8

CT CLASSIFICATION DEVELOPED BY THE AUTHORS

Development of a comprehensive classification of scapular fractures, reflecting the actual clinical needs, is rendered complex due to a complicated architecture of this bone and the variety of potential injuries. That is why none of the classifications presented in the preceding chapter has been generally accepted. A successful solution of this task requires meeting several basic prerequisites.

The classification should respect the complicated external shape of the scapula, as well as its internal architecture.

The analysis should be based on an adequately large, preferably spontaneously formed series of scapular fractures.

Radiological examination of these fractures should be focused on the elimination of any doubts about their anatomy, so that only the true fracture patterns be included in the classification. For this reason, it is essential to have high-quality 3D CT reconstructions of a maximum of cases available.

The series should comprise an adequate number of fractures treated operatively, in order to derive a detailed picture of these injuries, the optimal surgical approach and technique of internal fixation.

PRINCIPLES OF DEVELOPMENT OF THE CLASSIFICATION

The presented classification had been developed in the period from January 2002 until April 2020, on the basis of an analysis of a series of 519 scapular fractures treated or consulted at the authors' departments (Table 8-1).

All fractures were radiologically examined; CT examination was performed in 475 cases, in combination with 3D CT reconstructions in 383 cases. A total of 153 patients were operated on. This documentation provided exact information about the anatomy of the individual scapular fracture patterns, as well as about the optimal surgical approach, as well as the technique of reduction and internal fixation in the operated cases.

We performed an anatomical study, focused primarily on the internal architecture of the scapula, based on 100 specimens [55]. That study respected a two-pillar architecture of the anatomical body of the scapula, and identified certain clinically important details that have not previously been described, such as the spinomedial angle, the coracoglenoid notch, or the central weakened part of the scapular spine (see Chapter 2).

We analyzed in detail all previously, or currently, used classifications (see Chapter 7), as well as historical descriptions and illustrations of various fracture patterns based on autopsy findings in deceased patients [1-4, 8, 22-39, 41-54].

The first step in the analysis was the identification of individual main fragments, their anatomical shape and the part(s) of the scapula to which they belonged. The anatomical shape was determined on the basis of 3D CT reconstructions and, where applicable, intraoperative findings. In the next step, the courses of the main and secondary fracture lines were analyzed, using radiographs, CT scans, 3D CT reconstructions and intraoperative findings. Some of the fracture lines in undisplaced fractures were not revealed by 3D CT reconstructions, but could be seen on CT scans, or on plain radiographs. The courses of fracture lines were assessed in terms of the internal architecture of the scapula, i.e., their relationship to the major anatomical structures (see below). The determination of the fracture pattern was based on the anatomical part(s) of the scapula involved, the main and secondary fragments and fracture lines.

Our classification does not bring any revolutionary change. It respects a number of generally accepted facts from the preceding schemes, which are only logically arranged and, where necessary, detailed. The few changes made relate primarily to the scapular body fractures and certain peripheral fractures.

BASIC PATTERNS OF SCAPULAR FRACTURES

The basic classification of fractures respected four anatomical parts of the scapula: the body, the neck, the glenoid and processes. A total of five basic groups of scapular fractures were identified, each of which is specific in terms of mechanism of injury, associated injuries to the shoulder girdle, and the degree of severity [5-7, 9-17]:

- scapular body fractures,
- scapular neck fractures,
- glenoid fractures,
- fractures of processes and angles,
- complex scapular fractures.

Each basic type was defined in such a way as to avoid any misunderstandings or confusion.

SCAPULAR BODY FRACTURES

Definition: Scapular body fractures were considered to be those fractures of the anatomical body of the scapula, involving its primary biomechanical construction, i.e., one or both pillars [13, 35, 55].

In this way, three basic types of scapular body fractures were identified, namely those of the spinal pillar, of the lateral pillar and fractures affecting both pillars (Fig. 8-1, Table 8-1).

Fx type	Fxs (N)	Fxs (%)*	M/F (N)	M/F (%)	Age G	Age M	Age F	R/L	Op (N)	Op (%)	Cla (N)	Cla (%)*
Glenoid	**128**	**25**	**99/29**	**77/23**	**48**	**46**	**55**	**62/66**	**59**	**46**	**15**	**12**
AG	41	32	30/11	73/27	52	48	62	24/17	13	32	2	5
PG	5	4	3/2	60/40	48	39	60	3/2	0	0	0	0
SG	22	17	16/6	73/27	43	42	47	6/16	6	27	3	14
IG	50	39	44/6	88/12	48	49	45	21/29	34	68	10	20
TG	10	8	6/4	60/40	45	39	53	8/2	6	60	0	0
Neck	**26**	**5**	**19/7**	**73/27**	**40**	**36**	**51**	**7/19**	**14**	**58**	**6**	**23**
Anat	6	23	4/2	80/20	44	35	61	2/4	4	67	0	0
Surg	13	50	9/4	69/31	39	35	49	4/9	6	46	1	8
Trans	7	27	6/1	86/14	38	38	42	1/6	4	57	5	71
Body	**243**	**47**	**213/30**	**88/12**	**46**	**44**	**56**	**112/131**	**61**	**25**	**64**	**26**
LP	189	78	166/23	88/12	45	43	59	87/102	52	28	55	29
SP	14	6	11/3	79/21	55	54	57	8/6	0	0	3	21
Both Pill	40	16	36/4	90/10	45	46	37	17/23	9	23	6	15
Processes	**102**	**20**	**79/23**	**78/22**	**46**	**45**	**52**	**43/59**	**12**	**12**	**9**	**9**
Co	39	38	29/10	74/26	43	41	49	11/28	2	5	5	13
Ac/LS	35	34	30/5	86/14	48	48	53	15/20	10	29	3	9
SA	6	6	6/0	100/0	40	40	0	4/2	0	0	0	0
IA	22	22	14/8	64/36	53	49	62	13/9	0	0	1	5
Complex	**18**	**3**	**16/2**	**89/11**	**43**	**44**	**37**	**11/7**	**9**	**50**	**2**	**11**
Compl Ea	6	33	6/0	100/0	45	45	0	4/2	3	50	1	17
Compl Ia	12	67	10/2	83/17	42	43	37	7/5	6	50	1	8
STD	**2**	**0**	**1/1**	**50/50**	**48**	**28**	**68**	**0/2**	**1**	**50**	**1**	**50**
Total	**519**	**100**	**427/92**	**82/18**	**46**	**44**	**54**	**235/284**	**153**	**29**	**97**	**19**

Table 8-1 Authors' own series of adult patient scapular fractures – basic data on the 2002-2020 series. **Ac/LS** – fractures of the acromion and the lateral spine, **AG** – anterior glenoid fractures, **Anat** – anatomical scapular neck fractures, **Body** – scapular body fractures, **Both Pill** – fractures of both pillars, **Cla** – associated clavicular fractures, **Co** – coracoid fractures, **Complex** – complex scapular fractures, **Ea** – extraarticular, **F** – females, **Fx, Fxs** – fracture(s), **G** – the entire group, **Glenoid** – glenoid fractures, **IA** – fractures of the inferior angle, **Ia** – intraarticular, **IG** – inferior glenoid fractures, **LP** – lateral pillar fractures, **M** – males, **N** – number, **Neck**– scapular neck fractures, **Op** – operatively treated cases, **PG** – posterior glenoid fractures, **Processes** – process and angles fractures, **R/L** – right/left side, **SA** – fractures of the superior angle, **SG** – superior glenoid fractures, **SP** – spinal pillar fractures, **STD** – scapulothoracic dissociation, **Surg** – surgical scapular neck fractures, **TG** – total glenoid fractures, **Trans** – transspinous neck fractures, * – The share of individual fracture types in the whole series is shown in the white line, the share of individual subtypes in the respective fracture type is included in the light blue line. The percentage is rounded to whole numbers. Age in years.

Fractures of the spinal pillar

These fractures involved both the supraspinous and infraspinous fossae (**Fig. 8-2**). In a majority of cases, the main fracture line passed vertically from the supraspinous fossa, through the weakened central part of the scapular spine towards the medial border of the infraspinous fossa, or to the inferior angle of the scapula (**Fig. 8-3**). Less frequently, the base of the scapular spine was broken off the scapular body (**Fig. 8-4**). The lateral pillar always remained intact and fragments were displaced relatively insignificantly.

