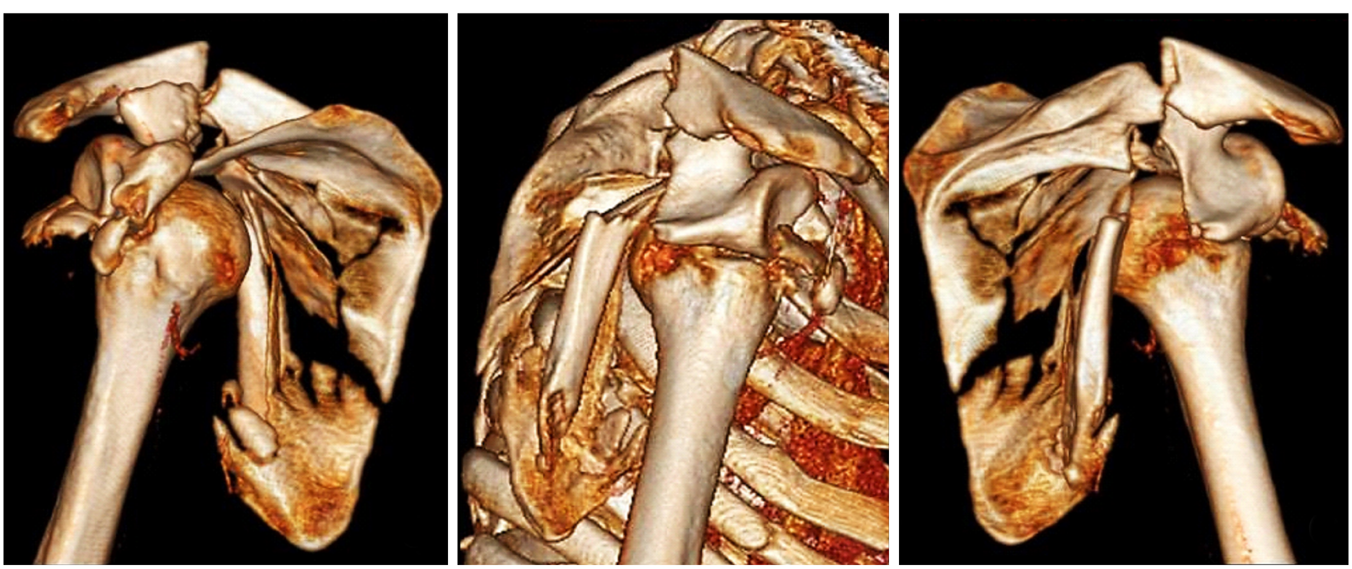

Fig. 4-11 Complex extraarticular fracture of the scapula associated with glenohumeral dislocation and avulsion of the greater tubercle, caused by high-energy trauma in a polytrauma motorcyclist.

abdomen, pelvis and the extremities. Prior to the introduction of whole-body CT scanning, injuries of the scapula were often missed and discovered coincidentally only after several days. Whole-body CT scanning has considerably improved the diagnosis. However, examination of the entire scapula, including 3D CT reconstructions, remains essential.

High-energy trauma typically results in complex (Fig. 4-11), or bilateral (Fig. 4-12), scapular fractures, rarely in open scapular fractures (Fig. 4-2).

MEDIUM-ENERGY TRAUMA

Medium-energy injuries have recently become quite frequent. They are caused typically by falls from bicycles (Fig. 4-13), or a motorcycle travelling at slow speed (Fig. 4-14), a fall from a horse, or from a small height [4]. We have encountered also one case of a scapular fracture sustained during big-wave surfing.

On careful clinical examination, such injuries to the scapula and the shoulder girdle are usually evident, often associated with rib fractures, sometimes with cerebral concussion, or injuries to extremities. Injuries to internal organs of the body, except for the chest, are usually absent. The patients are almost always able to communicate and cooperate. Their general condition, as a rule, allows primary focus on the diagnosis and treatment of the fracture of the scapula, as well as injuries to other structures of the shoulder girdle.

This type of trauma includes primarily fractures of the infraspinous part of the scapular body, often combined with a clavicular, scapular neck or inferior glenoid fracture.

In our series, patients in this group constitute a majority of those who were treated operatively.

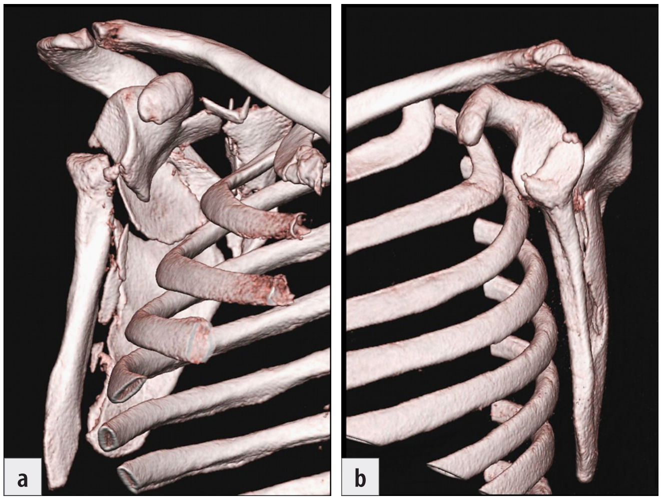

Fig. 4-12 Bilateral scapular fracture caused by high-energy trauma in a car accident: **a)** a complex intraarticular fracture on the right; **b)** a complex intraarticular fracture on the left.

LOW-ENERGY TRAUMA

The most frequent causes of these injuries include a simple fall onto flat ground, or from a small height, e.g., down stairs, with an impact on the shoulder, or dislocation in the glenohumeral joint (Fig. 4-15, Fig. 4-16). In the majority of patients it is an isolated injury to the scapula. We have also recorded a case of a direct fall of a relatively small object onto the scapula. These injuries occur most commonly in elderly patients with a poor quality of the bone stock (osteoporosis), or in patients with pre-existing bone pathology (a cyst, metastasis, metabolic disease) (Fig. 4-9, Fig. 4-10).

Typically low-energy injury involves the glenoid, primarily its rims, and the scapular processes. We have also recorded bilateral fracture of the anterior rim of the glenoid resulting from a fall onto outstretched arms.

