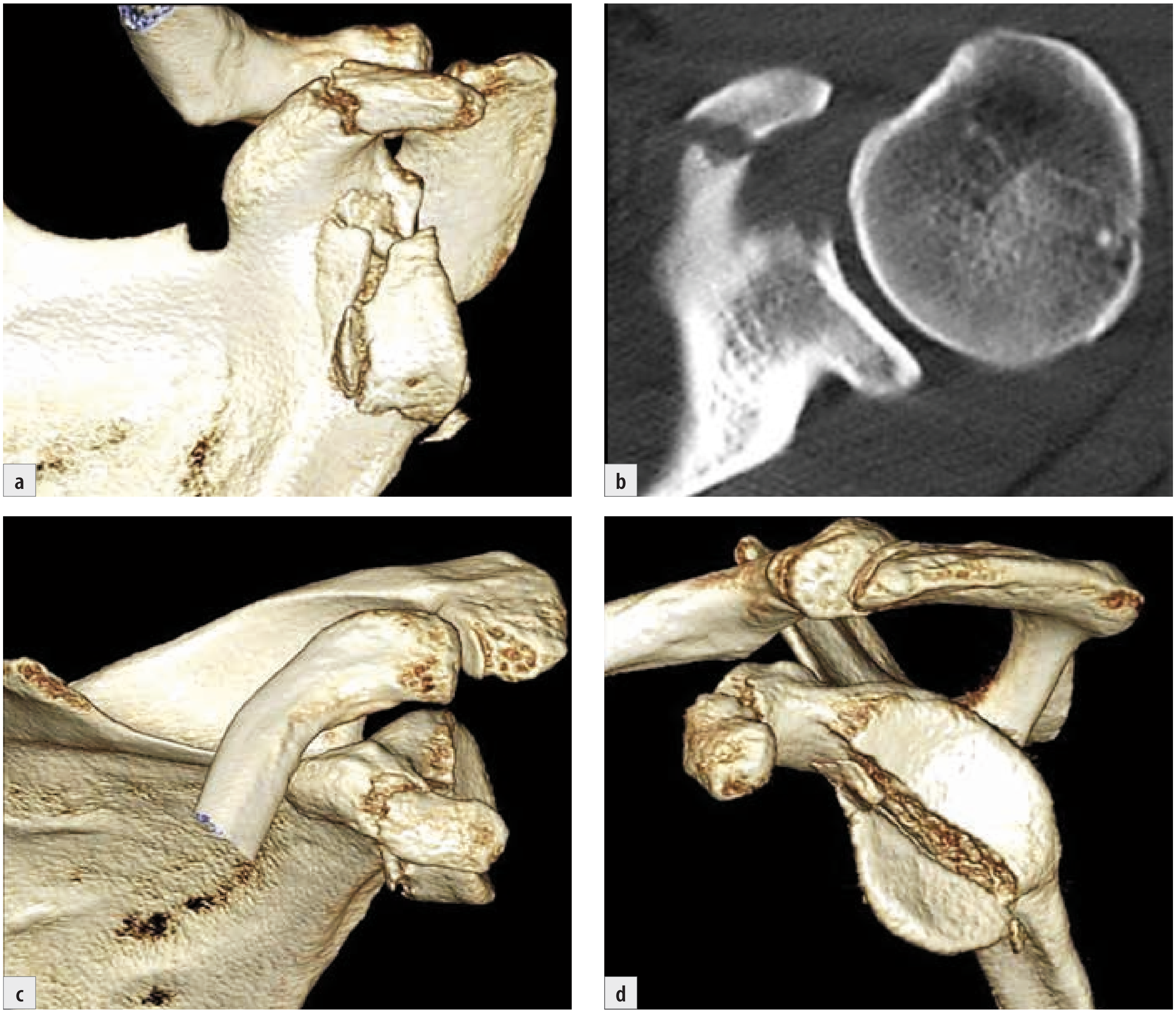

Fig. 4-5 Glenoid fracture with the arm abducted horizontally. The humeral head is driven against the central part of the glenoid, its impact results in avulsion of the anterior rim of the glenoid and coracoid process: **a)** anterior view; **b)** CT transverse scan; **c)** superior-anterior view; **d)**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