Fractures of the lateral pillar

These fractures affected only the infraspinous fossa. The main fracture line always propagated from the proximal half of the lateral pillar, usually close to the circumflex groove. Based on its course, the presence of secondary fracture lines and the number of circumferential fragments, fractures of the lateral pillar were divided into three subtypes. In assessing the number of fragments, distinction was made between the circumferential and the intercalary fragments. *Circumferential fragments* carried part of the circumference of the infraspinous fossa. *Intercalary fragments* were those separated from the

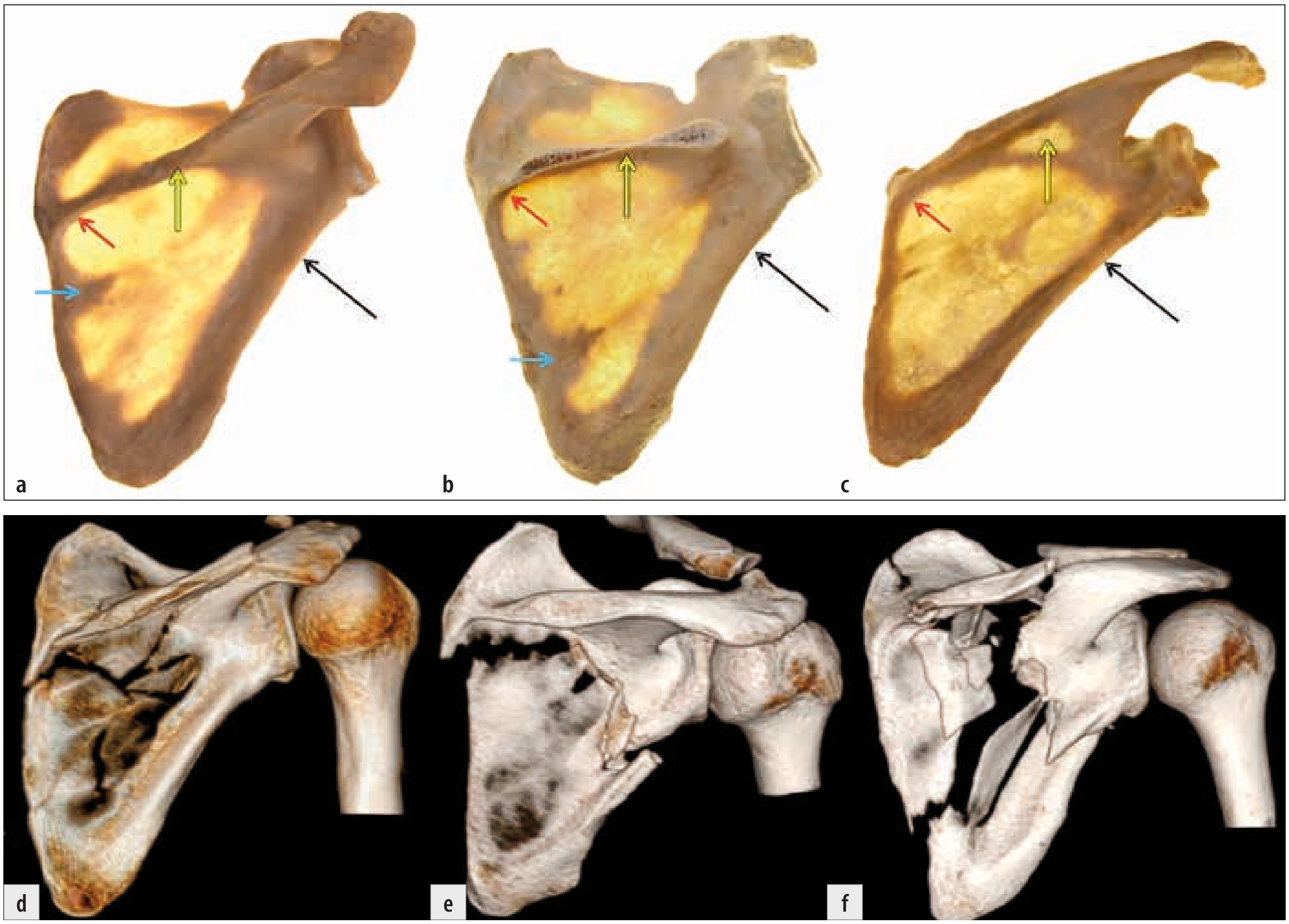

Fig. 8-1 Architecture of the scapula and courses of fracture lines in scapular body fractures: **a)** transilluminated scapula, posterior view; **b)** transilluminated scapula with resected scapular spine, posterior view; **c)** transilluminated scapula, posteroinferior view; **d)** fracture of the spinal pillar; **e)** fracture of the lateral pillar; **f)** fracture of both pillars. Red arrow – spinomedial angle; black arrow – circumflex groove (weakened area of the lateral pillar); blue arrow – horizontal muscular septum; yellow arrow – central weaker area of the scapular spine.

Fig. 8-2 Types of spinal pillar fractures: **a)** a fracture line passing through the weaker central part of the scapular spine; **b)** separation of the scapular spine from the scapular body.

passed through the medial third of the spinal pillar to the superior angle of the scapula, i.e., medial to the central weaker part, which always remained intact. Displacement of the fracture in the region of the spinomedial angle and the superior angle of the scapula was minimal (Fig. 8-12).

Fractures involving the central part of the spinal pillar were the most severe injuries to the scapular body. The fracture line always passed through the weaker central part of the scapular spine. A fracture of the lateral pillar was constantly displaced more than a fracture of the scapular spine. A large glenoid fragment carried the lateral part of the scapular spine, the acromion and the coracoid (Fig. 8-13).

Commentary

The above-described division of scapular body fractures, based on injuries to the pillars, has no analogy in the preceding classifications [1, 22-25, 48-50, 52] most of which distinguished between two groups of these fractures, i.e., two-part and comminuted ones. Only Imatani [33] divided them into vertical, transverse and comminuted fractures. As a whole, his scheme is similar to our division into the three basic patterns.

A classification respecting scapular pillars is logical. It reflects both the internal architecture of the scapula and the degree of fracture severity (displacement, operative treatment), and reduction and internal fixation of one or, if need be, both pillars is an essential step to restore continuity of the biomechanical body.

All fractures of the spinal pillar in our series were treated non-operatively, due to their insignificant displacement. Fractures of the lateral pillar were the most common and were usually caused by medium-energy trauma (a fall from a bicycle, or from a slowly-moving motorcycle). Many of them were markedly displaced. Their more detailed breakdown into subtypes was important mainly in terms of their operative treatment, particularly extension of the Judet approach and the scope of the internal fixation. As mentioned in the preceding chapter, two-part fractures are often incorrectly classified in the literature as scapular neck fractures. Fractures of both pillars, especially those with a fracture line passing through the central part of the scapular spine, were caused by high-energy mechanisms. These severest of scapular body fractures were in our series operated on most frequently.

SCAPULAR NECK FRACTURES

Definition: Scapular neck fractures are extraarticular fractures of the lateral angle separating the glenoid from the scapular body (Fig. 8-14, Fig. 8-15) [7, 22, 25, 51, 52]. Three basic types were distinguished based on the course of the fracture line and the shape of the glenoid fragment, i.e., fractures of the anatomical neck, of the surgical neck and transspinous fractures of the neck (Fig. 8-16).