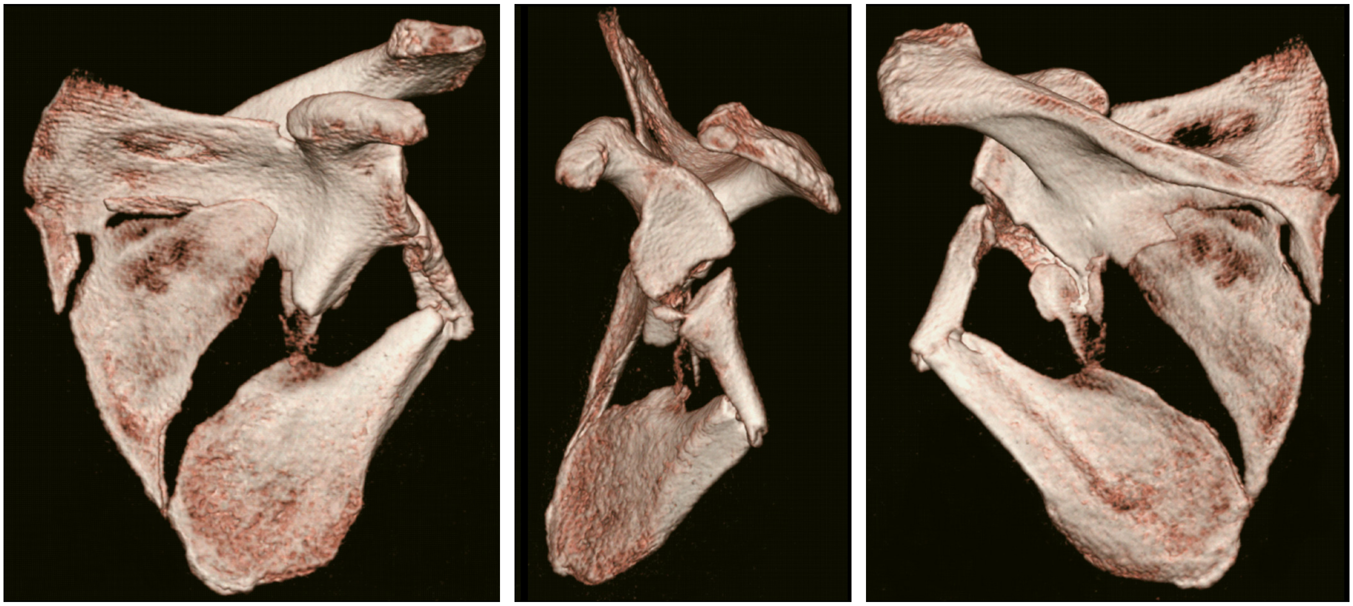

Fig. 4-13 Fracture of the inferior glenoid with the infraspinous part of the scapular body caused by a fall from a bicycle on 3D CT reconstructions.

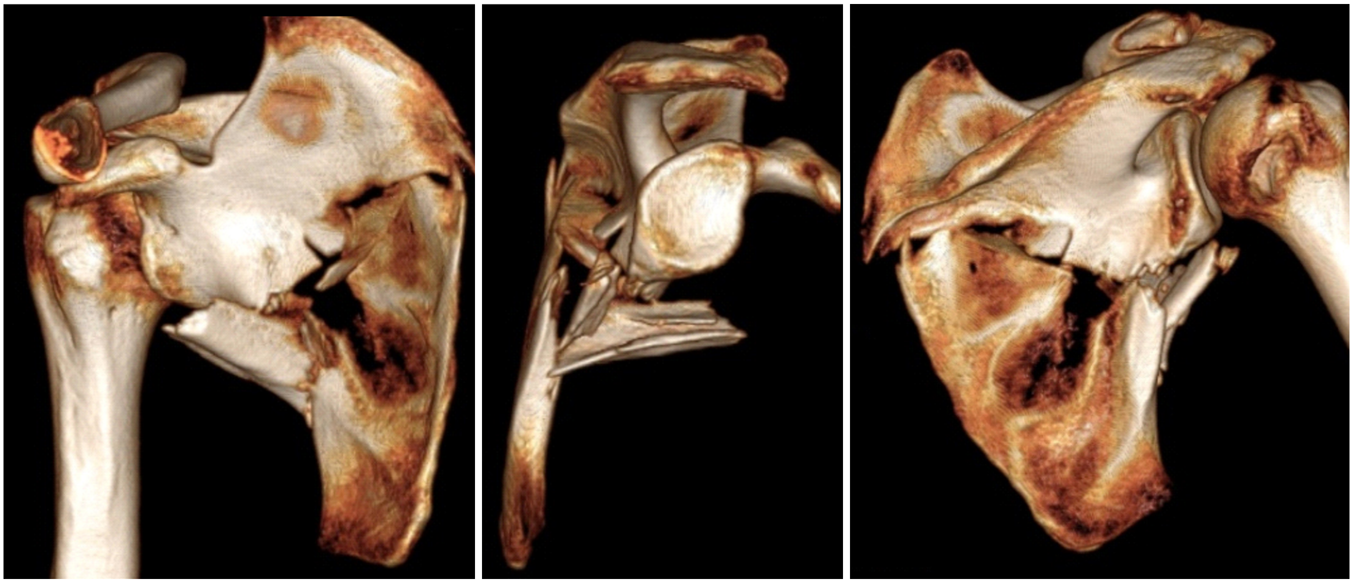

Fig. 4-14 Fracture of the infraspinous part of the body caused by a fall from a motorcycle travelling at slow speed.

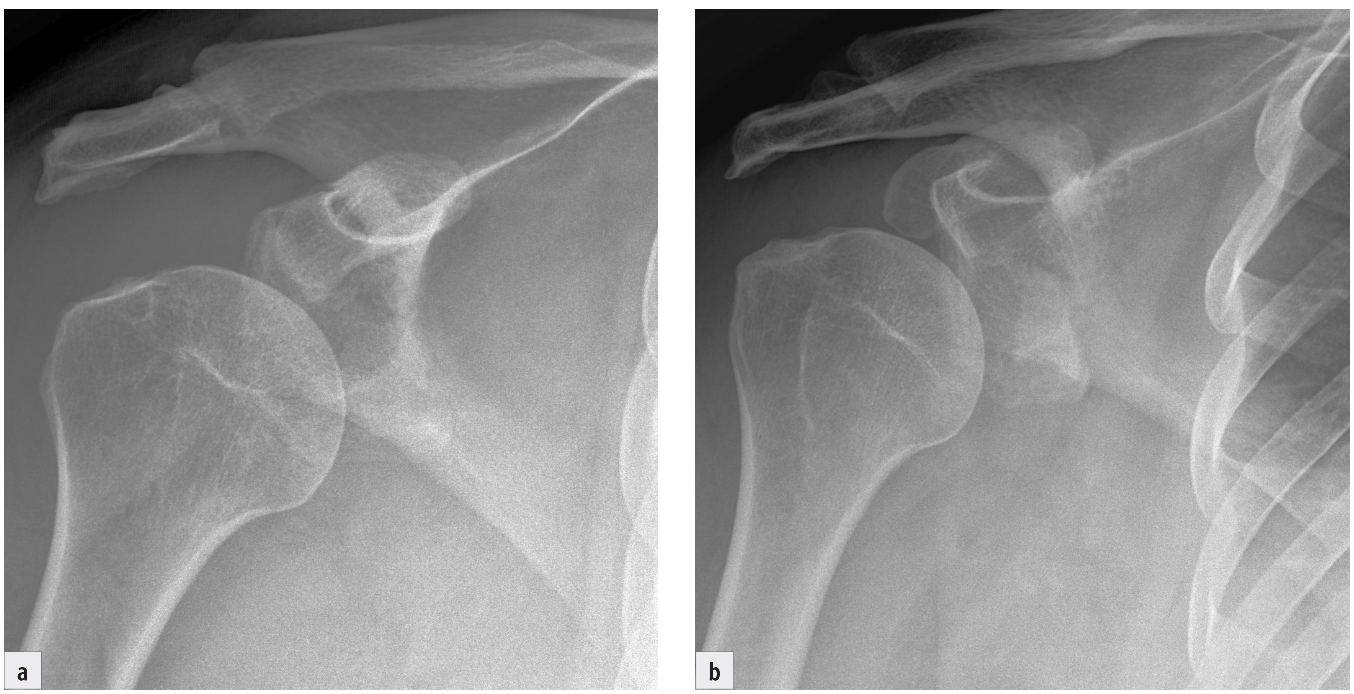

Fig. 4-15 Fracture of the anterior rim of the glenoid caused in anterior glenohumeral dislocation: **a)** post-injury radiograph; **b)** post-reduction radiograph.

