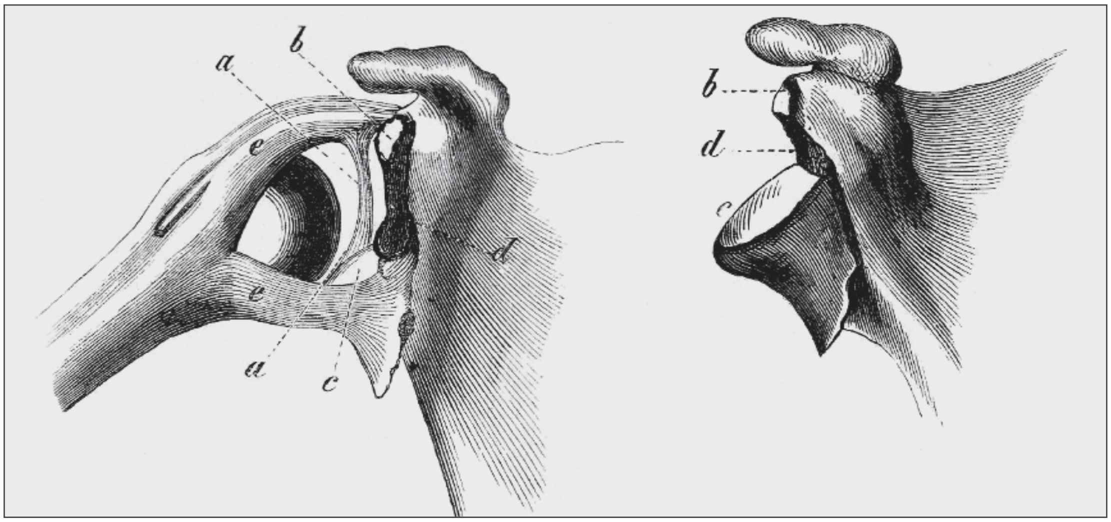

Fig. 1-15 Fracture of the lower glenoid associated with separation of the long head of biceps in a case treated by Spence and Steell [161], but published in the Gurtl's textbook [66].

Kirbride [97] described, in 1835, the case of a man hit by a railway locomotive, who sustained a transverse fracture of the scapula and laceration of the gluteal muscles, and who died as a result of the injuries.

Of great value for understanding the mechanism and anatomy of fractures of the coracoid process were case reports published by **South** [160] in 1839 and **Holmes** [81] in 1858.

A case of an open fracture of the inferior pole of the scapula, in a 16-year-old boy run over by a carriage, was described by **Sissons** [158] in 1860. The patient recovered in three weeks.

Spence and **Steell** [161] were probably the first authors to present a case of glenoid fossa fracture on the basis of clinical description and autopsy in 1863 (see below).

A combined fracture of the scapular body, the acromion and the coracoid in a patient run over by a vehicle, with fatal consequences, was reported by **Kelly** in 1869 [94].

A case of a successfully treated open scapular fracture, caused by a man's fall onto his axe whilst cutting down a tree, was described by **Rosser** in 1873 [152].

A gunshot injury to the scapular body with fatal consequences was recorded by **Stokes** [162] in 1884.

Division of the scapula by a sword wielded by a *"Mohammedan fanatic"* was reported by **Ogilvie** [132] in 1894.

In 1895, **Holmden** [80] reported an open fracture of the neck of the scapula and a closed fracture of the shaft of the humerus. The patient recovered without sequelae.

A fatal injury to the scapula, caused by a falling crane, and associated with rupture of the subclavian artery and vein, was presented in 1891 by **Smith** [159].

In 1896, **Bonnet** [17] published a case of a comminuted fracture of the scapula with devastation of soft tissues and fracture of the humerus, also caused by a falling crane, in which interthoraco-scapular amputation did not prevent the patient's death.

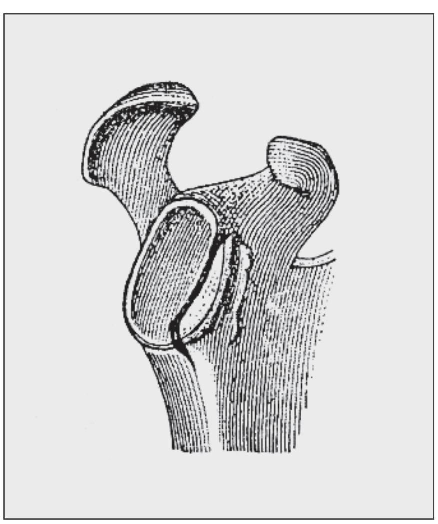

Fig. 1-16 Drawing of a fracture of the anterior rim of the glenoid in Hoffa's textbook of 1888 [79].

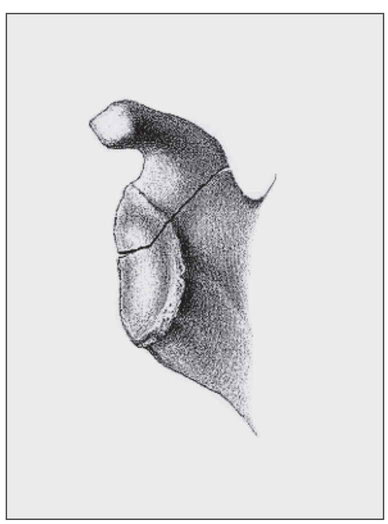

Fig. 1-17 Fracture of the superior glenoid, published by Braun in 1891 [20].

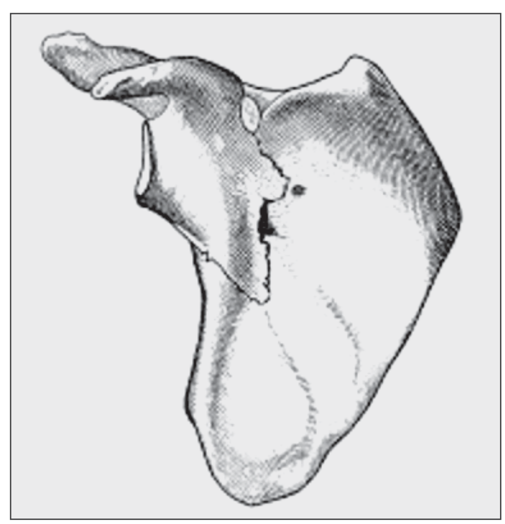

Fig. 1-18 Fracture of the surgical neck, published by Morestin in 1894 [123].

2

ANATOMY OF THE SCAPULA

The scapula is part of the shoulder girdle (Fig. 2-1). It is attached to the axial skeleton by the clavicle, which serves as a mobile strut and, together with the acromioclavicular (AC) and sternoclavicular (SC) joints, forms an articulation chain maintaining a constant distance of the scapula from the sternum (Fig. 2-2).