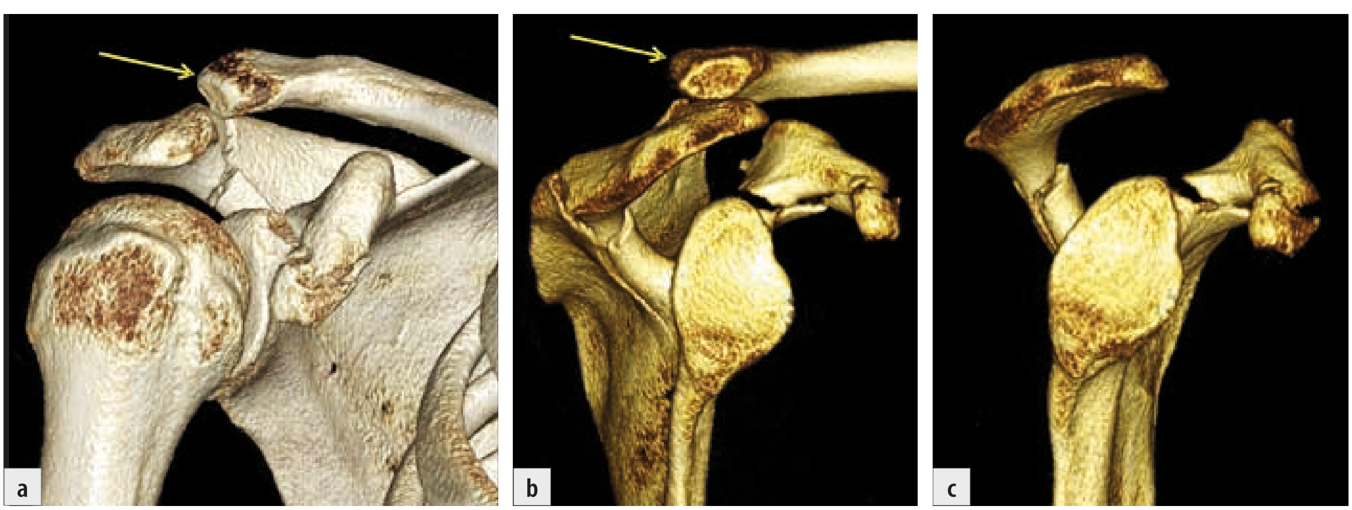

Fig. 4-6 Process fracture with the arm in adduction, the humeral head is driven proximally and hits the surrounding processes: **a)** comminuted fracture of the coracoid, fracture of the lateral scapular spine and AC dislocation; **b)** subtraction of the humeral head; **c)** subtraction of the humeral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

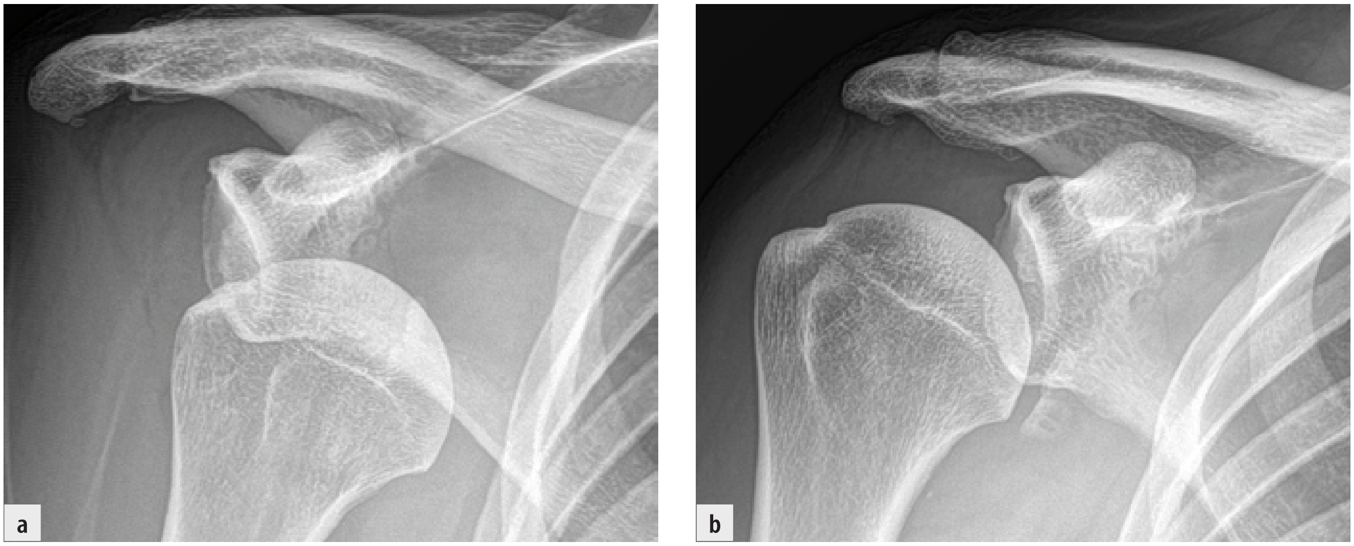

Fig. 4-7 Fracture of the anterior rim of the glenoid in anterior dislocation of the humeral head: **a)** post-injury radiograph; **b)** post-reduction radiograph; **c)** 3D CT reconstruction after reduction.