ASSOCIATED INJURIES

Isolated fractures of the scapula are not so frequent. In the relevant literature, their incidence ranges between 14% and 33% of all scapular fractures [1, 3, 27, 31, 38, 42]. An exception in this respect was reported by Thompson [41], who recorded only 2% of single injuries in a group of 56 scapular fractures.

A majority of scapular fractures are associated with other injuries, the severity and number of which correspond to the intensity of the trauma energy. These injuries involve different parts and organ systems of the body, including injuries to the *head* (fractures of the skull, cerebral concussion or contusion, intracerebral hemorrhage), injuries to the *spine* (cervical, thoracic, lumbar), injuries to the *chest* (fractures of the ribs, flail chest, sternal fractures, lung contusion, pneumothorax, hemothorax, myocardial contusion, injury to the aorta, or to the subclavian artery), injuries to the *abdomen* (diaphragm, liver, spleen, intestines, retroperitoneum, kidneys), *pelvic* injuries and injuries to *extremities* (**Table 4-1**).

Some of the associated injuries are typically combined with scapular fractures (rib fractures), whereas others are rarely associated (rupture of the aorta).

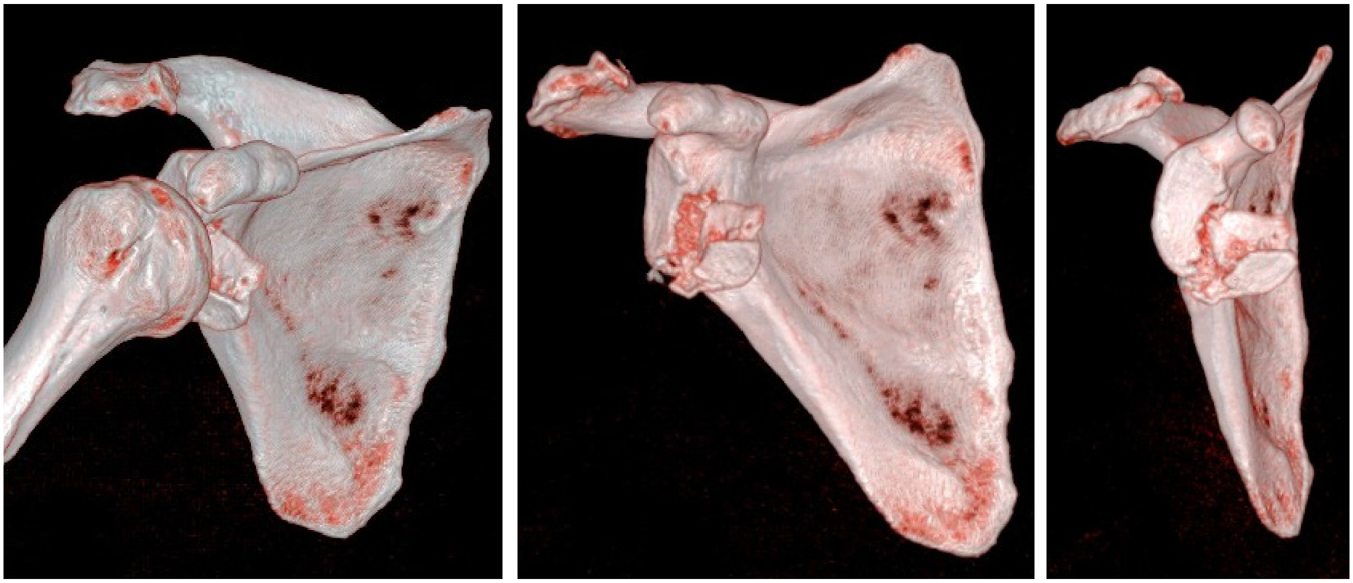

Fig. 4-16 Fracture of the anterior rim of the glenoid from Fig. 4-15 on 3D CT reconstructions.

Therefore, we should always think about the possible spectrum of associated injuries in scapular fractures caused by high-energy and medium-energy violence.

The incidence of associated injuries reported in the literature varies significantly [42] due to the selection of patients in individual studies (number of patients in the cohort, only a certain scapular fracture pattern, only operated-on patients, only polytrauma patients, etc.).

The incidence is also influenced by the way of presentation of associated injuries. For example, chest injuries are aggregated in some studies [8], whereas other authors [49] separate individual types of chest injuries, such as pneumothorax, lung contusion, rib fractures, etc. The same applies to abdominal injuries.

Head injuries, ranging from simple fractures of the skull up to intracranial hemorrhage, occur in between 10% and 60% of all cases of scapular fractures [8, 31, 43, 45].

Fractures of the ribs are the most frequent injuries associated with fractures of the scapula, which is to be expected in view of its intimate relationship to the rib cage (Fig. 4-17). In groups of patients reported by different authors [1, 3, 43, 45, 49], the frequency of associated rib fractures ranged from 15% [44] up to 65% [42]. Such a wide range may have several explanations. A study by Imatani [22] reporting 27% of rib fractures, was published in 1975, when these fractures were diagnosed only by radiographs. By contrast, in all patients in the Tuček's group of 2010 a CT scan of the scapula was obtained, capturing the surrounding ribs [42]. Rarely, there may occur also a fracture of 1st rib, even bilaterally [15].

Injuries to the thoracic cavity and lungs, such as pneumothorax, hemothorax, emphysema and lung contusion, have an incidence, according to various studies, in the range between 15.2% and 67% [3, 11].

Abdominal injuries, both to parenchymal and hollow organs, are also highly frequent, reported in the range between 26.2% and 42.6% [8, 11, 43, 45, 49].

Injuries to the spine, involving any of the three segments, i.e., cervical, thoracic and lumbar spine, are reported in a wide range between 6.4% and 44.7% [1, 8, 31, 43, 49]. Folman et al. [13] found that the highest number of injuries to the spinal cord (76%), in association with scapular fractures, occurred in fractures of the thoracic spine.

Pelvic fractures are among the most severe associated injuries, with a variable incidence ranging from 5% to 33% [1, 31, 38, 43, 45, 49].

Injuries to the extremities are also common and may involve any of the bones of the upper and lower extremities. The most common are fractures of the *tibia* reported in between 11% and 32% [1, 31, 43, 49], fractures of the *forearm* occurring in 18.1% [31, 43, 49] and fractures of the *humerus* in up to 16.7% [31, 43]. However, in fractures of the forearm and the humerus it is not specified whether these were ipsilateral, or contralateral, injuries.

Region	Incidence (%)
Head	7–60
Ribs	15–65
Chest	15–67
Abdomen	26–43
Spine	6–45
Pelvis	5–33
Extremities	22–64

Table 4-1 Frequency of associated injuries in patients with scapular fractures. For details see the text.

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OPERATIVE TREATMENT

In the past, few authors have given detailed descriptions of operative techniques for treating scapular fractures, primarily from the AO school [6, 12, 30, 31, 40, 42, 48, 66]. However, lately there have already been numerous studies that focus on the operative techniques in detail, specify indication criteria and evaluation of outcomes of operative treatment of these fractures [1, 2, 4, 5, 7-11, 13, 16-24, 29, 32-38, 41-47, 49, 51, 60, 61, 63, 64, 70, 71].

BASIC PREREQUISITES

The basic prerequisite for successful operative treatment is to follow a sequence of necessary steps, starting with a detailed radiological examination and ending with postoperative rehabilitation. This requires an individualized approach to each particular fracture and the availability of adequate equipment and surgical skills (**Table 11-1**).