Fractures of the anatomical neck

These fractures are rare [6, 7]. They separate only the glenoid fossa from the scapular body. The fracture line starts in the coracoglenoid notch and runs through the spinoglenoid groove to the lateral border of the scapular body, as a rule 3-4 cm distal to the inferior rim of the glenoid (Fig. 8-17). The glenoid fragment bearing only attachments of the long head of the biceps

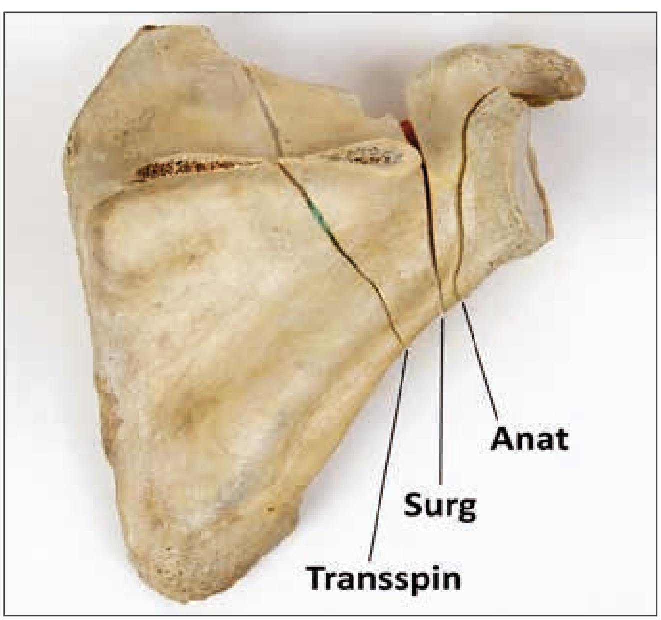

Fig. 8-14 Scapular neck fractures – courses of fracture lines on a scapular bone specimen. **Anat** – anatomical neck fracture, **Surg** – surgical neck fracture, **Transspin** – transspinous neck fracture.

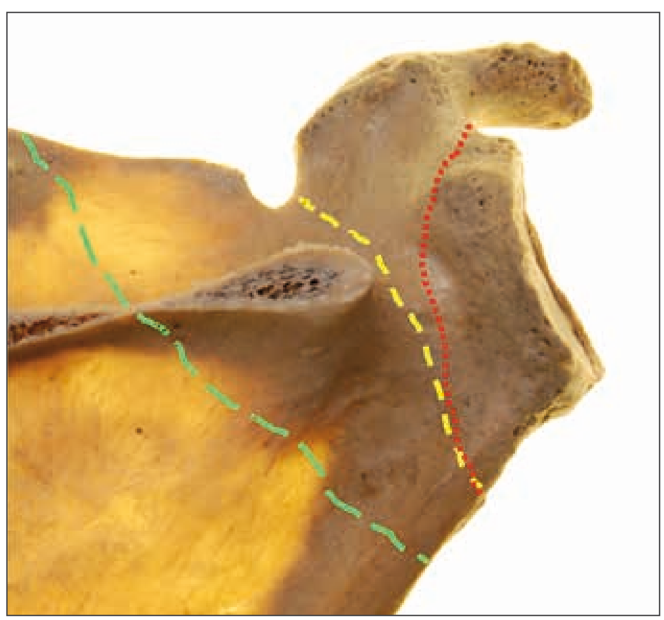

Fig. 8-15 Scapular neck fractures – detailed courses of fracture lines on a scapular bone specimen. Red line – anatomical neck fracture, yellow line – surgical neck fracture, green line – transspinous neck fracture.

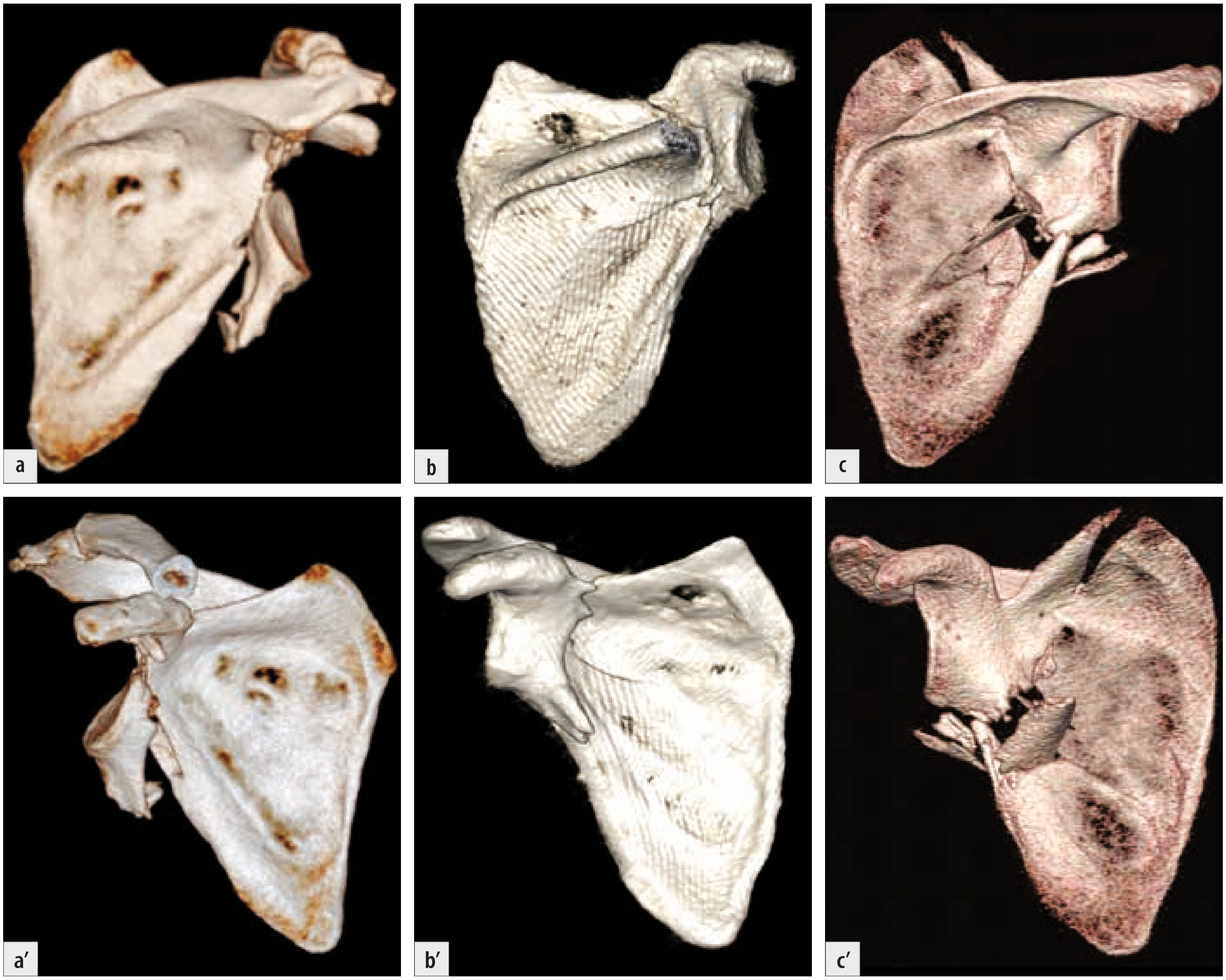

Fig. 8-16 Scapular neck fractures – anterior and posterior views, on 3D CT reconstructions: **a)** anatomical neck fracture; **b)** surgical neck fracture (posterior view with subtraction of the acromion); **c)** transspinous neck fracture.