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,

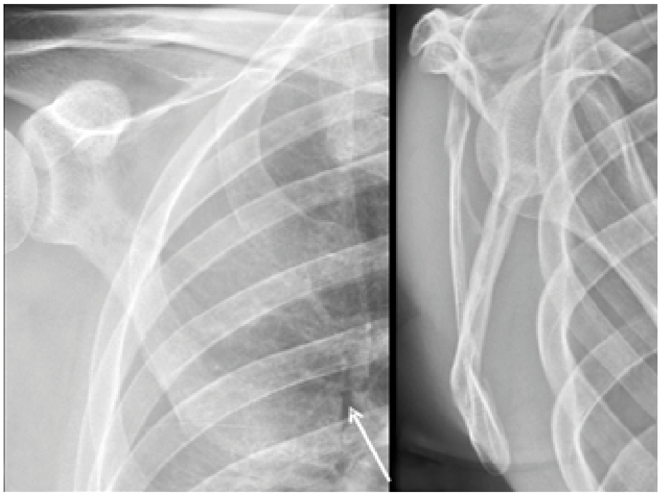

Fig. 4-8 Fracture of the inferior angle of the scapula resulting from muscle contraction. The white arrow shows the fracture.

5

CLINICAL EXAMINATION

Clinical examination of patients with scapular injuries depends on the patient's general condition [2]. In a number of polytrauma patients, scapular fractures are often found coincidentally, e.g., on a chest radiograph, or CT scan [3, 7]. The introduction of spiral CT has considerably improved primary diagnosis of scapular fractures in polytrauma patients. In these patients, the priority has always been to save life, and detailed examination and treatment of a scapular fracture is usually postponed to a later time. An exception is an open scapular fracture. Patients in a less severe general condition, who are able to communicate, may undergo standard clinical examination [2, 5]. As scapular fractures are often associated with other injuries, it is firstly essential to perform a comprehensive examination of the whole patient and only then to focus on the shoulder. Where one fracture of a shoulder girdle is found, e.g., of the clavicle, it is necessary to exclude other potential associated injuries [2].