PREOPERATIVE RADIOGRAPHIC EXAMINATION

Essential for establishing a correct indication and a well-conducted operation is a detailed definition of the fracture anatomy [3, 10]. Such knowledge can reliably be obtained only by standardized 3D CT reconstructions, with the subtraction of surrounding bones, serving as a basis for determining the pattern of the fracture, its displacement, an optimal therapeutic procedure and, in case of operative treatment, also the surgical approach to provide the required exposure.

INDICATIONS FOR OPERATIVE TREATMENT

Indication criteria were discussed in detail in Chapter 9. It should be noted that the mentioned radiological criteria are only a part of the decision-making process (**Fig. 11-1**). Of decisive importance is the patient's general and local condition, and their functional demands and expectations. Of no less importance are the knowledge, experience and skills of the attending surgeon [13].

PREPARATION OF THE PATIENT, AND OPERATING RESOURCES

Prior to operation, patients should be duly informed about the necessity and goals of the operative procedure, its potential complications, postoperative rehabilitation and the expected duration of treatment. It is beneficial to use a radiolucent table, which allows adjusting the patient's position according to the chosen surgical approach. However, radiolucency is not always a necessary precondition as the use of an image intensifier is helpful only in certain fracture patterns. Endotracheal anesthesia is necessary in view of the patient's positioning, and, in case of a presumed longer procedure, the patient should have a urinary catheter inserted.

The patient's position on the operating table must be stable, especially if a change in orientation of the operating table is required during operation. Care should be taken to avoid pressure sores, mainly with the use of the Judet approach with the patient in a semi-prone position (**Fig. 11-2**).

Complying informed patient
Preoperative plan based on 3D CT reconstructions
Surgical approach
Patient's position
Reduction and internal fixation plan
Basic equipment of operating theater
Positioning operating table
Positioning and anti-sore aids
Image intensifier
Patient's preparation
General anesthesia with intubation
Bladder catheterization
Patient's stable positioning with sore prevention
Draping allowing free motion of the operated on limb
Instruments and implants
Basic instruments for bone surgery
Implant set 2.7-mm or 3.5-mm
K-wires, tension band wire
Drilling machine
Scapula model
Postoperative physiotherapy
Shoulder continuous passive motion machine
Skilled physiotherapist

Table 11-1 Basic prerequisites of a successful operative treatment.

EQUIPMENT AND CHOICE OF IMPLANTS

In addition to basic surgical tools for internal fixation, it is beneficial also to have available other instruments, such as Hohmann-Müller retractors of different types and sizes, raspatories, bone curettes of different sizes, small reduction forceps and bone drills.

As a rule, internal fixation of scapular fractures does not require special implants. Reduction and temporary fixation is performed with the use of 0.5-2mm K-wires, and final internal fixation with implants from the 2.7-mm, or 3.5-mm, instrumentation set, including the appropriate cortical screws, 2.7-mm or 3.5-mm reconstruction plates, 2.7-mm or 3.5-mm semitubular plates, and T- or L-shaped plates. Locking plates are required only in exceptional cases.

We currently prefer 2.7-mm implants that better fit the shape of the scapula, whilst providing sufficient stability, without projecting excessively from the bone surface. Only exceptionally are 3.5-mm implants required in more robust patients, or in case of greater comminution of one of the pillars [10].

Sometimes, we use smaller, 2.4-mm or 2.0-mm screws to fix small fragments of the articular surface, or intermediate fragments of the lateral pillar. Cannulated screws (3.5-mm or 4.0-mm) are useful for internal fixation of the coracoid process.

Anatomically-shaped plates contoured to the circumference of the biomechanical triangle, which are recommended by some authors [25, 26, 69], cannot be used in all patients, due to the considerable variability of the shape and size of the scapular body. Several reports have been published on the use of a modified AO calcaneal plate [57], or a distal humeral Y-plate [39], a "3D printed" and Y-plate [59] in a comminuted scapular body fracture, and an AO 2.7-mm mesh plate [36], as well as a plate for a lateral clavicular fracture [35, 36] in a multi-fragmentary fracture of the acromion.

STRATEGY

Assessment of the fracture and the choice of the surgical approach are followed by planning the actual reconstruction. This applies particularly to complex fractures. In terms of internal fixation it has to be taken into account that the scapula has an irregular distribution of its bony mass, with only certain areas offering sufficient anchorage for implants. These include mainly the lateral pillar of the scapular body, the scapular spine, the scapular neck and glenoid, the acromion, and the inferior angle (Fig. 11-3).

FRACTURES OF THE SCAPULAR BODY

In fractures of the scapular body, it is essential to restore the integrity of the biomechanical triangle, primarily the lateral pillar and, when necessary, the spinal pillar. The first step in infraspinous fractures is always reconstruction of the lateral