The scapula lies on the posterior chest wall, extending between 2nd and 8th ribs (Fig. 2-2b), and its position is controlled by scapula-axial muscles. The anterior, costal surface of the scapula makes a 30-to-40-degree angle with the frontal plane (Fig. 2-2c). When the arm is by the side, the medial border of the scapula runs parallel to the spinous processes, at a distance of 6 to 8 cm. The scapula slightly overhangs the lateral wall of the rib cage.

The scapula, which is enveloped in multiple layers of muscles, is separated from the chest wall by thin gliding loose connective tissue, allowing its smooth excursion over the posterolateral thorax. Thanks to its relatively free connection with the axial skeleton, the scapula is highly mobile, but, at the same time, provides efficient support to the humeral head (Fig. 2-3). As a result, compressive forces are optimally transmitted from the upper limb to the axial skeleton.

EXTERNAL SHAPE OF THE SCAPULA

The scapula is a flat bone. Its basic part, the body, is triangular, with its base situated proximally and its apex distally. The scapula is formed by two surfaces (the costal and the dorsal), three borders (superior, medial and lateral) and three angles (superior, inferior and lateral) (Fig. 2-4).

The lateral angle is a three-dimensional structure which gets gradually thicker to form an articular process, consisting of the neck, bearing an articular surface for the humeral head – the glenoid fossa, in clinical terminology simply the glenoid. The hook-shaped coracoid process curves laterally and forwards from the superior surface of the scapular neck. On the dorsal surface of the scapular body there arises a prominent bony crest, the scapular spine, which is laterally continuous with a flattened bony process, the acromion, curving forwards.

The described basic shape of the scapula varies considerably in details, depending on the individual's gender, habitus and muscularity. Some varieties may have clinical implications [13, 15, 23, 27, 68, 70, 82].

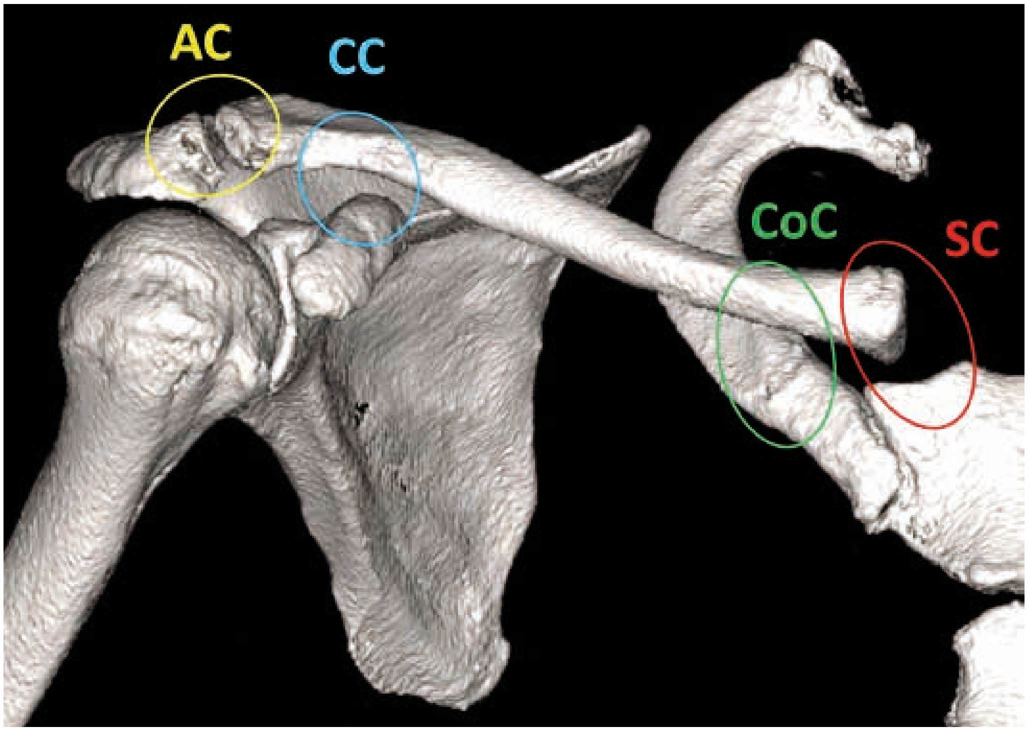

Fig. 2-1 Connection of the scapula with the axial skeleton. AC – acromioclavicular joint, CC – coracoclavicular ligament, CoC – costoclavicular ligament, SC – sternoclavicular joint.

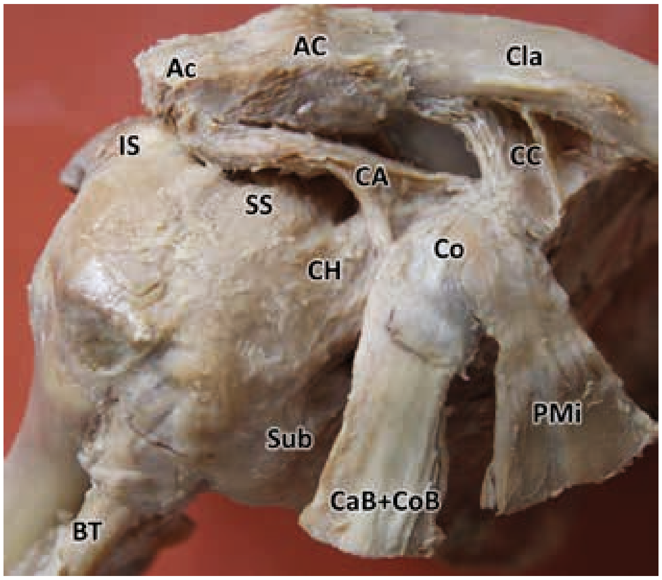

Fig. 2-19 Structures attached to the coracoid process. **AC** – acromioclavicular joint, **Ac** – acromion, **BT** – long head of the biceps brachii, **CA** – coracoacromial ligament, **CaB+CoB** – conjoined tendon of the short head of the biceps brachii and the coracobrachialis, **CC** – coracoclavicular ligament, **CH** – coracohumeral ligament, **Cla** – clavicle, **Co** – coracoid process, **IS** – infraspinatus, **PMi** – pectoralis minor, **SS** – supraspinatus, **Sub** – subscapularis.

origin to the conjoined tendon of the short head of the biceps brachii and the coracobrachialis. The medial surface of the distal part receives the insertion of the pectoralis minor. The entire lateral surface is reinforced with a broad insertion of the coracoacromial (CA) ligament. The rough area of the superior surface affords insertion to the coracoclavicular (CC) ligament and the coracoglenoid notch to the coracohumeral ligament. The medial rim of the base receives the insertion of the superior transverse scapular ligament.

INTERNAL BONE ARCHITECTURE OF THE SCAPULA

The distribution of the bony mass of the scapula is highly uneven, with areas of thick bone contrasting with other areas that are almost translucent (Fig. 2-20). A knowledge of thick and thin bone areas is important both in terms of the courses of fracture lines and fixation of implants [3, 13, 15, 18, 27, 48, 65].