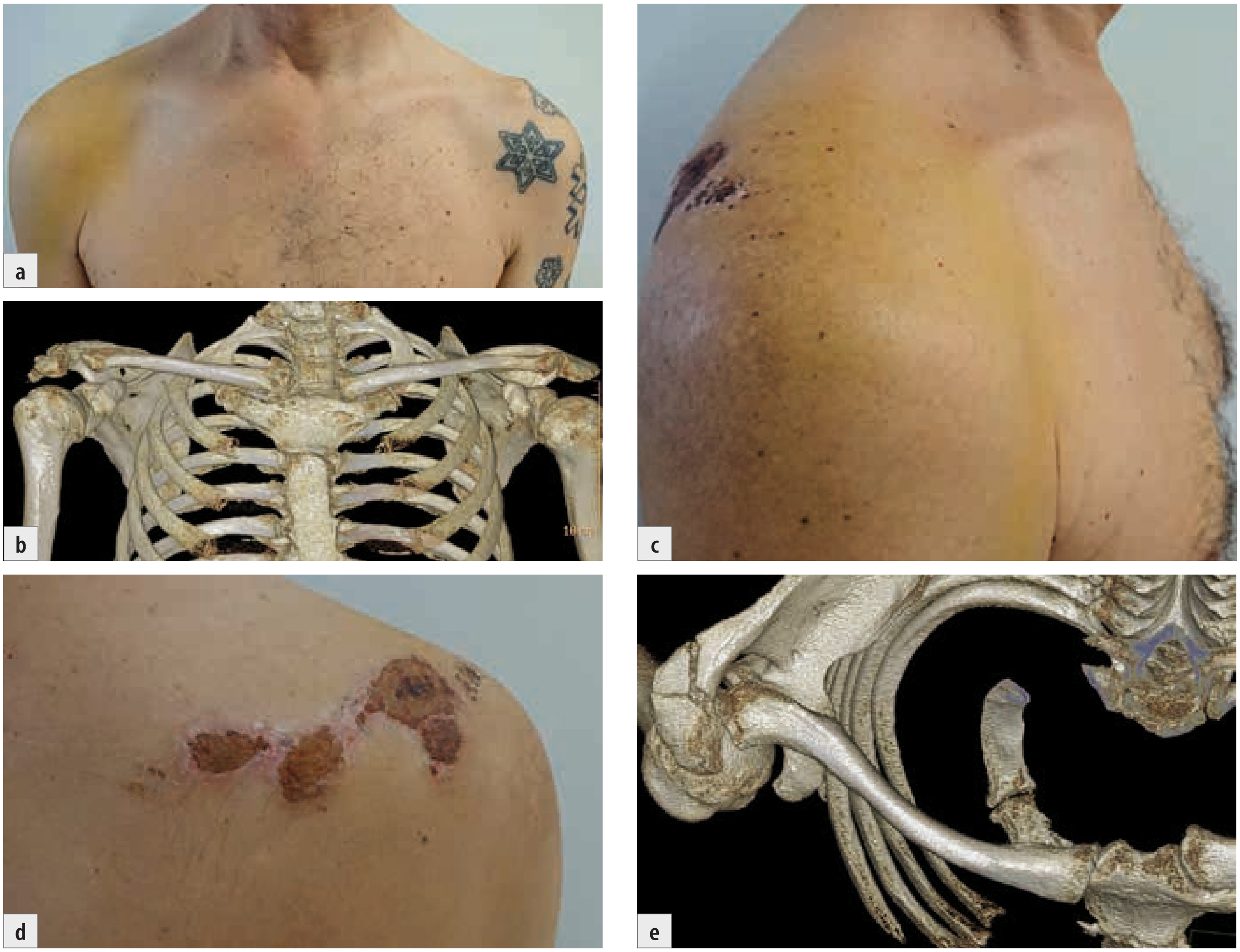

Fig. 5-1 Patient with a fracture of the acromion and anterior subluxation in the SC joint: **a)** a visible swelling in the region of the SC joint and a resorbing hematoma in the region of the shoulder; **b)** 3D CT reconstruction; **c)** lateral view, abrasions in the region of the scapular spine and hematoma in the region of the shoulder; **d)** posterior view, abrasions in the region of the scapular spine; **e)** 3D CT reconstruction, a superior view showing subluxation of the SC joint, subluxation of the AC joint and fracture of the acromial angle.

6

RADIODIAGNOSTICS

Essential for diagnosing a scapular fracture, determination of the fracture pattern and for planning the treatment regimen is radiological examination, CT in particular [2, 10, 11, 14, 15, 19, 21]. Other imaging methods, discussed in the literature, include MRI and ultrasound scanning, although they are indicated only exceptionally and their contribution is limited [7, 22, 23].

The radiodiagnostic algorithm must be adjusted to the patient's general condition. A majority of cooperating patients with a dominant injury to the shoulder girdle first undergo radiological examination, followed, where necessary, by CT examination. Polytrauma patients are initially examined by full-body CT scanning, on the basis of which scapular fractures are diagnosed [29].

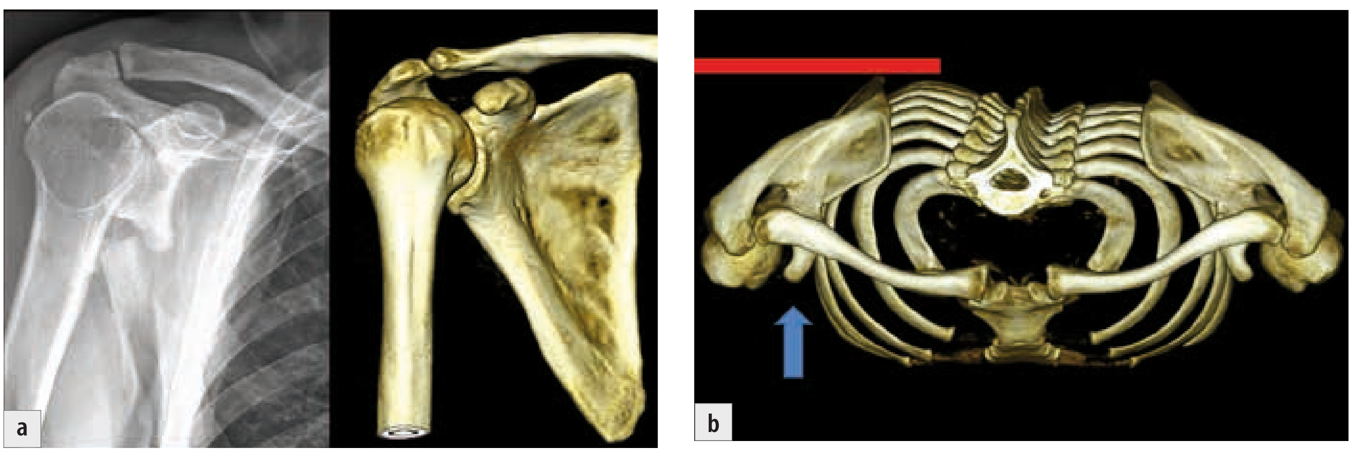

Fig. 6-1 Anteroposterior view of the shoulder: **a)** radiograph and CT reconstruction; **b)** position of the scapula and the X-ray cassette.

RADIOLOGICAL EXAMINATION

The examination is based on three basic projections. The first is the anteroposterior view of the shoulder girdle, which is subsequently supplemented with anteroposterior and lateral views of the scapula.

Anteroposterior radiograph of the shoulder girdle is the basic examination in any suspected scapular fracture (Fig. 6-1). It should cover not only the whole scapula, but also the proximal humerus, AC joint and the whole clavicle, including the SC joint, in order to provide general information about the whole shoulder girdle (Fig. 6-2) [2]. This projection is usually not sufficient to determine the fracture pattern and displacement of fragments in detail.