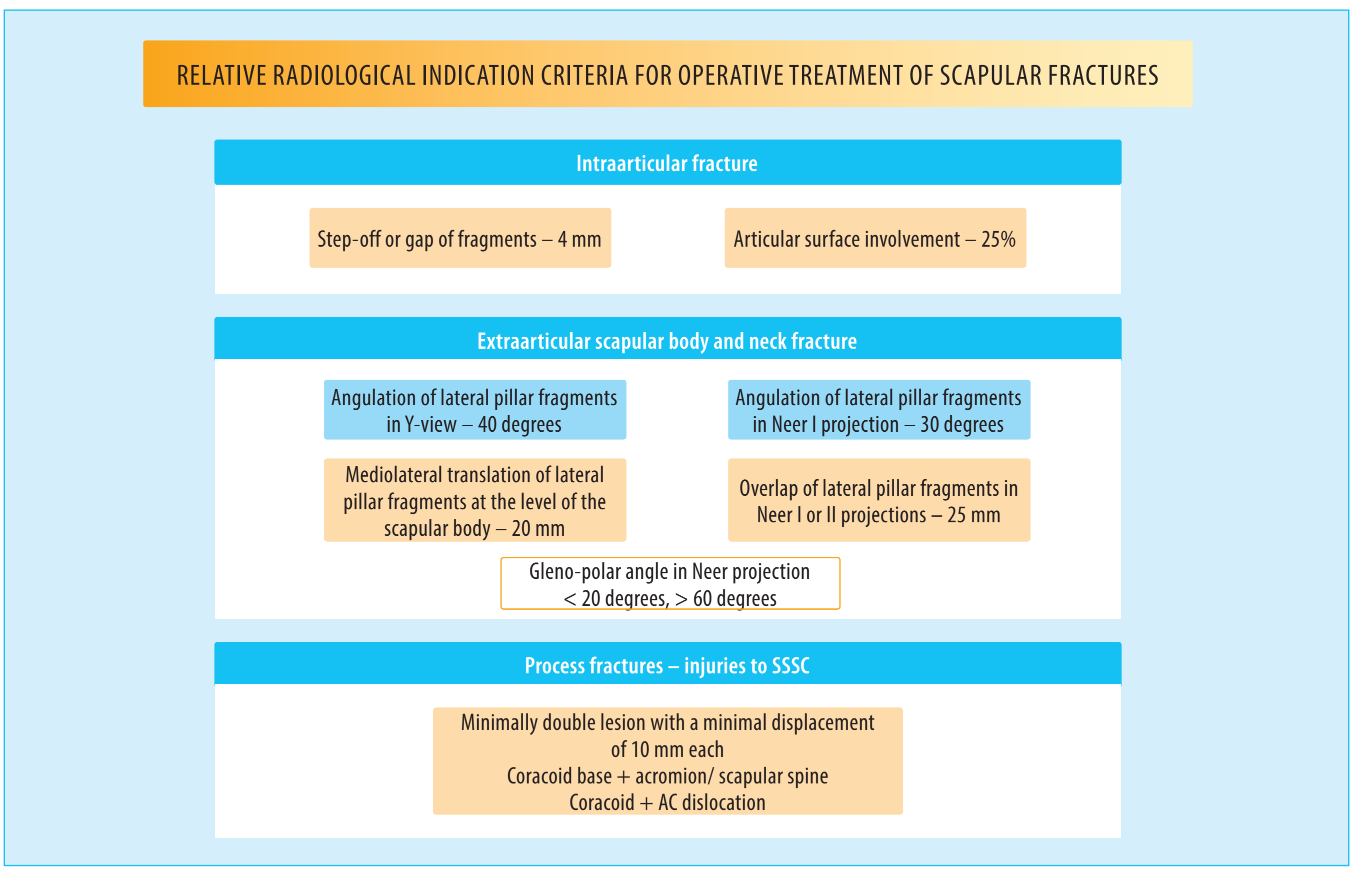

Fig. 11-1 Indication criteria for operative treatment

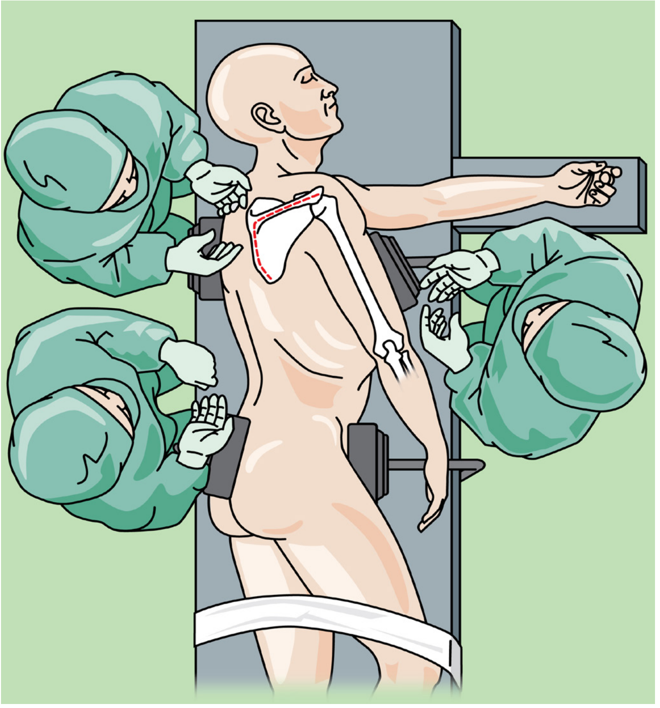

Fig. 11-2 Judet approach – the patient's position and disposition of surgical team members.

pillar. Two-part fractures, after reconstruction, are checked for the situation in the spinomedial angle. If there is only minimal, or no, displacement, slight movement between the fragments can be tolerated, and internal fixation is not necessary. Three--part and multi-part infraspinous fractures also require stabilization of the medial border and/ or of the inferior angle of the scapula.

Fractures of both pillars are almost always treated by internal fixation, with the lateral pillar usually being fixed first.

Central fragments from the infraspinous fossa need not be fixed; those impacted deeply in the muscles must be reduced, or removed. Internal fixation is used only exceptionally.

FRACTURES OF THE SCAPULAR NECK

In all three basic types of scapular neck fractures, it is important to restore the integrity and stability of the lateral pillar. Fractures of the anatomical and surgical necks usually require placement of an additional small plate in the area of the spinoglenoid notch. Stability of internal fixation in surgical neck fractures can be increased by the insertion of a lag screw from the scapular spine. In transspinous fractures, internal fixation of the spinal pillar is added.

GLENOID FRACTURES

The main goal of the operation is to restore congruence of the articular surface and stability of the glenohumeral joint. Treatment of these fractures depends on whether the fracture is partial, or total. Partial fractures are reduced and the avulsed fragment(s) fixed to the intact part of the glenoid fossa. In case of two, or three, separate fragments it is sometimes necessary first to create a single fragment of them, and then to reduce it to the intact part of the glenoid. Reduction and fixation of total glenoid fractures are very difficult and require an individualized approach. Where the fragments are separated from the scapular body along the line of the surgical neck, the easiest way is to reconstruct the glenoid fossa and then fix it to the scapular body.

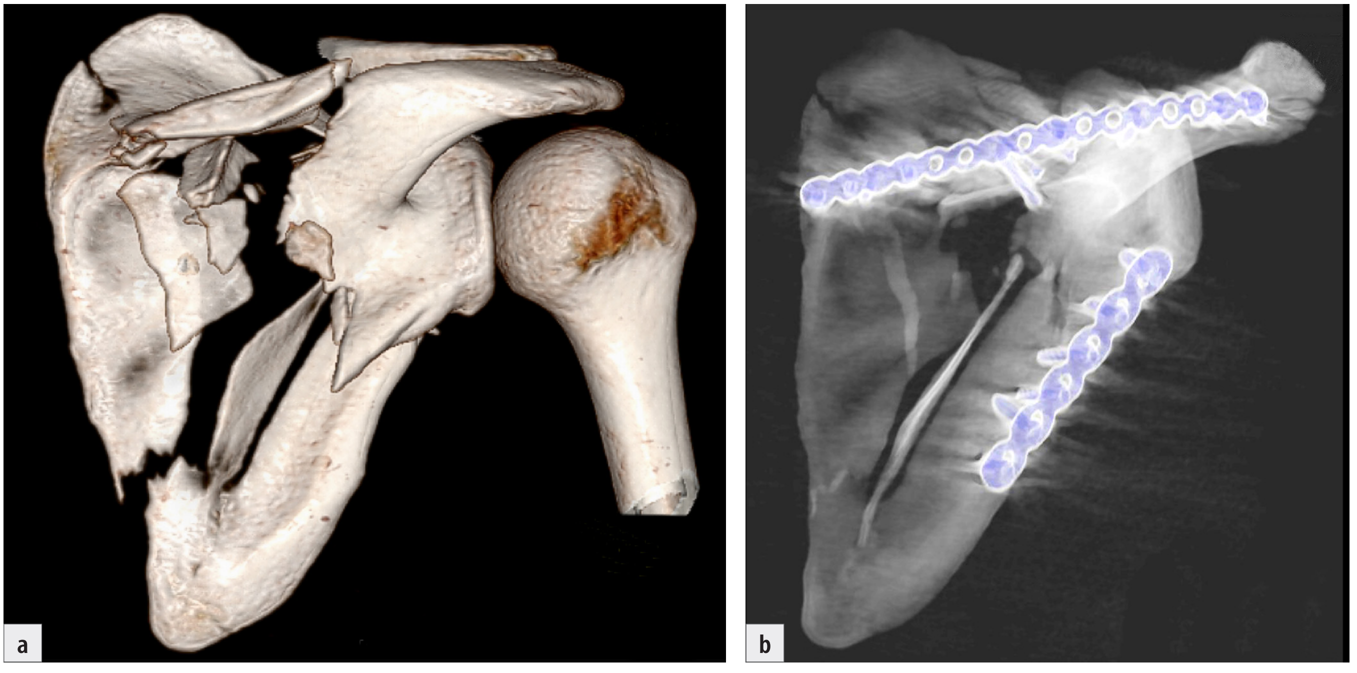

Fig. 11-3 Distribution of bony mass of the scapula and areas offering sufficient anchorage for implants: **a)** a two-pillar fracture of the scapular body; **b)** internal fixation of the lateral and spinal pillars.