When held up to the light, the scapula shows the highest concentration of bony mass in the lateral angle, the scapular spine and the lateral border of the scapular body. Therefore, cancellous bone can be found only in these regions of the scapula. Extending between the glenoid and the scapular body are two massive bony pillars that transmit compressive forces from the glenoid fossa (Fig. 2-21) [43, 71].

The lateral pillar connects the inferior rim of the glenoid with the inferior angle. Its weakest part is between its proximal and middle thirds, i.e., at the point of crossing with the circumflex groove (Fig. 2-22). In cross-section, the lateral pillar has an undulated profile (Fig. 2-23).

The spinal pillar arises from the central part of the glenoid and continues medially to become part of the base of the scapular spine. Its course can be seen better by viewing the scapula from the front against a light. Its weakest part is in the medial quarter.

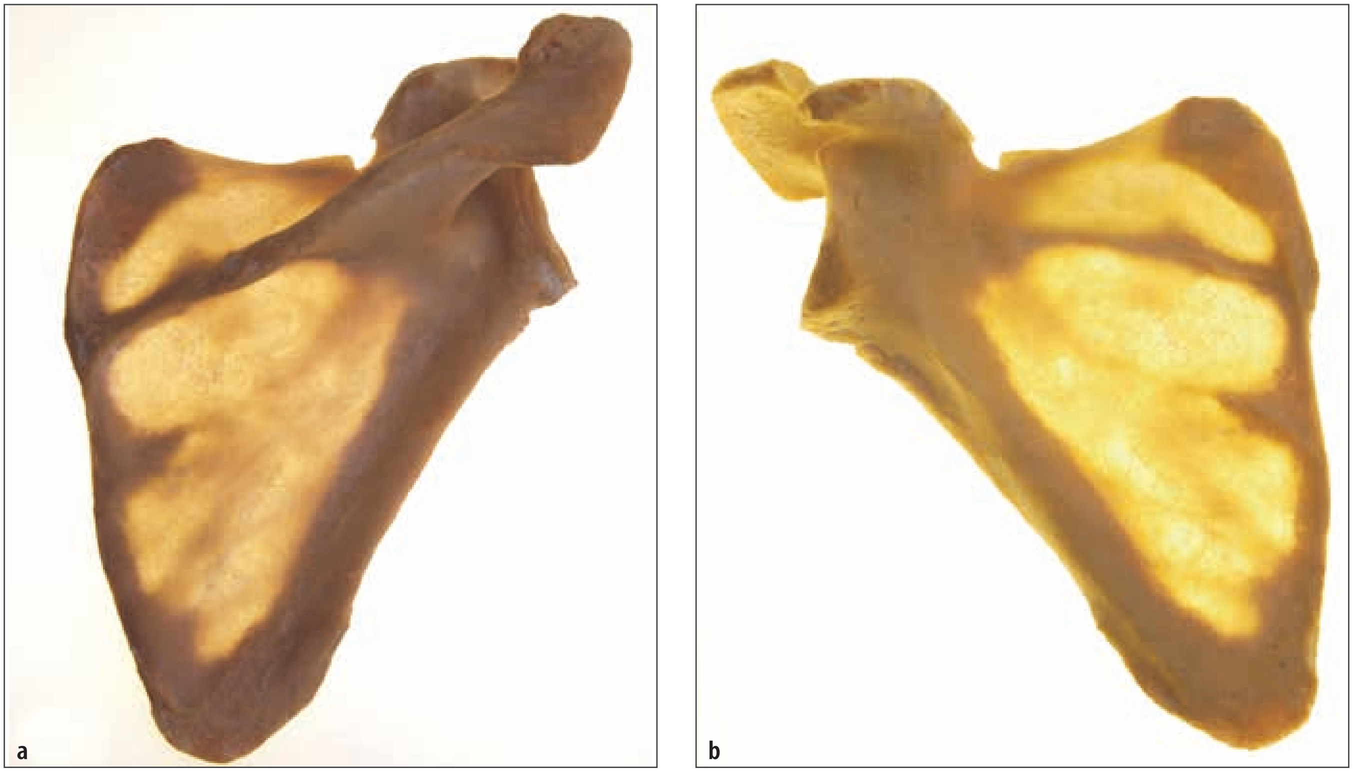

Fig. 2-20 Internal architecture of the transilluminated scapula: **a)** posterior view; **b)** anterior view.

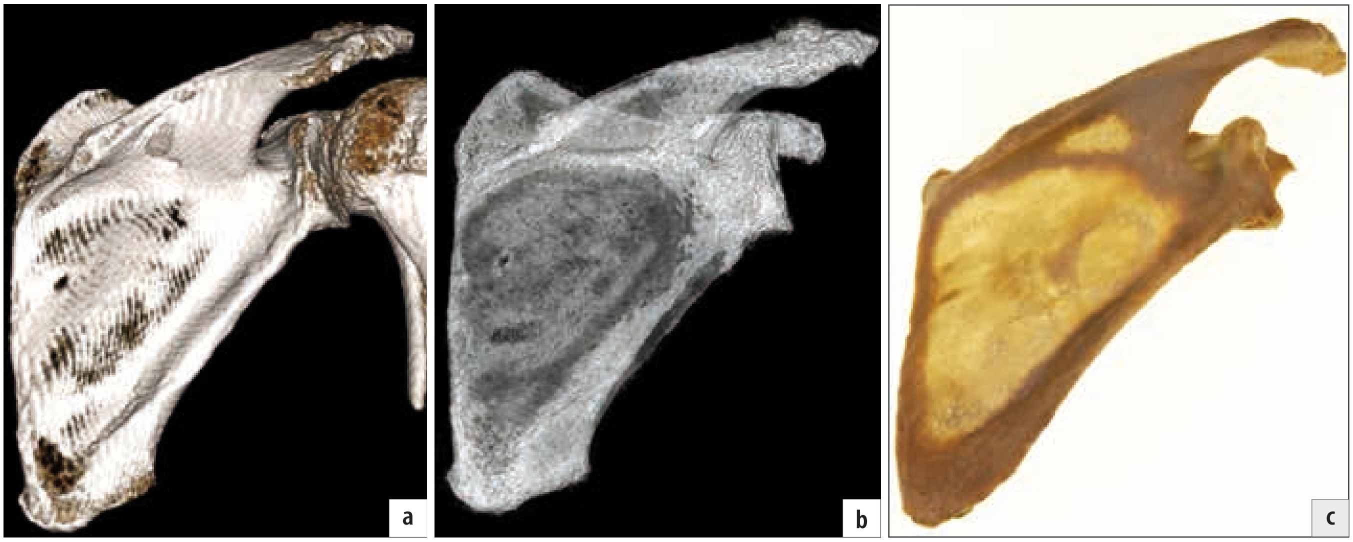

Fig. 2-21 Pillars of the scapula – posterior view: a) 3D CT reconstruction of scapula; b) semi-transparent 3D CT reconstruction of scapula; c) transilluminated scapula.