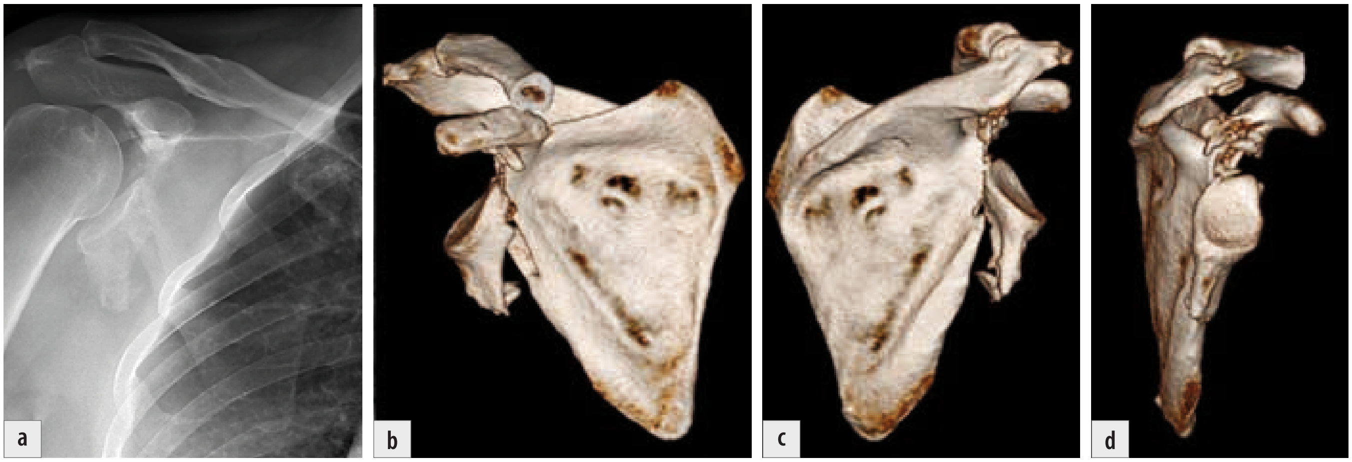

Fig. 8-17 Fracture of the anatomical neck of the scapula: **a)** radiograph, Neer I projection; **b)** 3D CT reconstruction – anterior view; **c)** 3D CT reconstruction – posterior view; **d)** 3D CT reconstruction – lateral view.

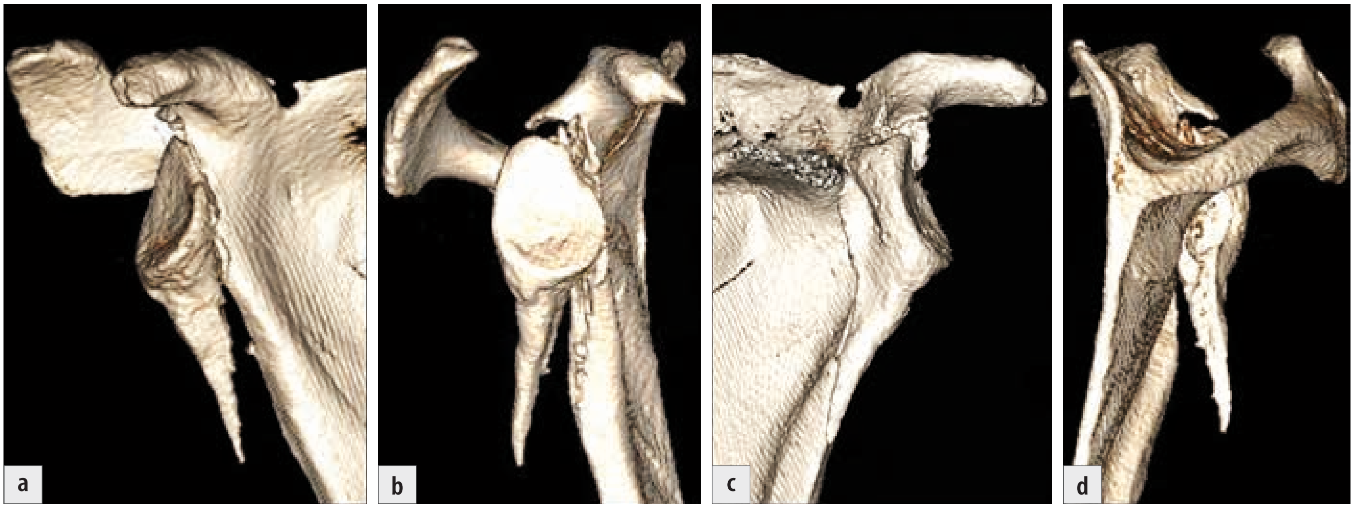

Fig. 8-18 Typical displacement of an anatomical neck fracture. Fragment displaced distally and into valgus, the superior pole of the glenoid is rotated anteriorly, the distal spike of the fragment rotated posteriorly: **a)** anterior view; **b)** lateral view; **c)** posterior view with subtraction of the acromion; **d)** medial view.

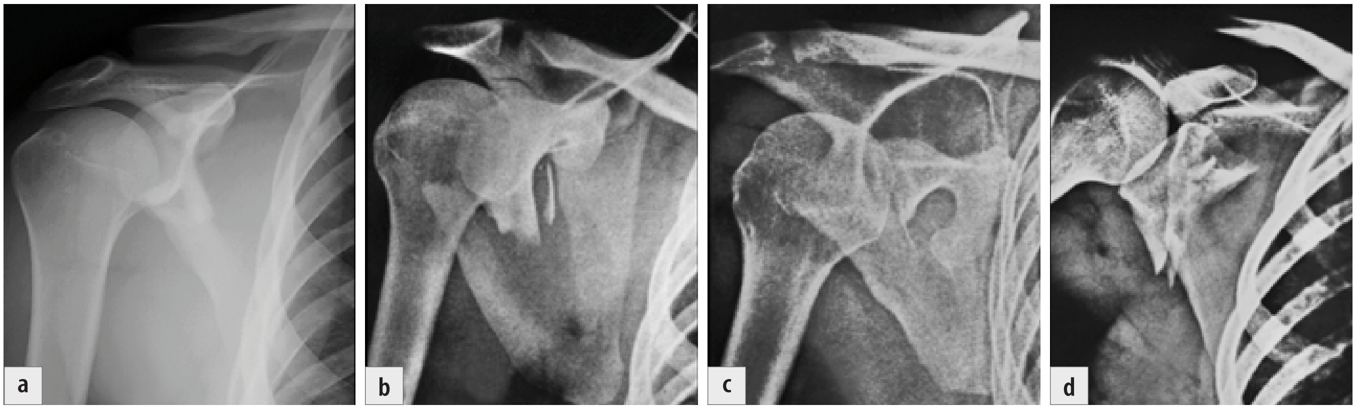

Fig. 8-19 Fractures of the surgical neck of the scapula: **a)** stable fracture; **b)** rotationally unstable fracture; **c)** completely unstable fracture; **d)** unstable fracture with a separated coracoid.

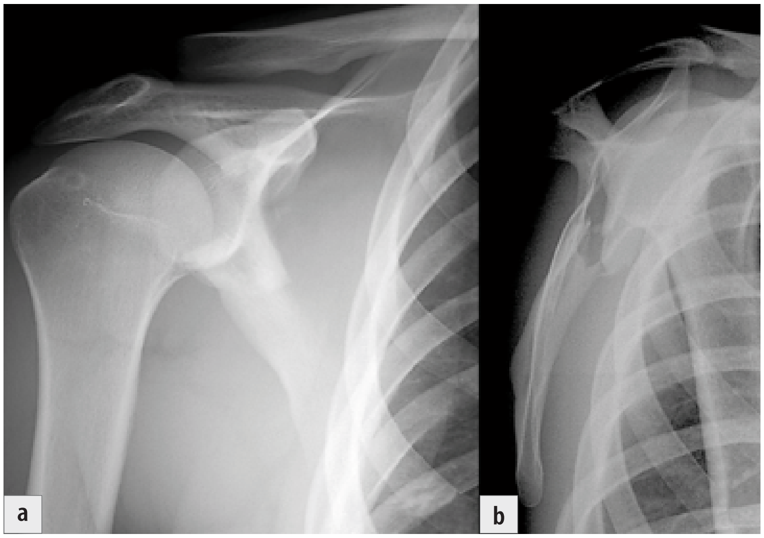

Fig. 8-20 Radiograph of a stable fracture of the surgical neck of the scapula: **a)** antero-posterior view; **b)** lateral view.

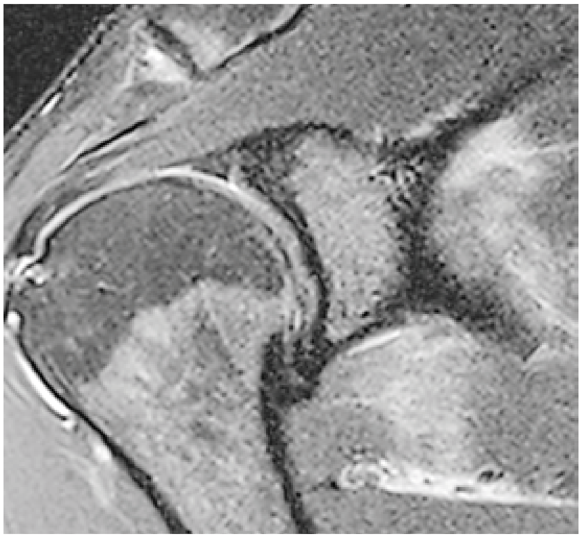

Fig. 8-21 A stable fracture of the surgical neck of the scapula on MRI coronal scan.