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FRACTURES OF THE SCAPULAR BODY

Fractures of the scapular body account for about one half of all scapular fractures. Despite this, little attention was paid in the past to this type of scapular injury in terms of diagnosis, classification and treatment. This may be explained by the fact that, until recently, almost all fractures of the scapular body were treated non-operatively and there was, therefore, no reason for analyzing them in detail [4, 23, 26, 27, 33, 37, 52]. However, some studies questioned universal non-operative treatment of scapular body fractures [1, 43, 47], while other authors recommended operative treatment only in markedly displaced fractures. In the last 30 years, the situation has changed and the number of indications for operative treatment of certain scapular body fractures has been increasing [8, 9, 14, 15, 17-19, 24, 30, 31, 34, 36, 42, 49, 51, 55, 57]. In this context, a new problem has arisen, related to the definition of these fractures. Historical publications clearly distinguished between scapular body and scapular neck fractures and presented exact illustrations of scapular body fractures, based on cadaver specimens [8, 20, 28, 29, 38, 54]. Despite this, a number of authors still classify these fractures as scapular neck fractures, particularly those with a fracture line passing across the proximal part of the lateral pillar [17, 32, 35]. Conflating these two fracture patterns results in terminological confusion, the presentation of unrealistic data on the incidence of scapular neck fractures and the floating shoulder, and contradictory outcomes of their treatment [12, 22].

EPIDEMIOLOGY

Data on the prevalence of scapular body fractures vary widely in the literature, ranging between 19% and 65% [27, 40, 41, 53, 56]. There are several reasons for that. One of them is the already-mentioned absence of a standard definition of scapular body factures, and their intentional classification as scapular neck fractures. Another reason may be different understanding of fractures of the superior and inferior angles of the scapula, when some authors [26, 33] classify them as scapular body fractures and others [10, 11, 13] consider them to be so-called corner body fractures. The third reason is the fact that, mainly in older studies, scapular body fractures were unintentionally confused with scapular neck fractures due to inadequate radiological diagnosis.

Zhang [56], in 2012, identified a total of 256 fractures of type OTA 14-A3 (scapular body fractures) in a series of 587 scapular fractures, i.e., in 44% of cases.

Tuček et al. [53], in 2017, recorded 52% of scapular body fractures in their series of 250 scapular fractures. The last review of our series of 519 scapular fractures from the period of 2002-2020 revealed scapular body fractures in 50% of cases. The exact fracture pattern was determined on the basis of CT examination and intraoperative findings.

DIAGNOSIS

An exact determination of a scapular body fracture, or its pattern, based on radiographs alone is extremely difficult, if not impossible. Many two-part infraspinous fractures of the scapular body have been interpreted, on the basis of radiographs alone, as fractures of the surgical neck of the scapula. Scapular body fractures can be reliably specified only by means of 3D CT reconstructions (Fig. 12-1) [7, 39], not only with the view of the anterior aspect, but, more importantly, of the posterior aspect, which shows the course of the fracture lines in relation to the scapular spine.

CLASSIFICATION

The first to classify scapular body fractures was Petit [48] in 1723. Another classification, by Tanton [50], was published as late as at the beginning of 20th century. This and all the subsequent schemes classified scapular body fractures according to involvement of the supraspinous and infraspinous fossae, or according to the course of fracture lines [21, 33]. These classifications are descriptive and do not address the severity of individual types of injury, or the methods of their treatment. A majority of recent classifications distinguish between two--part (non-comminuted) and multi-part (comminuted) fractures of the scapular body [5, 25, 44–46]. Some classifications mention this fracture pattern only marginally, if at all [1].

OVERVIEW OF CLASSIFICATIONS

The following overview shows that the first to deal in detail with scapular body fractures were primarily the French surgeons.

Petit [48], in 1723, classified these fractures according to the course of fracture lines into transverse, oblique and longitudinal ones.

Tanton [50], in 1915, divided scapular body fractures into four groups. The first group comprised fractures of the supraspinous and infraspinous fossae. Based on the course of the fracture line, he distinguished between vertical, transverse and comminuted fractures. The second group included fractures