The biomechanical body of the scapula is a triangle bounded by the two pillars and the medial border of the scapula. It is the basic load-bearing structure of the scapular body [71]. The superior angle and the adjacent part of the supraspinous fossa form merely an appendage, which gives insertion or origin to muscles. Therefore, it is necessary to distinguish between the *anatomical* and *biomechanical bodies* of the scapula.

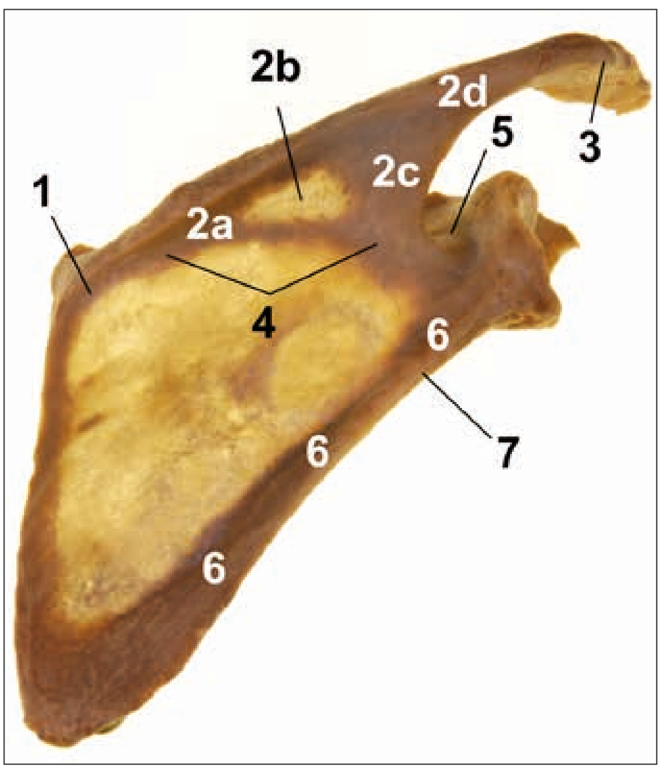

Fig. 2-22 Pillars and weakened areas of a transilluminated scapular bone specimen – posterior view. 1 – spinomedial angle, 2a – medial arm of the scapular spine, 2b – central weakened area of the scapular spine, 2c – lateral arm of the scapular spine, 2d – lateral (free) part of the scapular spine, 3 – acromial angle, 4 – spinal pillar, 5 – spinoglenoid notch, 6 – lateral pillar, 7 – circumflex groove.

The thinnest parts of the scapula include primarily the central part of the infraspinous and supraspinous fossae, where the bone is only a few millimeters thick.

The thinnest site along the circumference of the biomechanical triangle is the *spinomedial angle*, which correlates with the fact that in a majority of scapular body fractures one of the main fracture lines passes through this region. Another critical site is *between the proximal and middle thirds of the lateral pillar*. A thin area may be found also in the *central part of the scapular spine,* i.e., between its two arms, where the longitudinal cross-section of the spine resembles a lying figure eight. Analysis of the internal architecture of the scapula has shown that there exist three types of a weakened central part (Fig. 2-24) [71]: non-transparent in *type I* (30%); a small transparent central facet in *type II* (44%); and a triangular or oval-shaped central facet

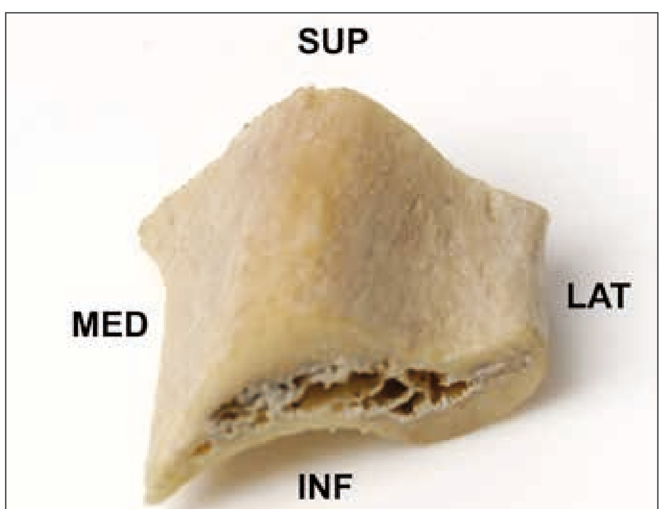

Fig. 2-23 Cross-section of the lateral pillar of the right scapula, posterior view: INF – inferior, LAT – lateral, MED – medial, SUP – superior.

Fig. 2-24 Variability of the central weakened area of the scapular spine at a transilluminated scapula specimen: **a)** absence of transillumination; **b)** slight transillumination; **c)** marked transillumination. Reproduced from [71].