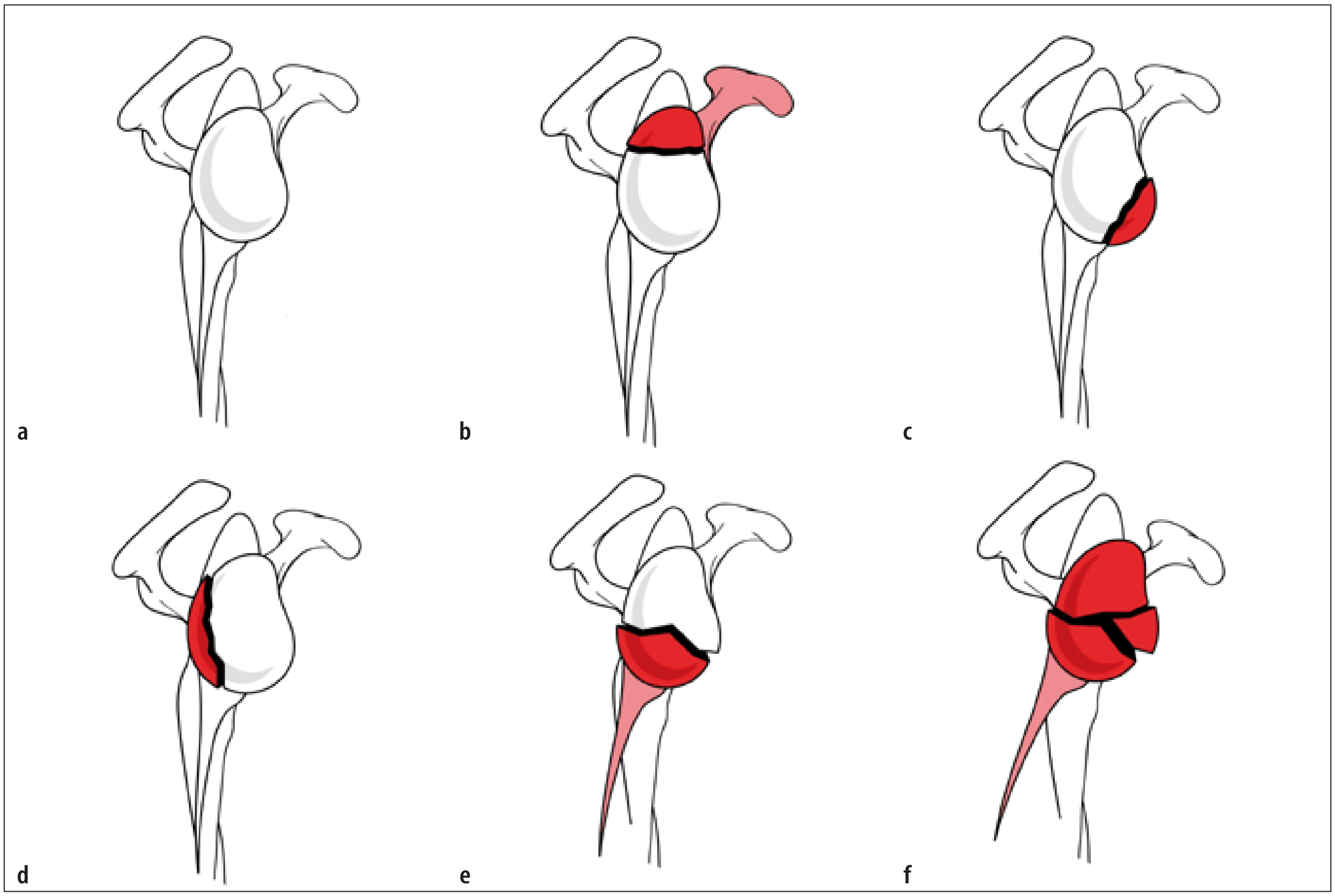

Fig. 8-30 Basic types of glenoid fractures: **a)** intact glenoid; **b)** superior glenoid fracture; **c)** anterior glenoid fracture; **d)** posterior glenoid fracture; **e)** inferior glenoid fracture; **f)** entire glenoid fracture.

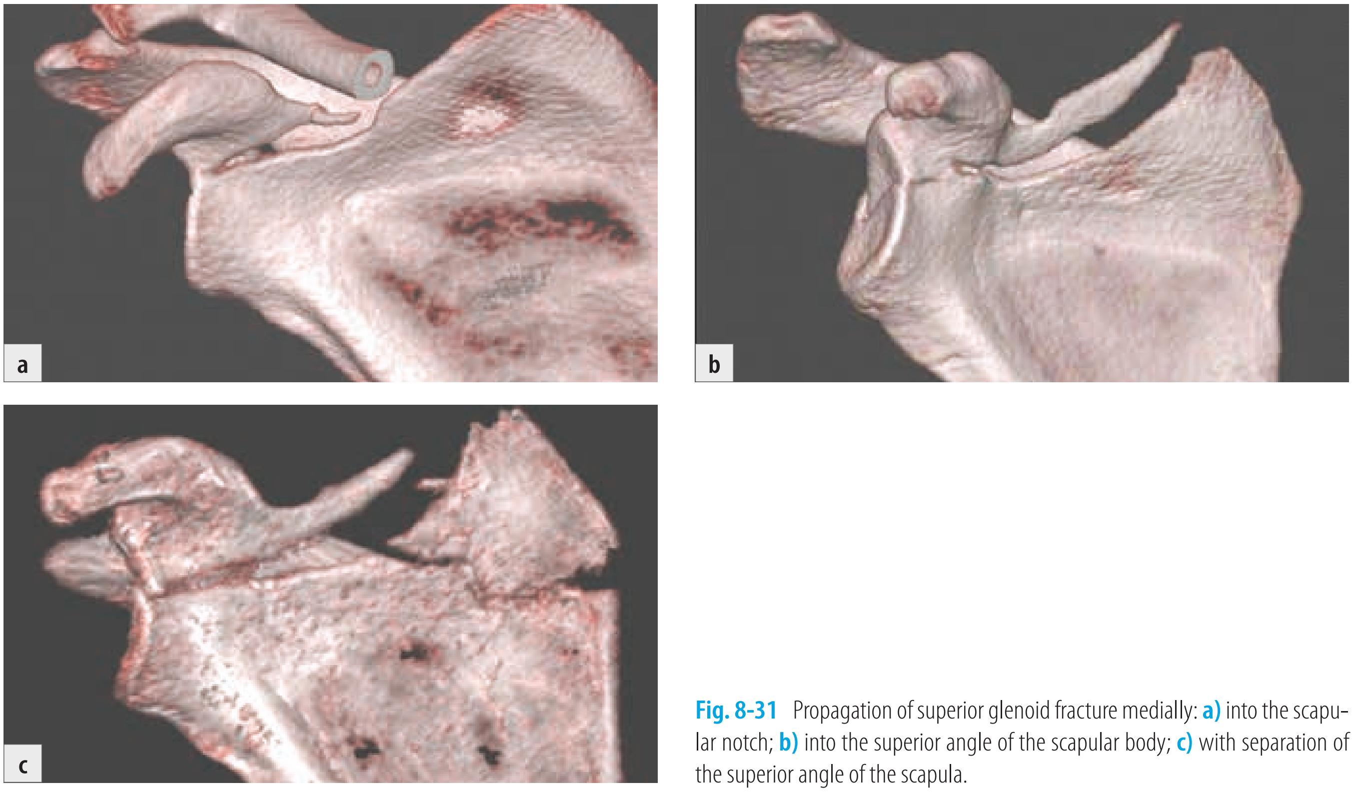

Fig. 8-31 Propagation of superior glenoid fracture medially: **a)** into the scapular notch; **b)** into the superior angle of the scapular body; **c)** with separation of the superior angle of the scapula.