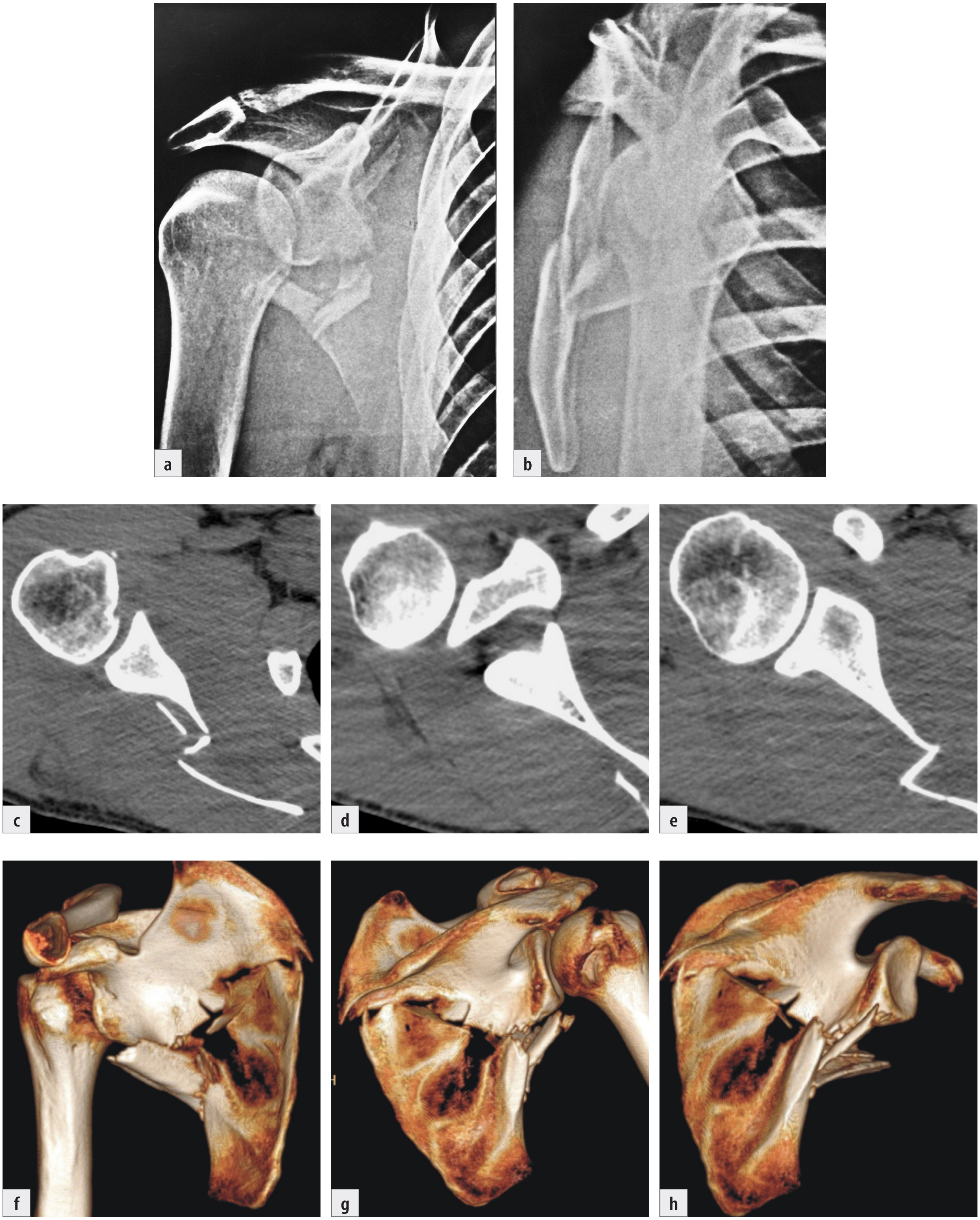

Fig. 12-1 Importance of 3D CT reconstructions for a proper determination of the fracture pattern: **a)** Neer I view; **b)** Neer II view; **c+d+e)** CT transverse sections at the level of the infraspinous fossa; **f)** 3D CT reconstruction, anterior view; **g)** 3D CT reconstruction, posterior view; **h)** 3D CT reconstruction, posterolateral view with subtraction of the humeral head. Only 3D CT reconstructions show that it is a two-part fracture of the infraspinous part of the scapular body, with two intermediate fragments separated from the lateral pillar.

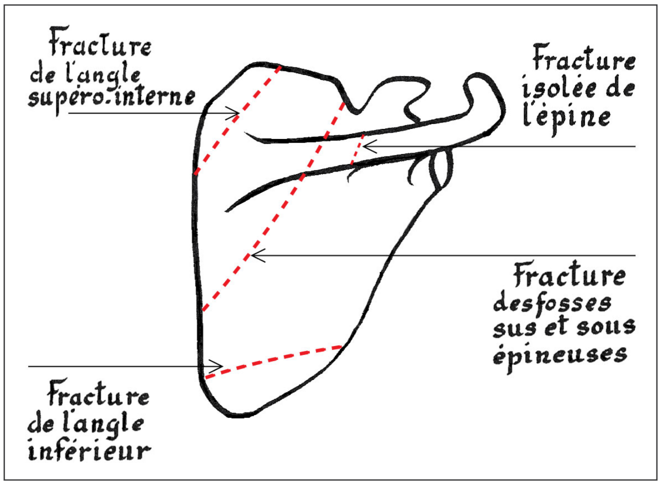

Fig. 12-2 Decoulx classification of scapular body fractures. Modified according to [21].

of the inferior angle, the third group fractures of the superior angle and the fourth group fractures of the scapular spine.

Decoulx et al. [21], in 1956, merely reduced the Tanton's classification into three groups: those involving the supra- and infraspinous fossae, those involving the superior or inferior angle, and isolated fractures of the scapular spine (**Fig. 12-2**).

Imatani [33], in 1975, divided *central fractures* of the scapular body into vertical, horizontal and comminuted ones. Fractures of the superior or inferior angle were included in the group of *corner body fractures* (**Fig. 12-3**).

OTA classification denoted in its first and second editions of 1996 [44] and 2007 [45] respectively, scapular body fractures with the code 14-A3 and distinguished between *"noncomminuted"* (14-A3.1) and *"comminuted"* fractures (14-A3.2). The third version of 2018 [46] uses the code 14-B for these fractures, distinguishing between *"fractures exiting the body at 2 or less points"* (14-B1) and *"fractures exiting the body at 3 or more points"* (14-B2) (**Fig. 12-4**).

AUTHORS' CT-BASED CLASSIFICATION

Our classification is based on analysis of 187 scapular body fractures, the exact pattern of which was verified by CT, and/or intraoperatively [10]. In its development, we respected the anatomical architecture of the scapula and *considered scapular body fractures to be only those involving the biomechanical triangle, with the fracture line passing through at least one of the two pillars*. Fractures of the superior, or inferior, angle of the scapula were classified as peripheral.

When evaluating the number of fragments, we distinguished between two basic types of fragments, i.e., circumferential and central (intercalary) fragments.

Circumferential fragments carry a part of the circumference of the infraspinous fossa. *Central fragments* are avulsed from the thin central part of the infraspinous fossa.

Only those fragments that carried a part of the circumference of the scapular body were assessed as separate. In this way we have identified three basic types of scapular body fractures, i.e., fractures of the spinal pillar, of the lateral pillar and fractures involving both pillars (**Fig. 12-5**), (**Table 12-1**). This division respecting the spinal pillars is logical. It takes into account not only the internal architecture of the scapula, but also severity of the fractures. Reduction and fixation of one, or both, pillars is the fundamental step in restoration of the continuity of the biomechanical body.

Although classification of scapular body fractures reflecting injury to the pillars has no analogy in the previous schemes [1, 5, 21, 25, 26, 33, 44–46], realistic drawings of individual patterns of these fractures based on cadaver specimens may be found in historical publications [20, 28, 29, 38, 54].

Spinal pillar fractures

These, as a rule, minimally displaced fractures, accounting for only 6% of all scapular body fractures, involved both the supraspinous and infraspinous fossae. We found the first

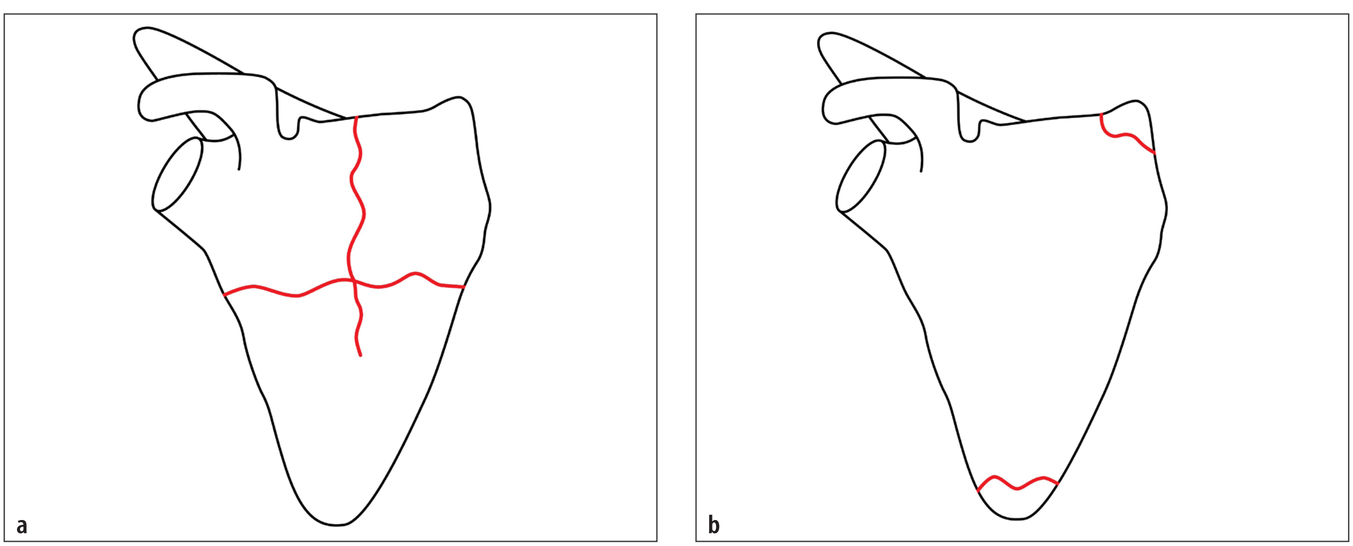

Fig. 12-3 Imatani's classification of scapular body fractures: **a)** central fractures, vertical or horizontal; **b)** "corner body fractures". Modified according to [33].