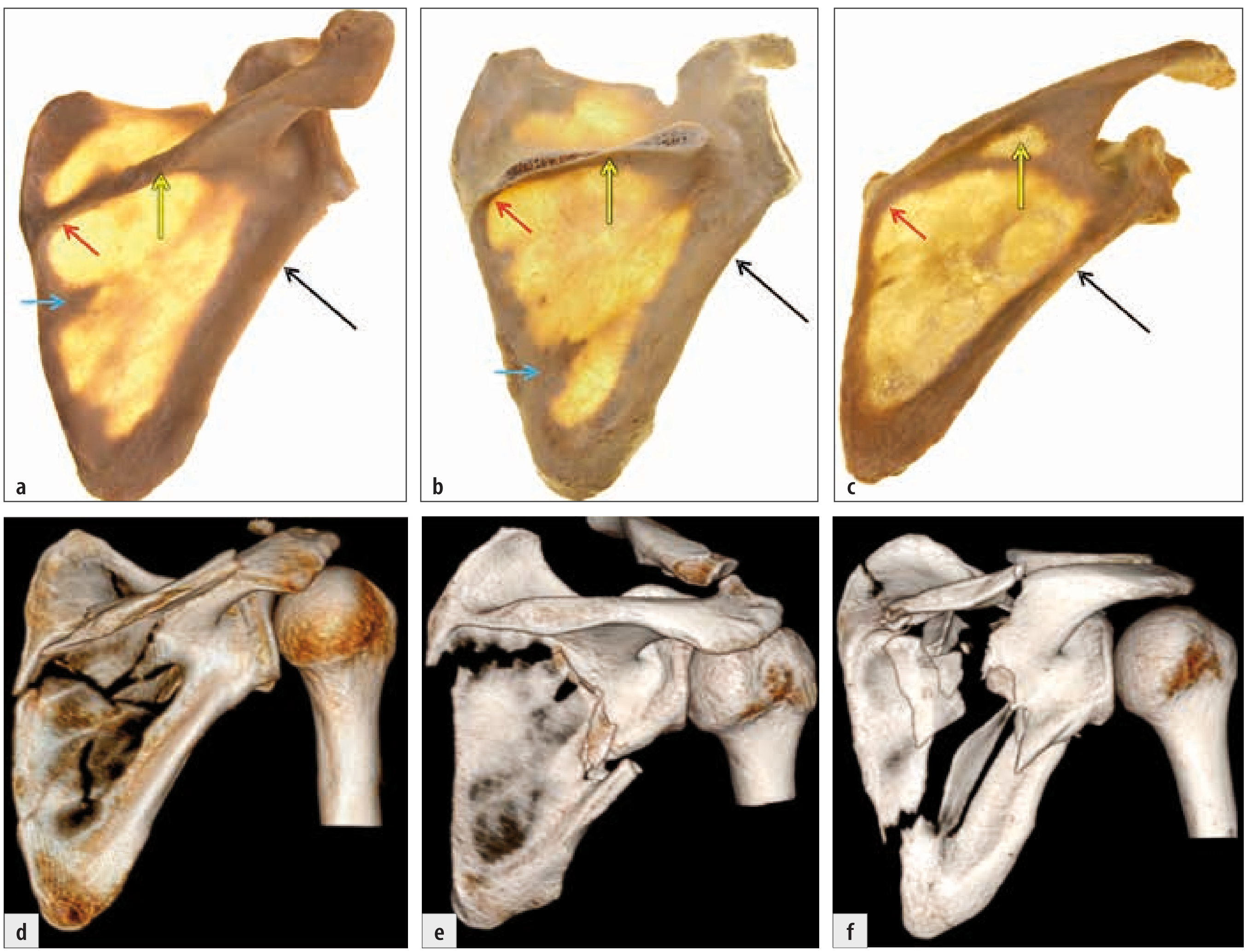

Fig. 2-25 Course of fracture lines relative to the thin areas of the scapula: **a)** transilluminated scapula specimen; **b)** transilluminated scapula with resected scapular spine; **c)** transilluminated scapula specimen; **d)** fracture of the spinal pillar with a fracture line passing through the central weakened area of the scapular spine; **e)** fracture of the lateral pillar (infraspinous part of the scapular body) with a fracture line passing from the lateral pillar to the spinomedial angle; **f)** fracture of both pillars with a fracture line passing through the central weakened area of the scapular spine, the superior part of the lateral pillar and below septum of the medial rim. Red arrow – spinomedial angle, black arrow – weakened part of the lateral pillar, blue arrow – variable medial septum, yellow arrow – central weakened area of the scapular spine.

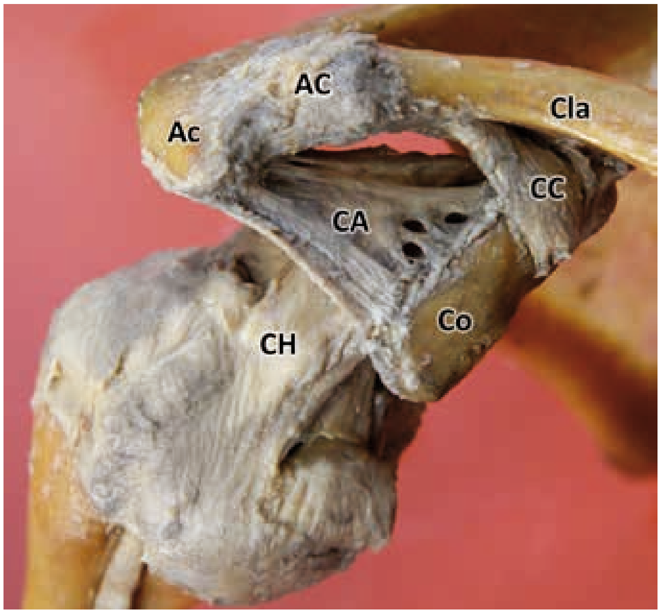

Fig. 2-26 Superior shoulder suspensory complex – superior view. **AC** – acromioclavicular joint, **Ac** – acromion, **CA** – coracoacromial ligament, **CC** – coracoclavicular ligament, **CH** – coracohumeral ligament, **Cla** – clavicle, **Co** – coracoid.

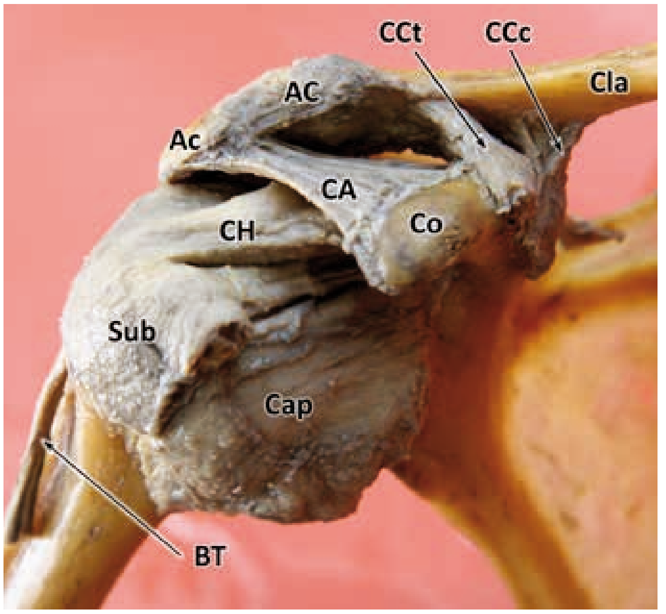

Fig. 2-27 Superior shoulder suspensory complex – anterior view. **AC** – acromioclavicular joint, **Ac** – acromion, **BT** – long head of the biceps brachii, **CA** – coracoacromial ligament, **Cap** – articular capsule, **CCc** – coracoclavicular ligament – conoid part, **CCt** – coracoclavicular ligament – trapezoid part, **CH** – coracohumeral ligament, **Cla** – clavicle, **Co** – coracoid process, **Sub** – subscapularis.

in *type III* (26%), significantly bigger than in type II. Analysis of the courses of fracture lines traversing the scapular spine has revealed that in most cases they passed through the central weakened area described above (Fig. 2-25).

JOINTS AND LIGAMENTS OF THE SCAPULA

The scapula bears the articular surfaces of two joints, the acromioclavicular and the glenohumeral, and receives the insertions of three separate ligaments, two of which form osseofibrous channels.

The acromioclavicular joint connects the scapula with the clavicle (Fig. 2-26) [24]. Oval-shaped facets on the acromion and the lateral epiphysis of the clavicle are highly variable, as is also the articular disc that is interposed between the two bones. The short and thin joint capsule attached along the circumferences of the articular surfaces is reinforced by the *superior and inferior acromioclavicular ligaments* [6, 61].

Decisive for stability of the AC joint is a strong *coracoclavicular ligament* [12, 39, 62]. This extraarticular ligament consists of two parts, the posteromedial, conoid part and the anterolateral, trapezoid part. They both arise from the inferior aspect of the clavicle 1 cm to 3 cm medial to the AC joint space, slightly converge distally and attach to the superior surface of the curvature of the coracoid process (Fig. 2-27). Rarely, in about 1% to 9% of individuals, the ligamentous connection of the coracoid process and the clavicle is replaced by a true synovial joint, i.e., the *coracoclavicular joint* (Fig. 2-28) [49, 50, 65].