9

PRINCIPLES OF TREATMENT

The aim of treatment of scapular fractures is to restore the normal function of the shoulder girdle, i.e., a full, pain-free range of motion and restoration of muscle strength.

In cases of glenoid fractures, it is necessary to restore the congruence and functional stability of the glenohumeral joint; fractures of the scapular neck require restoration of its anatomical relationship to other parts of the scapula; in fractures of the scapular body it is essential to reconstruct the affected pillars and "congruence" of the costal surface of the body of the scapula, allowing its normal movement over the chest wall. In process fractures it is important to eliminate narrowing of the subacromial space (impingement syndrome) and to restore the function of the superior shoulder suspensory complex (SSSC).

Due to the rich blood supply to the scapula, scapular fractures heal readily. Non-unions, resulting from biomechanical factors, occur most commonly in fractures of the scapular spine and of the coracoid. In scapular body fractures, non-unions are rare, and scapular neck fractures and central glenoid fossa fractures have never been described as failing to unite.

The following methods are currently used to treat scapular fractures:

- nonoperative treatment,
- open reduction and internal fixation,
- arthroscopic treatment,
- percutaneous fixation under radiographic, or arthroscopic, control,
- combination of arthroscopy and open reduction and internal fixation.

The choice of the treatment method depends on several factors. On the one hand, they include primarily the fracture pattern and displacement, bone quality, local soft-tissue condition, the patient's age, general condition and functional demands; and the experience and skills of the treating surgeon, on the other.

DEVELOPMENT OF TREATMENT METHODS

Opinions on an optimal method of treatment have undergone a long historical evolution [6]. Although the first efforts to treat scapular fractures operatively date back to the beginning of 20th century, for decades there was a general consensus that scapular fractures should be treated nonoperatively, as the results of this treatment were reportedly very good. This opinion was based mainly on the studies by Zdravkovic and Damholt [73], Lindholm et al. [50] and Wilber et al. [72] published in the 1970s. Publications dealing with operative treatment were quite rare at that time and their authors came primarily from the AO community [37, 38, 52, 68].

Ten years later, the situation began to change, mainly thanks to studies by Hardegger et al. [29, 30] of 1984. These, as well as other, studies [44] showed excellent and very good results of open reduction and stable internal fixation in both the intra- and extraarticular scapular fractures.

At the same time, Armstrong and Spuy [5] and Gagey et al. [25] published studies pointing out poor long-term results of nonoperative treatment of scapular fractures. After another decade, a similar fact was noted in studies by Ada and Miller [1] and by Nordqvist and Petersson [58]. At the beginning of 21st century, additional articles were published by other authors [60, 62], who found correlation between the outcomes of nonoperative treatment of displaced fractures and the GPA value. It became obvious that a number of patients with scapular body, or neck, fractures, which healed in a nonanatomical position, suffered from pain, limited range of movement and sometimes even damage to the rotator cuff demonstrated by MRI. Treatment philosophy has also changed following the introduction of CT, and especially 3D reconstructions.

Three analytical articles published between 2006 and 2013, dealing with the results of nonoperative and operative treatment of scapular fractures, marked an important milestone in addressing this highly complex issue [21, 47, 74].

Zlowodski et al. [74], in 2006, analyzed 520 scapular fractures in 22 studies and found that:

- 80% of the glenoid fractures were treated operatively, with excellent or good results achieved in 82% of isolated glenoid fractures,
- 80% of isolated fractures of the scapular body were treated nonoperatively, with excellent or good results achieved in 86% of them,
- 83% of all scapular neck fractures without involvement of the glenoid were treated nonoperatively, with excellent or good results achieved in 77% of them.

Lantry et al. [47], in 2008, reviewed the results of 243 scapular fractures treated operatively in 17 cohorts, with the following conclusions:

- 48% of patients sustained a fracture of the glenoid fossa, 7% a fracture of the glenoid rim, 26% a fracture of the scapular neck, and 8% a process fracture; ipsilateral fractures of the clavicle, or an AC dislocation, were noted in 26% of them,
- the indication for operative treatment of any glenoid fracture was displacement of 4 to 10 mm, most often 5 mm,
- 4.2% of patients developed postoperative infective complications, 2.4% sustained an injury to a nerve, most frequently the suprascapular nerve, 7.1% of cases required removal of hardware for local problems, or for implant breakage,

- 163 patients were evaluated in terms of their functional outcomes, using different scoring systems, at an average follow-up of 50 months, with excellent or good results achieved in 83% of cases, and fair or poor results in 17% of patients.

Dienstknecht et al. [21], in 2013, evaluated the outcomes of treatment of 463 scapular neck fractures reported in 22 articles, with the following result:

- the number of scapular neck fractures was quite high, compared to other types of scapular fractures, and seems to have been overestimated,
- 234 fractures were treated operatively,
- the number of pain-free patients was higher in the operatively-treated cases,
- operative treatment allowed restoration of normal GPA values and elimination of translational displacement, which, as expected, led to better long-term results,
- the total number of complications in patients who were operated on accounted for 10%.

The authors of all three articles came to the same conclusion, i.e., that there were significant differences between individual studies, and that the validity of the data presented was often questionable.

Since then, additional studies have been published, reflecting the development of both nonoperative and operative treatment [2, 4, 8–10, 12, 18, 34, 35, 45, 66, 67].

EVALUATION METHODS AND TREATMENT RESULTS

At the beginning of the 1980s, evaluation of the results of treatment of scapular fractures was highly subjective. At that time, various scoring systems began to develop, leading to a more objective assessment of the achieved outcomes.

EVALUATION SYSTEMS

There are various evaluation systems to measure functional outcomes of the shoulder joint: American Shoulder and Elbow Surgeons (ASES) score [61], Constant-Murley score [19], DASH score [36], Herscovici score [33], Neer score [57], Rowe score [63], Oxford questionnaire [20], Short Form 36 score [71], Simple Shoulder Test (Gosens) [51], University of California Los Angeles (UCLA) score [23]. Authors inspired by P.A. Cole assess also muscle strength and range of motion on the involved and intact sides [18, 66, 67]. The most frequently used are the Constant-Murley score [19], DASH score [36] and Short Form 36 score [71]. The variability of measurement tools, however, does not allow an accurate comparison of the outcomes of individual studies.

OUTCOMES OF NONOPERATIVE TREATMENT

In the last 50 years, there appeared a number of studies of varying quality, evaluating the outcomes of nonoperative treatment of scapular fractures. Older studies were burdened with serious methodological deficiencies, nevertheless, their conclusions had for a long time served as arguments to support this type of treatment. More recent studies began to use the above-mentioned scoring systems, allowing a more objective evaluation of functional outcomes. The following overview presents the published studies in the chronological order.

Zdravkovic and **Damholt** [73], in 1974, reported a group of 40 patients, with a mean age of 44 years (range, 13-72), evaluated after nonoperative treatment for a comminuted, or markedly displaced, scapular fracture (2 fractures of the anatomical neck, 31 of the surgical neck, 7 of the surgical neck and glenoid), on average over a period of 107 months (range, 2-96). The authors came to the conclusion that nonoperative treatment provides fully satisfactory results.

Note – the structure of fracture patterns and inaccuracies of the follow-up data make the study questionable.

Lindholm et al. [50], in 1974, evaluated the results of treatment of scapular fractures (13 scapular body fractures, 6 scapular neck fractures, including one with glenoid involvement) in 19 patients, with the mean age of 39 years (range, 15-81) and the follow-up of 0.5 to 10 years. But for one patient, the results were classified as excellent.

Müller-Färber [56], in 1976, reported 48 patients treated nonoperatively for a scapular fracture, without specifying their mean age, or the follow-up period. Of 27 patients with a scapular body fracture, the result was found good in 21 and fair in 5 cases; in 1 case it was poor. In 18 patients with a scapular neck fracture, the result was evaluated as good in 13 and satisfactory in 4 cases; in 1 case it was unsatisfactory. Of 3 glenoid fractures, the result was good in 2 cases and unsatisfactory in 1 case.