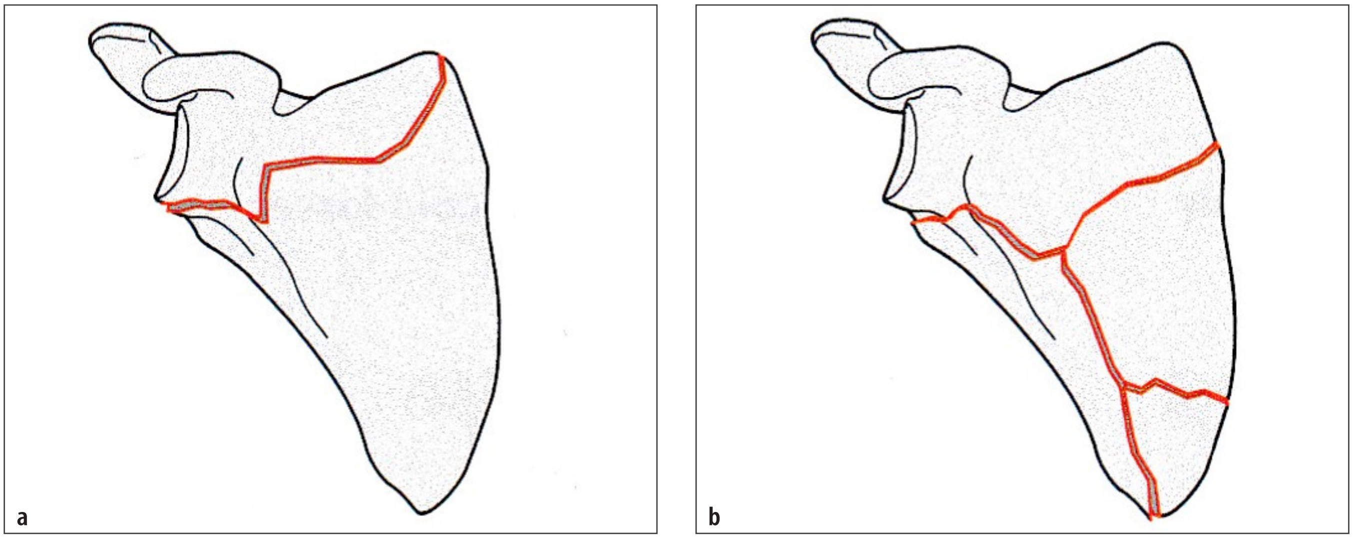

Fig. 12-4 OTA classification of scapular body fractures: **a)** "a fracture exiting the body at 2 or less points" (14-B1); **b)** "a fracture exiting the body at 3 or more points" (14-B2). Modified according to [46].

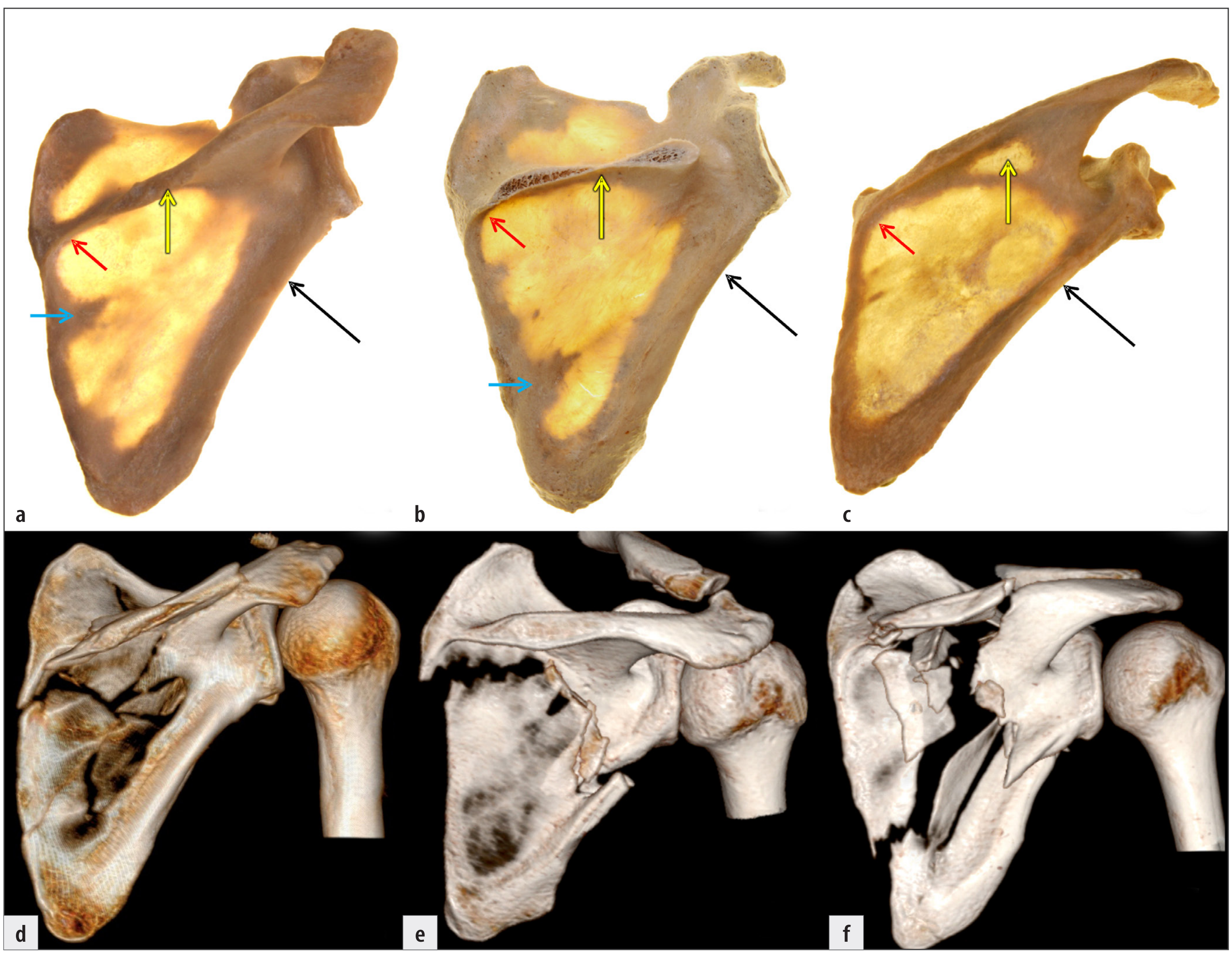

Fig. 12-5 Three basic patterns of scapular body fractures, defined according to injury to the pillars of the scapula: **a)** transilluminated specimen of the scapula, posterior view; **b)** transilluminated specimen of the scapula with resected scapular spine, posterior view; **c)** transilluminated specimen of the scapula, posteroinferior view; **d)** spinal pillar fracture involving always the supraspinous and infraspinous fossae; **e)** lateral pillar fractures involving only the infraspinous fossa; **f)** fractures of both pillars involving both fossae. The red arrow – the spinomedial angle, the black arrow – the critical region of the lateral pillar, the blue arrow – the septum reinforcing the medial border of the scapular body, the yellow arrow – the central weaker part of the scapular spine.

SUBJECT INDEX

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