The glenohumeral joint is formed by the pyriform articular surface of the glenoid and the head of the humerus. The scapular articular surface, the glenoid cavity, is enlarged and deepened by a strong fibrous ring, the *glenoid labrum*. The articular capsule originates close to the circumference of the glenoid cavity and attaches to the head of the humerus along the circumference of its anatomical neck. The upper surface of the capsule is strengthened by the *coracohumeral ligament* [20, 24], which arises from the inferior aspect of the beak of the coracoid process, blends with the upper surface of the capsule and converts into the *intertubercular ligament*.

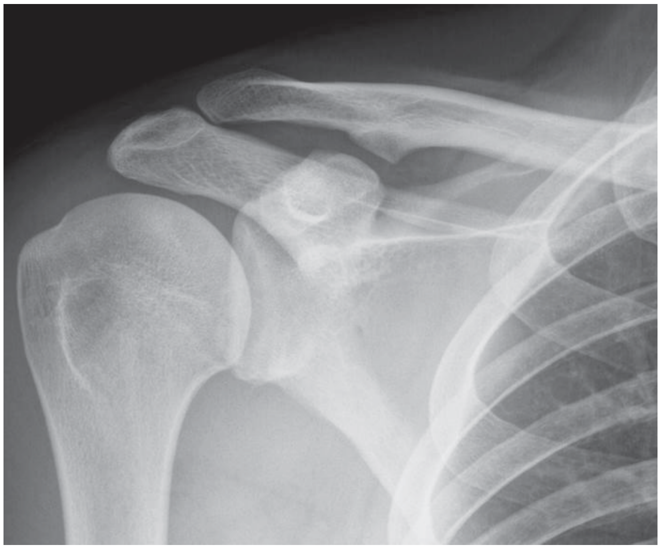

Fig. 2-28 A radiograph of the coracoclavicular joint.

Thoraco-scapular group

This group is composed of only two muscles of different size, the serratus anterior and the pectoralis minor.

The serratus anterior is a large flat muscle originating from the convex side of nine cranial ribs, turning dorsomedially and inserting between the chest wall and the scapula. It is separated from the scapula by thin gliding fibro-fatty tissue. The muscle extends as far as the medial border of the scapula to which it attaches along its whole length, including the inferior angle. It is innervated by the long thoracic nerve [26].

The pectoralis minor is a small flat muscle originating from 3rd to 5th ribs and inserting via its narrow tendon into the medial border of the distal coracoid (Fig. 2-19). It is innervated by the medial pectoral nerve [26].

SCAPULO-BRACHIAL SYSTEM

A total of ten muscles of this system originate from the scapula and attach to the bones of the upper limb, i.e. the humerus, radius and ulna. Only three of them, the subscapularis, the supraspinatus and the infraspinatus, originate from the surface of the scapula and together with the teres minor they form the rotator cuff (Fig. 2-34). The remaining seven muscles attach along the circumference of the scapula, or its processes.

The subscapularis is a strong muscle originating from the subscapular fossa [26], including fibrous bands arising from the horizontal bony septa. Laterally, the fascicles are continuous with a strong flat tendon which inserts on the lesser humeral tubercle (Fig. 2-35). The tendon is separated from the anterior surface of the scapular neck and the joint capsule by a large subscapular bursa communicating with the joint cavity [16, 46]. The anterior circumflex humeral artery passing along the lower edge of the tendon is accompanied by two veins of the same name (so-called *"three sisters"*). The muscle is innervated by three branches of the subscapular nerve (upper, middle, lower). These branches enter the anterior surface of the muscle about 2.5 cm medial to the musculotendinous junction [45, 47].

The supraspinatus arises from the lateral part of the supraspinous fossa (Fig. 2-36) [73]; laterally it gets narrower, passes under the acromion and inserts via a flat tendon into the greater humeral tubercle. It is innervated by the suprascapular nerve.

The infraspinatus is a strong muscle attached by its broad base almost to the whole surface of the infraspinous fossa [44]. It has three parts (Fig. 2-37): two superficial (proximal and distal) and one deep (middle). The proximal, transverse, superficial portion arises from the scapular spine. The middle, central, deep portion of the muscle originates from the middle part of the infraspinous fossa, while the distal, oblique, superficial