True anteroposterior radiograph of the scapula, described by Grashey (Grashey's projection) and later by Neer (Neer I projection), allows assessment of the glenohumeral joint space [19, 24]. In this projection, the scapular plane is parallel to the X-ray cassette. This may be achieved by rotating the patient, standing with his/her back to the X-ray cassette, by about 30 to 40 degrees towards the affected side (the exact angle of rotation is specific for each patient). A correctly set projection will show the glenohumeral joint space (Fig. 6-3).

Lateral scapular projection is also known as the Y-view, or Neer II projection (Fig. 6-4). In this projection, the scapular plane is perpendicular to the X-ray cassette. This may be achieved by rotating the patient, facing the X-ray cassette, by about 50 to 60 degrees towards the affected side (the exact angle of rotation is specific for each patient). The Y-view

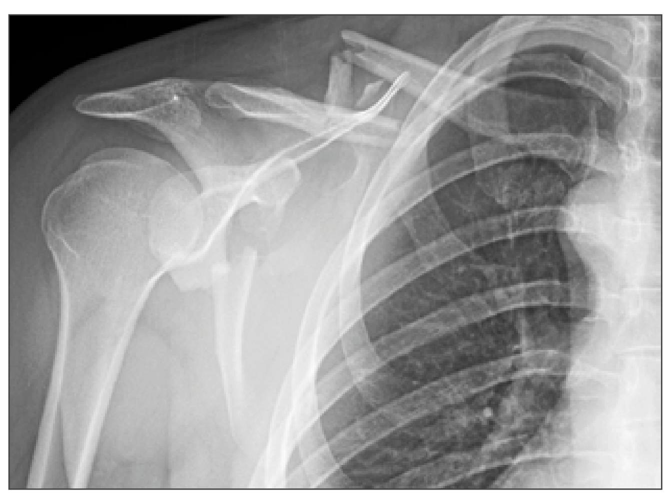

Fig. 6-2 General anteroposterior radiograph of the shoulder girdle.

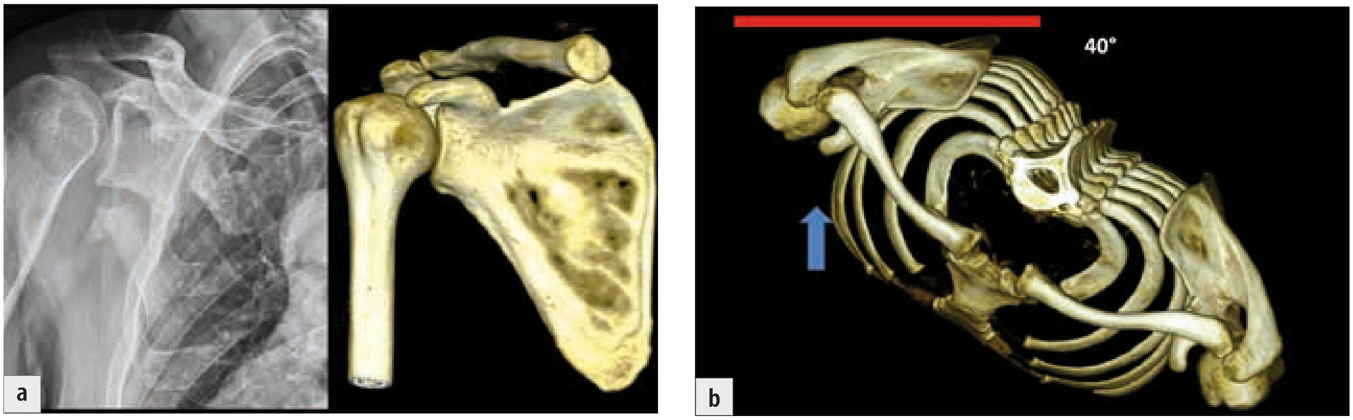

Fig. 6-3 Anteroposterior view of the scapula (Neer I projection): **a)** radiograph and CT reconstruction; **b)** position of the scapula and the X-ray cassette.

Fig. 6-4 Lateral view of the scapula (Neer II projection): **a)** radiograph and CT reconstruction; **b)** position of the scapula and the X-ray cassette.

Fig. 6-5 Displacement of the lateral pillar fragments in Neer II projection.

Fig. 6-6 Fracture of the acromion, the coracoid and AC dislocation in Neer II projection.

Fig. 6-7 Fracture of the inferior glenoid and the infraspinous part of the scapular body in Neer II projection.

Fig. 6-8 Axillary projection of the shoulder in a case of a gunshot injury to the scapula.

allows assessment of displacement of lateral pillar fragments, in terms of their translation, angulation and overlap (**Fig. 6-5**). It also displays the status of processes of the scapula (coracoid, acromion, scapular spine) and of the AC joint (**Fig. 6-6**), and it can identify certain fractures of the glenoid (**Fig. 6-7**) [2].