Wilber and **Evans** [72], in 1977, presented their experience in the treatment of 55 scapular fractures (30 fractures of the body, 6 of the neck, 6 of the glenoid, 4 of the acromion, 3 of the spine and 1 of the coracoid) in 40 patients with a mean age of 34 years (range, 3-80). Only 2 patients (1 fracture of the body, 1 coracoid fracture) were operated on. The follow-up period ranged between 6 and 20 months. Excellent results were recorded in 30 patients with a fracture of the scapular body and neck; worse results were observed in 10 patients with a fracture of the acromion, the coracoid, the spine or the glenoid. Nonetheless, the authors have concluded that operative treatment is indicated only exceptionally, primarily in glenoid fractures.

Gagey et al. [25], in 1984, reviewed the results of nonoperative treatment of scapular fractures in 43 patients with a mean age of 40 years (range, 17-82) and a mean follow-up of 6 months (range, 3-24). They found that out of 12 displaced fractures of the scapular neck, the result was fair, or poor, in 11 cases.

Armstrong and **van der Spuy** [5], in 1984, studied a series of 64 nonoperatively treated fractures in 62 patients, with a mean age of 42.5 years (range, 20-67). Fractures of the scapular body accounted for 55%, of the scapular neck for 18%, of the glenoid for 9%, and process fractures for the remaining 18%. The study focused mainly on the mechanism of the injury and the incidence of associated injuries (in 81% of cases). Mortality accounted for 9.7%. The follow-up period was not specified in the 52 patients evaluated, but according to the available data it may be estimated to be in the range of

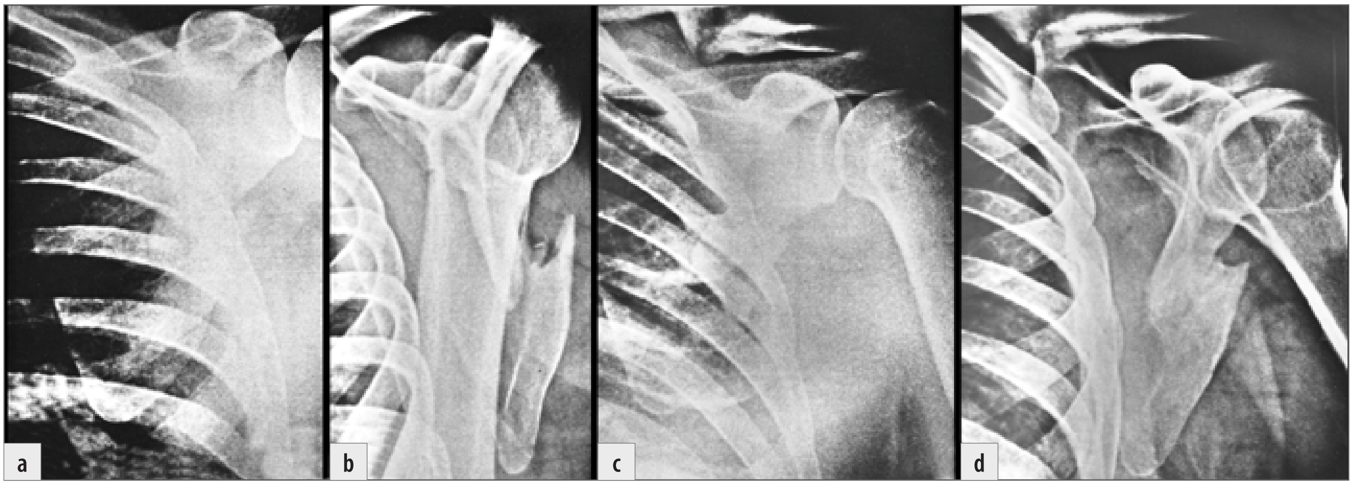

Fig. 9-1 Nonoperative treatment of an infraspinous fracture of the scapular body in a 55-year-old man: **a+b)** post-injury radiographs in the anteroposterior and Y-views showing an evident shortening of the lateral pillar; **c+d)** Neer I and ap projections of the shoulder joint 6 months post injury show healing in the original position.

Fig. 9-2 Non-operative treatment of an infraspinous fracture of the scapular body in the 55-year-old man from Fig. 9-1. Excellent functional outcome 6 months after the injury.

within one month of the injury. Full active range of motion should be restored during the second month. Beginning from the third month, strengthening of the rotator cuff muscles and parascapular muscles may be started, and during the fourth month, all restrictions can be lifted and full load-bearing permitted (**Fig. 9-1**, **Fig. 9-2**).

Exceptions are fracture-dislocations of the glenoid, where immobilization should be longer, 5 to 6 weeks, in certain cases. The same applies to fractures of the scapular spine and the coracoid, with a higher risk of non-union.

OPERATIVE TREATMENT

Operative treatment of scapular fractures, particularly the extraarticular ones, is currently the subject of intense debate; nevertheless, the number of its advocates is increasing. There are several options for operative management [6, 16, 30, 47, 74]:

- open reduction and internal fixation,
- percutaneous fixation under radiographic, or arthroscopic, control,
- arthroscopic treatment,
- combination of arthroscopy and open operative treatment.

INDICATION CRITERIA FOR OPERATIVE TREATMENT

There are two types of indication criteria used to determine an optimal therapeutic procedure.

Radiological criteria, based on radiographs and CT scans, are used to assess the fracture pattern, the number and displacement of fragments.

Clinical criteria serve for assessment of the patient's personality and include primarily the patient's age, general condition, limb dominance and functional requirements, as well as expectations from the suggested operation. In younger patients it is necessary to consider also the possibility of starting rehabilitation immediately after operation and, thereby, achieve a prompter restoration of the function. It is also important to take into account all other associated injuries, mainly those to the chest and the ipsilateral shoulder joint, and to assess the condition of soft tissues (skin abrasion, open fracture).

Essential for proper assessment of all the criteria and the choice of an optimal procedure is the knowledge, experience and skills of the treating surgeon.

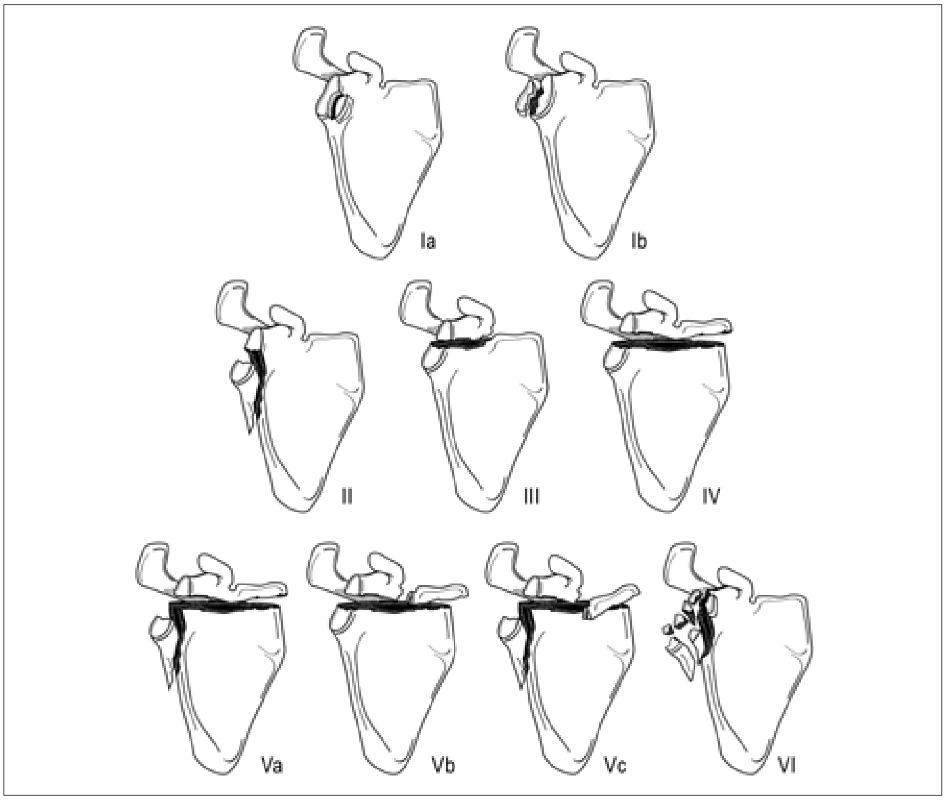

Fig. 9-3 Goss classification of glenoid fractures. For description see the text. Modified according to [26].