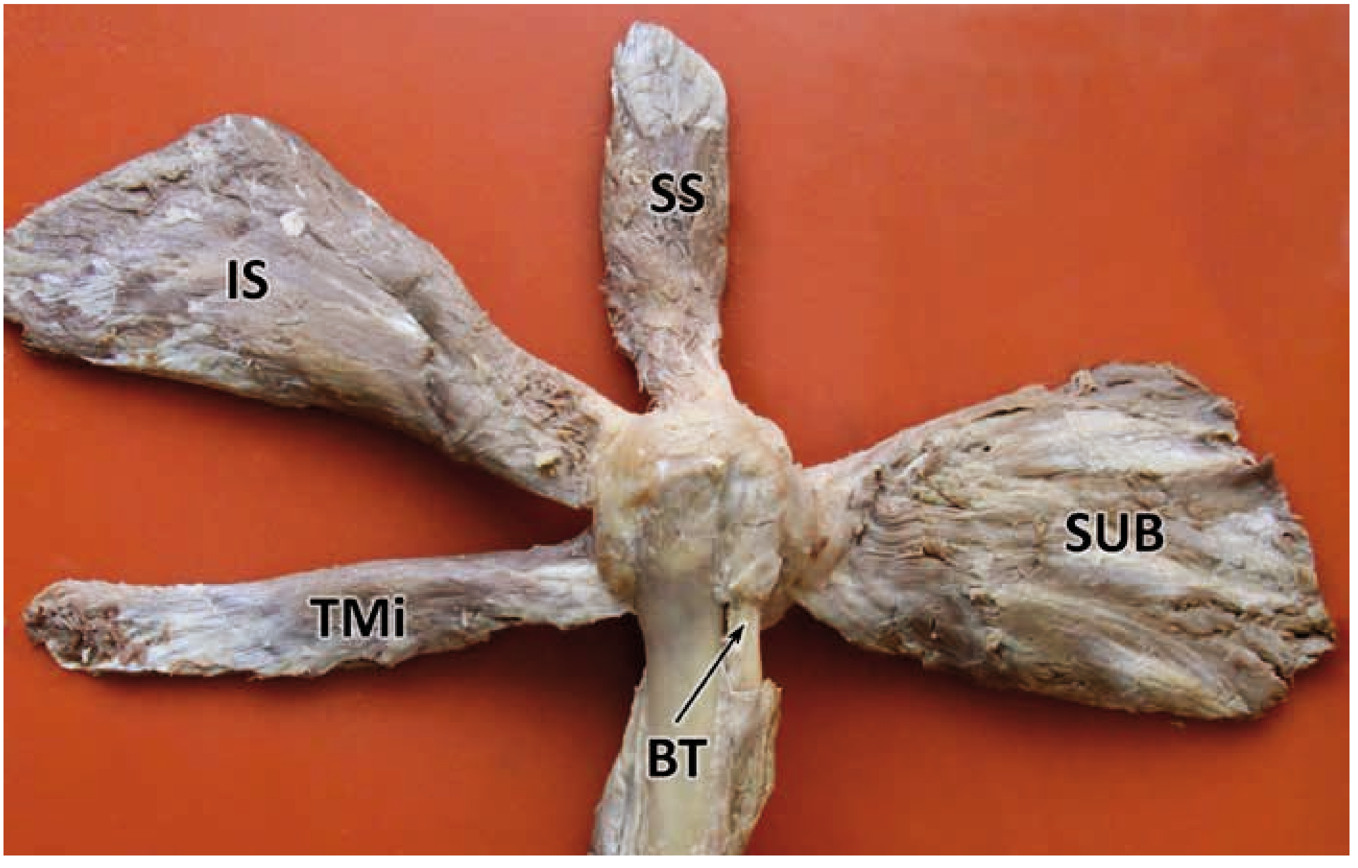

Fig. 2-34 Muscles of the rotator cuff. BT – tendon of the long head of the biceps brachii, IS – infraspinatus, SS – supraspinatus, SUB – subscapularis, TMi – teres minor.

3

EPIDEMIOLOGY OF SCAPULAR FRACTURES

According to data in the literature, scapular fractures are relatively uncommon, although their incidence seems to be on the increase in recent years [9, 27]. The causes may include, among other things, improved diagnostic procedures, particularly whole-body CT scanning of polytrauma patients, or the growing total number of scapular fractures quite often sustained by pedal cyclists and motorcyclists. In addition, scapular fracture record-keeping has improved, thanks to the establishment of national or local registries. Scapular fractures are usually unilateral injuries; bilateral fractures are much less frequent [14, 30, 32, 35] and open fractures very rare [11].

LITERATURE REVIEW

The incidence of scapular fractures has been reported in various formats, including their share in the total number of fractures, in the number of fractures of the shoulder girdle, their incidence as a part of polytrauma or injuries sustained in motor vehicle accidents [5, 8, 12, 25, 26, 28, 32-34]. In the last 150 years, numerous important studies have been published dealing with the incidence of scapular fractures.

Gurtl [13], in 1864, published one of the first statistical analyses. He reported 47 scapular fractures out of a total of 4,310 fractures treated in his department, i.e., 1.1%, and included also statistical data for London hospitals, with 230 scapular fractures diagnosed among a total of 22,616 fractures, i.e., 1%.

Plagemann [22], in 1911, found 13 scapular fractures in 1,393 fractures treated at the Surgical Clinic in Rostock between 1905 and 1910, i.e., 0.93%.

Reggio [23] in his statistics of 1938, found 17 scapular fractures in a group of 4,390 patients, i.e., 0.4% of all fractures. These statistical data were subsequently used by a number of authors and are cited to this day.

Court-Brown [10] in his Edinburgh statistical analysis of 5,953 fractures in adult patients, published in 2000, revealed 17 scapular fractures, i.e., 0.3%. Between September 2010 and August 2011, 37 scapular fractures were identified among 6,996, i.e., 0.5%, which represents a 0.2% increase over a period of 10 years [11].

Note: It should be noted that the details found by authors in such small series of scapular fractures differ substantially from our data [31]. This relates to, for instance, the mean age of the whole cohort of 54.8 years, the male/female ratio of 68:32, the mean age of women of 74.5 years, and the distribution of fracture types, i.e., 57% of glenoid fractures, 32% of scapular neck and body fractures and 11% of process fractures. The main reason seems to be the potential for error with small numbers.

Zhang [35], in 2012, analyzed a series of 595 scapular fractures (of which 7 were in children) diagnosed between 2003 and 2007, representing 1.0% of all the 60,266 recorded fractures.

Nordqvist and **Petersson** [21], in 1995, dealt with the incidence of scapular fractures in shoulder girdle injuries (clavicle, scapula, proximal humerus, AC dislocation, glenohumeral dislocation). Their series of 504 such injuries included 14 scapular fractures, i.e., 3%.

Veysi et al. [33], in 2003, found 79 scapular fractures in 1,164 polytrauma patients, i.e., 6.8%.

Dinopoulos et al. [12], in 2003, reviewed details in 621 polytrauma patients with chest injuries and identified scapular fractures in 79 of them, in 12.7%.

Baldwin et al. [5], in 2008, analyzed data from the "National Trauma Database" obtained between 1994 and 2002, from trauma centers in the USA, and found 9,453 scapular fractures.

Weening et al. [34], in 2010, recorded 94 scapular fractures in 2,538 motor vehicle accident traumas, i.e., 3.7%.

Coimbra et al. [8], in their study of the incidence of scapular fractures in motor vehicle accident trauma, published in 2010, found 54 isolated scapular fractures, i.e., 1.6%, in a cohort of 3,370 patients.

Uzkeser et al. [32], in 2012, identified 42 scapular fractures, i.e., 4%, in 1,039 patients with a high-impact blunt trauma.

Tatro et al. [27], in 2018, analyzed data from the "National Trauma Data Bank" for the 2002-2012 period and found 106,119 scapular fractures, accounting for 1.7% of all recorded fractures, with an increase of their incidence from 1.3% in 2002 to 2.1% in 2012 over the study period.

Literature review has shown that the share of scapular fractures ranges between 0.4% and 2.1% of all fractures (Table 3-1). In shoulder girdle injuries, they account for 3% [3]; in polytrauma patients for between 4% and 6.8% [32, 33], in polytraumas associated with chest injuries for between 7% – 12.7% [12]; while in motor vehicle accident traumas, their share is only between 1.6% and 3.7% [8].

The presented data are influenced by a number of geographical, time-related, medical and other factors, including, for instance, the period, provenance, the size and basic characteristics of the respective cohort, quality of statistical analysis, etc.

Author	Year	Characteristics of the series	No. of all fractures	No. of scapular fractures	% of scapular fractures
Gurtl	1864	All fractures treated at the department	4 310	47	1.1
Gurtl	1864	Fractures treated in London hospitals	22 616	230	1.0
Plagemann	1910	All fractures treated at the department	1 393	13	0.9
Reggio	1938	All fractures treated at the department	4 390	17	0.4
Court-Brown	2006	All fractures treated at the department	5 953	17	0.3
Court-Brown	2020	All fractures treated at the department	6 996	37	0.5
Zhang	2007	All fractures treated at the department	60 266	595	1.0
Nordqvist Petersson	1995	Shoulder girdle fractures	504	14	3.0
Veysi	2003	Polytrauma patients	1 164	79	6.8
Dinopoulos	2003	Polytrauma patients	621	79	12.7
Uzkeser	2012	Polytrauma patients	1 039	42	4.0
Weening	2010	Motor vehicle accident traumas	2 538	94	3.7
Coimbra	2010	Motor vehicle accident traumas	3 370	54	1.6
Tatro	2019	NTDB data	6 091 391	106 119	1.7

Table 3-1 Historical overview of epidemiology of scapular fractures.