General radiograph of the chest, indicated to examine the lungs, heart and chest wall, used to be, prior to introduction of the full-body CT scanning, often the first clue to the existence of a scapular fracture in polytrauma patients. A chest radiograph can be also used to assess the status of both shoulder girdles, and mainly the relationship of each scapula to the spine (scapulothoracic dissociation).

Other special projections, the axillary in particular (**Fig. 6-8**), are recommended by some authors as complementary views, to diagnose fractures of the glenoid, acromion and coracoid process [6, 10, 15]. However, axillary projection is, for most patients with a scapular fracture, highly unpleasant and can never be a substitute for CT examination.

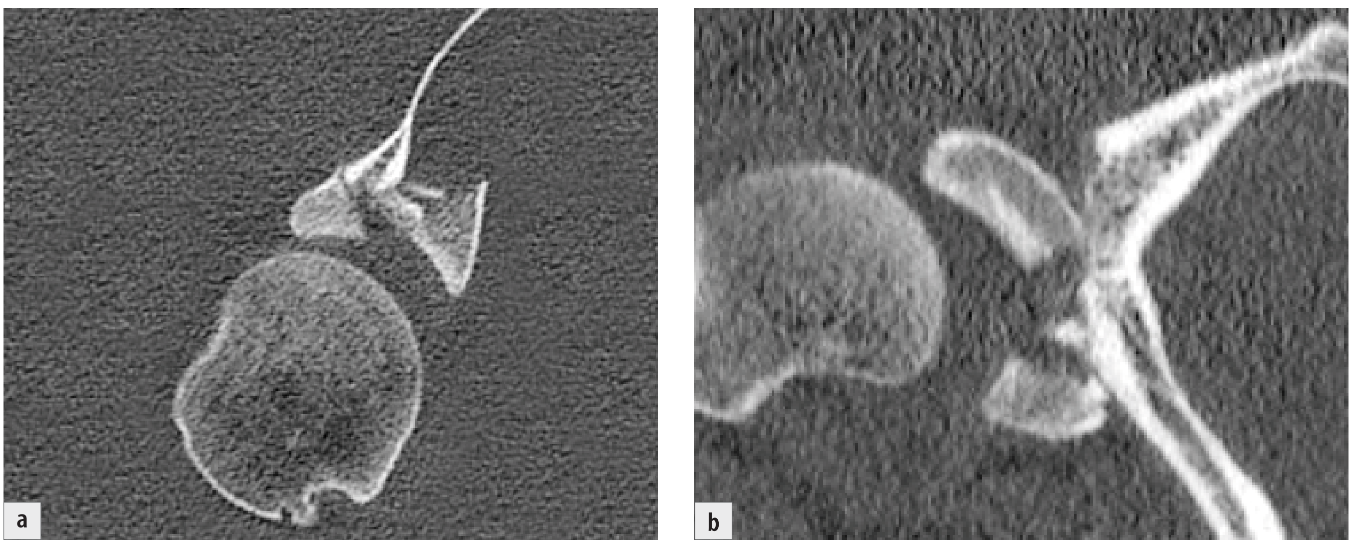

Fig. 6-9 CT scans of a complete fracture of the glenoid: **a)** transverse sections; **b)** 2D CT reconstruction in the plane of the scapular body.