Development of radiological criteria

Older studies only mentioned qualitatively greater, or more severe, fragment displacements, without quantification. Only later, did distinction begin to be made between indications for intraarticular and extraarticular fractures.

Intraarticular fractures

Goss [26], in 1992, was one of the first authors to publish more detailed indication criteria in individual patterns of glenoid fractures (Fig. 9-3):

- In types Ia and Ib, instability can be anticipated if the *fracture is displaced by 10 mm or more and at least one fourth of the anterior aspect, or one third of the posterior aspect, of the cavity is involved*.
- In type II, operation is indicated if there is *an articular step-off of 5 mm and greater,* or if *the inferior fragment displaces with inferior subluxation of the humeral head*.
- In type III, operation is indicated if there is *an articular step--off of 5 mm, or greater, and the superior fragment is displaced laterally relative to the inferior aspect of the glenoid cavity,* or if there is *a severe associated SSSC disruption*.
- In type IV, operation is indicated if there is *an articular step-off of 5 mm or greater,* or if *the superior and inferior glenoid fragments are widely separated*.
- In type V, indications for operation include *an articular step-off of at least 5 mm, or greater*, *severe separation of the articular surfaces, inferior displacement of an inferior glenoid fragment with associated inferior subluxation of the humeral head, or a severe SSSC disruption associated with a separate superior glenoid fragment*.
- In type VI, *nonoperative treatment* is recommended, due to extensive comminution of the articular surface.

Schandelmaier et al. [64], in their study of 2002, considered the indication for operative treatment of glenoid fractures of Goss type II to V as *fragment displacement of more than 5 mm*.

Anavian et al. [4], in 2012, indicated operation for glenoid fractures *with a step-off, or gap, in the articular surface of 4 mm or more* (Fig. 9-4).

Tatro et al. [67], in 2018, postulated as an indication an *intra-articular gap/step-off 4 mm or more, and involvement of 25% of the articular surface*.

Extraarticular fractures

Ada and **Miller** [1], in 1991, recommended operative treatment of scapular neck fractures with *a medial translation of more than 1 cm, or angulation of 40 degrees*.
Note – this applied primarily to type II C, which is now understood to be a transverse infraspinous fracture of the scapular body.

Goss [27], in 1994, slightly adapted these criteria for scapular neck fractures as *translational displacement greater than, or equal to, 1 cm, or angulatory displacement greater than, or equal to, 40 degrees (in either the coronal or the transverse plane)*. These values were later adopted by other authors [4].

Fig. 9-4 Indication criteria for operative treatment of glenoid fractures – a step-off, or gap, of 4 mm, involvement of 25% of the articular surface.

Cole [14] presented his new criteria in 2002. At that time, he evaluated three basic factors related to the position of fragments of the lateral border of the scapular body, including the glenoid, i.e., translation, angulation and medialization. Subsequently, the criteria were specified in greater detail [16, 66, 67].

The initial indication scheme recommended consideration of operative treatment in cases of [14]:

- *100% anterior/posterior translation of fragments of the lateral border* (**Fig. 9-5**),
- *30-degree angular displacement of the glenoid relative to the lateral border of the scapula* (**Fig. 9-6**),
- *"medialization" of the glenoid relative to the lateral border of the scapular body of more than 1 cm* (**Fig. 9-7**).

The current indications used by Cole and his colleagues in extraarticular fractures of the scapular body and neck include:

- *mediolateral translation of 20 mm,*
- *angular deformity of fragments of 45 degrees, as measured on the scapular Y-view,*
- *medial/lateral displacement of 15 mm, angulation of more than 30 degrees,*
- *double disruption of the SSSC (coracoid, acromioclavicular ligament, coracoclavicular ligament, clavicle, acromion, scapular neck) both displaced at least by 10 mm,*
- *a GPA less than 22 degrees,*
- *open fractures*.

In isolated fractures of the coracoid and acromion the criterion is a *displacement of at least 10 mm* [2, 4, 16, 66, 67].

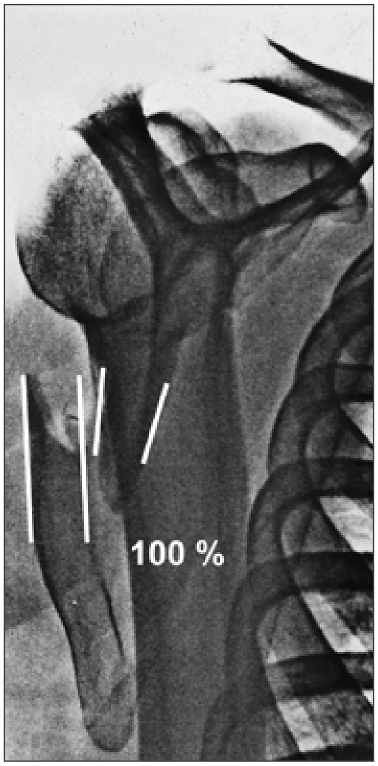

Fig. 9-5 The original Cole's indication criteria for operative treatment of the scapular body and neck fractures – 100% translation of lateral pillar fragments.

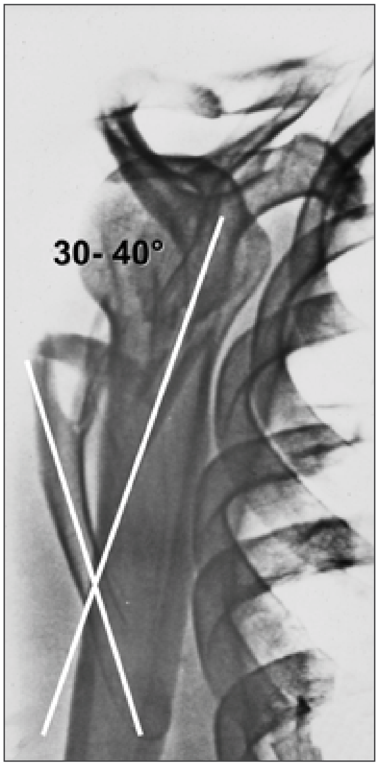

Fig. 9-6 The original Cole's indication criteria for operative treatment of the scapular body and neck fractures – angulation of lateral pillar fragments of more than 30 degrees.

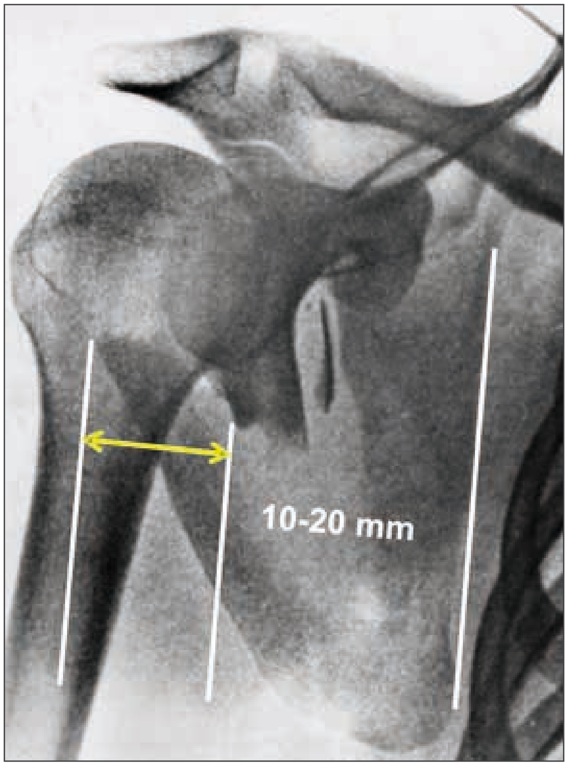

Fig. 9-7 The original Cole's indication criteria for operative treatment of the scapular body and neck fractures – mediolateral translation of lateral pillar fragments of more than 1 cm.