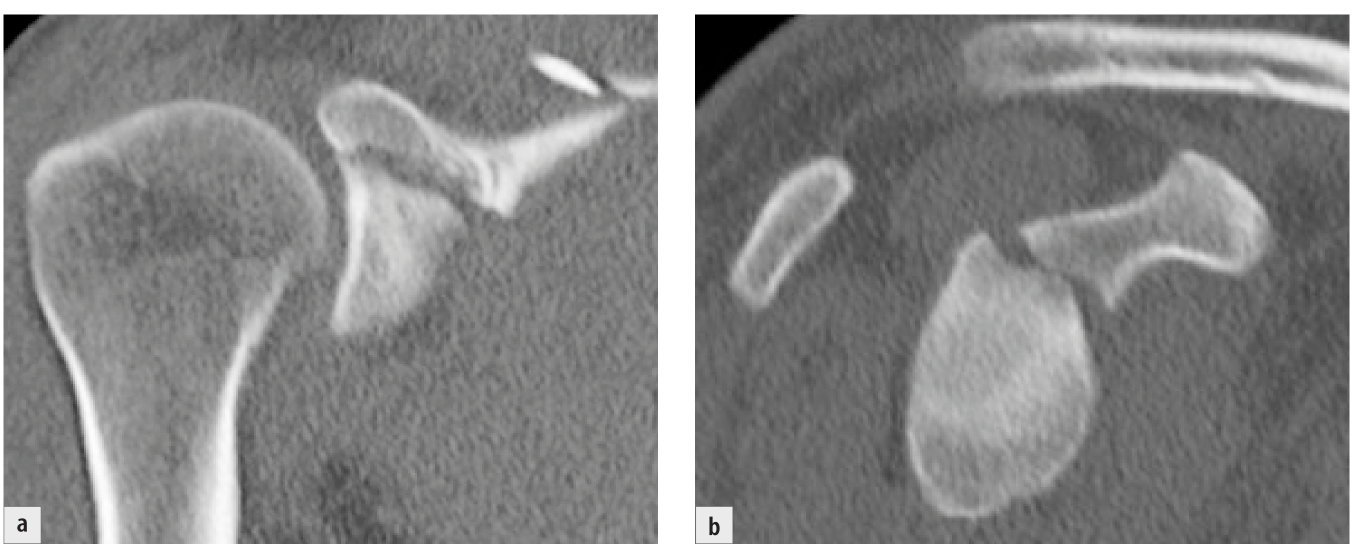

Fig. 6-10 CT scans of a fracture of the superior glenoid (intraarticular fracture of the coracoid base): **a)** 2D CT reconstruction in the plane of the scapular body; **b)** 2D CT reconstruction in the plane perpendicular to the scapular body.

CT EXAMINATION

CT examination has fundamentally changed the radiodiagnostics of scapular fractures [1, 2, 4, 12-15, 21]. It is always indicated when radiographic examination cannot reveal the precise fracture pattern, involvement of the articular surface, or the degree of displacement of the fragments. To get a complete picture of the anatomy of the fracture, it is necessary also to perform, in addition to CT transverse sections, 2D and 3D CT reconstructions.

CT transverse sections are very useful in the assessment of the condition of the glenoid fossa (Fig. 6-9a). They also help to reveal undisplaced fractures of the scapular processes, especially those of the coracoid and acromion.

Two-dimensional CT reconstructions (2D CT) are important for assessment of the articular surface, especially in intraarticular fractures of the base of the coracoid process, i.e., fractures of the superior glenoid or fractures of the entire glenoid (Fig. 6-9b, Fig. 6-10)).

Three-dimensional CT reconstructions (3D CT) are the only method reliably showing the anatomy of the fracture, although they do not capture fine fracture lines, especially in minimally displaced fragments. Reconstructions should be made in several basic views, preferably with subtraction of the ribs, the clavicle and the proximal humerus (Fig. 6-11, Fig. 6-12) [2, 14].

Fig. 6-11 Standardized 3D CT reconstructions of the scapula without subtraction of the surrounding bones: **a)** posterior view; **b)** lateral view; **c)** anterior view.

Fig. 6-12 Standardized 3D CT reconstructions of the scapula with subtraction of the surrounding bones show a complete fracture of the glenoid separated along the line of the surgical neck and an acromial fracture: **a)** posterior view; **b)** lateral view; **c)** view down the supraspinous fossa; **d)** anterior view.

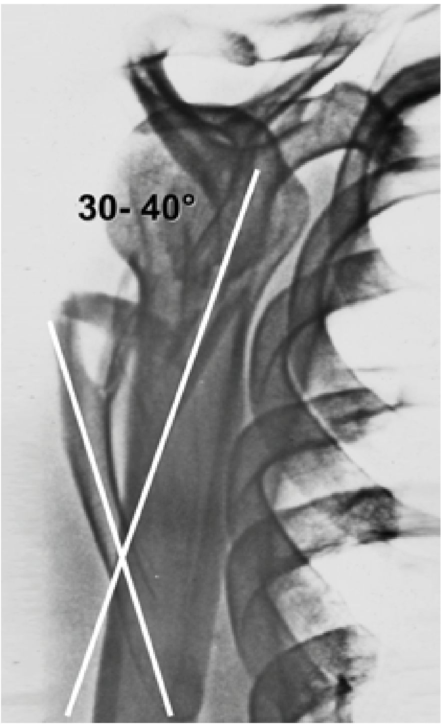

Fig. 6-15 Measuring angular displacement of fragments of the lateral pillar.

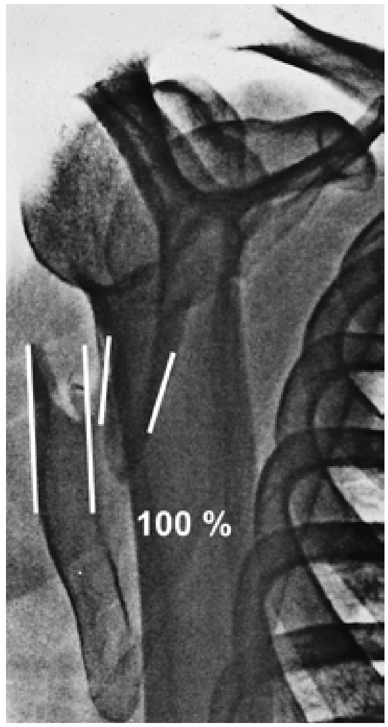

Fig. 6-16 Measuring anterior-posterior translation of fragments of the lateral pillar.

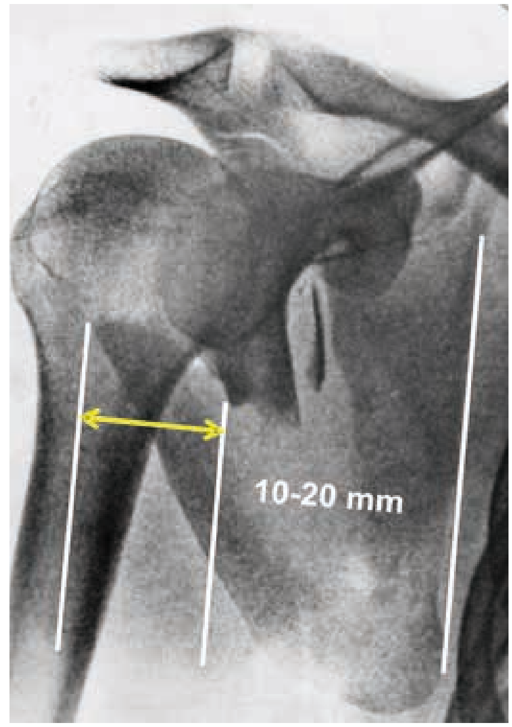

Fig. 6-17 Measuring mediolateral translation of fragments of the lateral pillar.

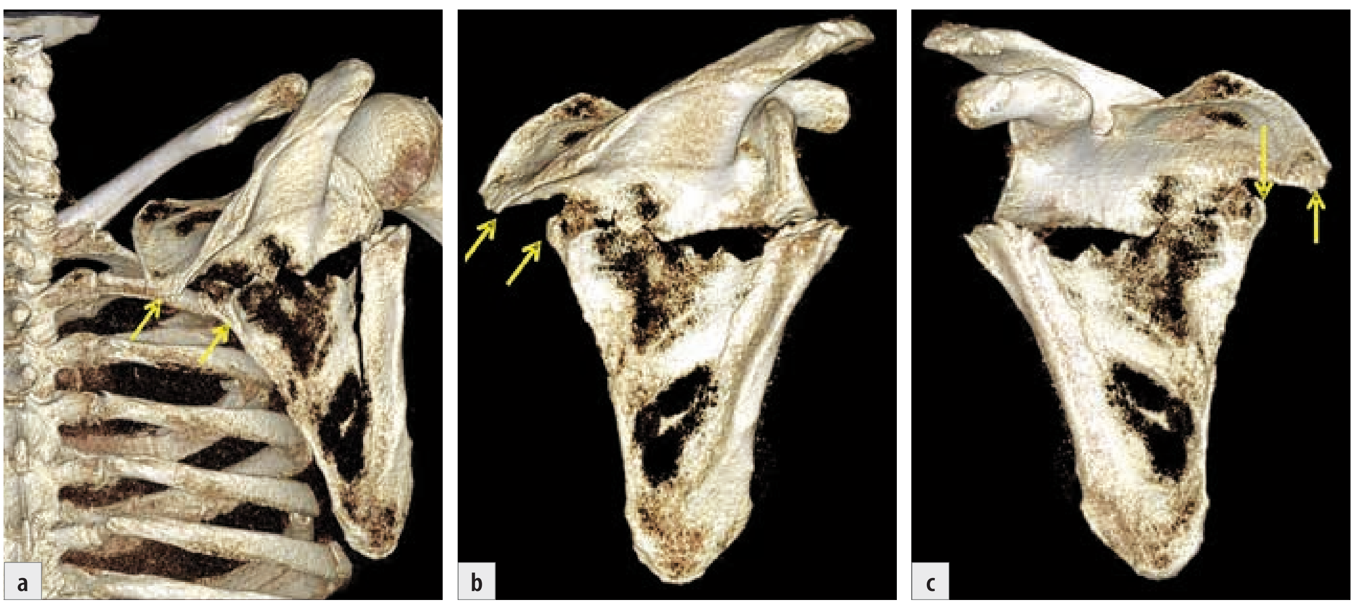

Fig. 6-18 Mediolateral translation of fragments in an infraspinous two-part fracture of the scapular body on 3D CT reconstructions showing lateral displacement of the distal fragment: **a)** posterolateral view; **b)** posterior view; **c)** anterior view.

MEASUREMENTS OF SCAPULAR FRACTURES

Decisions about the method of treatment of scapular neck or body fractures are based primarily on the assessment of the degree of displacement of fragments of the lateral border of the scapula and the relationship of the glenoid to the scapular body. Four basic assessment criteria, i.e., angulation, translation, mediolateral displacement and the glenopolar angle (GPA), quantify the degree of displacement [1, 10, 11]. Measurements may be made using both the Neer projections and 3D CT reconstructions, the advantage of which is a higher accuracy of measurement [1, 28, 30].

Angulation of the main fragments of the lateral border of the scapula may be determined in the Neer II projection, or in the lateral view based on 3D CT reconstructions (Fig. 6-15).