ANALYSIS OF AUTHORS' 2008-2014 OWN SERIES

The literature review has revealed that the available studies do not present detailed epidemiological data on scapular fractures, or that selection criteria of patients for these studies were specifically modified (type of injury, method of treatment). Therefore, we have carried out our own epidemiological analysis of 250 patients who either received primary treatment at our Department, or were referred there for specialized consultation in cases of an acute scapular fracture, between January 2008 and January 2014. CT examination was performed in all 250 patients, in combination with 3D CT reconstruction in 227 of them [31].

AGE AND GENDER

The study group comprised 199 men and 51 women. Their mean age was 45.3 years (range, 15-92); in men 43.5 years (range, 16-83) and in women 52.4 years (range, 15-92). The group of women was significantly older compared to the men ($p = 0.017$). Patients up to the age of 60 years totaled 204 (83%), while the total number of those older than 60 years was 46 (17%) (Table 3-2). The injury involved the right side in 119 patients and the left side in 131 patients.

The male/female ratio was 80:20 across the whole group. In the group up to the age of 60 years, the predominance of men was more significant, i.e., 84:16, compared to only 64:36 in the group over the age of 60 years. Consequently, men older than 60 years accounted for only 12% of the whole study group, while women comprised 38%.

The biggest difference in the male/female ratio across the whole group was found in scapular body fractures, i.e., 5.2:1, and the smallest in the group of scapular neck fractures, i.e., 1.4:1, although the difference in gender was generally statistically insignificant ($p > 0.2$).

Based on the above-mentioned data, scapular fractures cannot be considered to be osteoporotic in nature. On the contrary, they typically occur in young, active patients, predominantly men.

	Entire study group	Male	Female	M/F ratio
N	250	199	51	80/20
Age	45 (15-92)	44 (16-83)	52 (15-92)	–
Age ≤ 60	204	172	32	84/16
Age > 60	46	27	19	64/36

Table 3-2 Basic characteristics of the entire study group. Age-related data are rounded up.

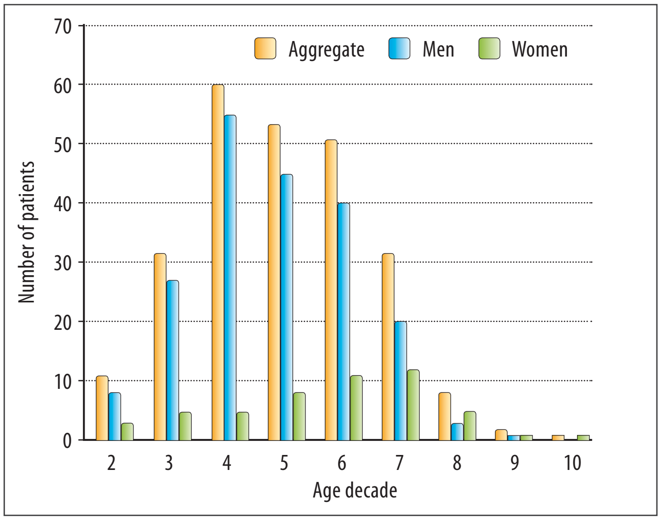

Fig. 3-1 Share of scapular fractures in individual age decades.

Decade	Study group (no. of patients)	No. of men	No. of women
2.	11	8	3
3.	32	27	5
4.	60	55	5
5.	53	45	8
6.	48	37	11
7.	35	23	12
8.	8	3	5
9.	2	1	1
10.	1	0	1

Table 3-3 Share of scapular fractures in individual age decades.

AGE DECADES

The majority of patients in the whole group (66%) were in their 4th to 6th decades. The same applied to men, while most women were in their 6th or 7th decades (Fig. 3-1, Table 3-3).

The presented data show that with advancing age, the share of women increased and exceeded the share of men, however, as late as in 8th decade.

FRACTURE PATTERNS

Scapular fractures were divided into four basic categories: *fractures of the scapular body*, *scapular neck*, *glenoid fossa* and *of the processes and borders* (i.e., fractures of coracoid, acromion, scapular spine, superior border, superior angle and inferior angle).

The fracture pattern was determined in 227 patients on the basis of 3D CT reconstructions and in 23 patients according to CT scans and intraoperative findings. The intraoperative findings in 61 patients corresponded exactly to preoperative 3D CT reconstructions. Of the 23 patients with CT scans without 3D CT reconstruction, the intraoperative findings corresponded with preoperative classification in 16 cases, whereas in 7 patients the fracture anatomy differed slightly from the preoperative assessment.

The most common fracture in the study group was that of the scapular body, in 131 cases (52%), followed by 73 fractures of the glenoid fossa (29%) and 27 fractures of the processes and borders (11%); the least frequent were fractures of the scapular neck, with only 19 cases (8%) (Table 3-4).

The highest mean age of 47 years was recorded in the group with a fracture of the glenoid fossa, followed by 46 years in the group with fractures of processes, or with fractures of the scapular body. The lowest mean age, i.e., 38 years, was found in patients with fractures of the scapular neck. The group of patients with scapular neck fractures was significantly younger as compared to the age of patients with glenoid fracture ($p = 0.021$), or scapular body fracture ($p = 0.035$).

ASSOCIATED INJURIES OF THE SHOULDER GIRDLE

These injuries included fractures of the clavicle, acromioclavicular (AC) dislocation, glenohumeral (GH) dislocation and proximal humerus (PH) fractures. Injuries to the sternoclavicular (SC) joint were not encountered in this cohort (Table 3-5).

The most frequent associated injuries of the ipsilateral shoulder girdle were clavicular fractures, which were diagnosed in 47 (19%) of 250 patients. They occurred most often in combination with fractures of the scapular body and neck, equally in 21% of cases. The mean age of 47 patients with an associated clavicular fracture was 41 years (range, 19-83). Of these 47 patients, 43 (91%) were in the group up to the age of 60 years and only 4 (9%) patients were older than 60 years. Clavicular fractures accounted for 23% (43 of 250) in the group up to the age of 60 years and only for 9% (4 of 46) in the group over the age of 60.

Dislocation of the glenohumeral joint occurred in 9 cases (4%), fractures of the proximal humerus, or AC dislocation, in 8 cases (3%) each.

The mean age of 8 patients with an associated proximal humerus fracture was 56 years (range, 35-79). In the group up to the age of 60 years, a proximal humerus fracture was sustained by 4 (2%) out of 204 patients, and in the group over the age of 60 years also by 4 patients (9%) out of 46. The above-mentioned

Fracture pattern	Entire study group N	Entire study group %	Average age total (y)	Average age men (y)	Average age women (y)
All types	250	100	45	44	52
Scapular body	131	52	46	45	51
Glenoid	73	29	47	45	54
Processes	27	11	46	40	61
Scapular necks	19	8	38	35	43

Table 3-4 Share of individual fracture patterns. Age-related data are rounded up.

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.

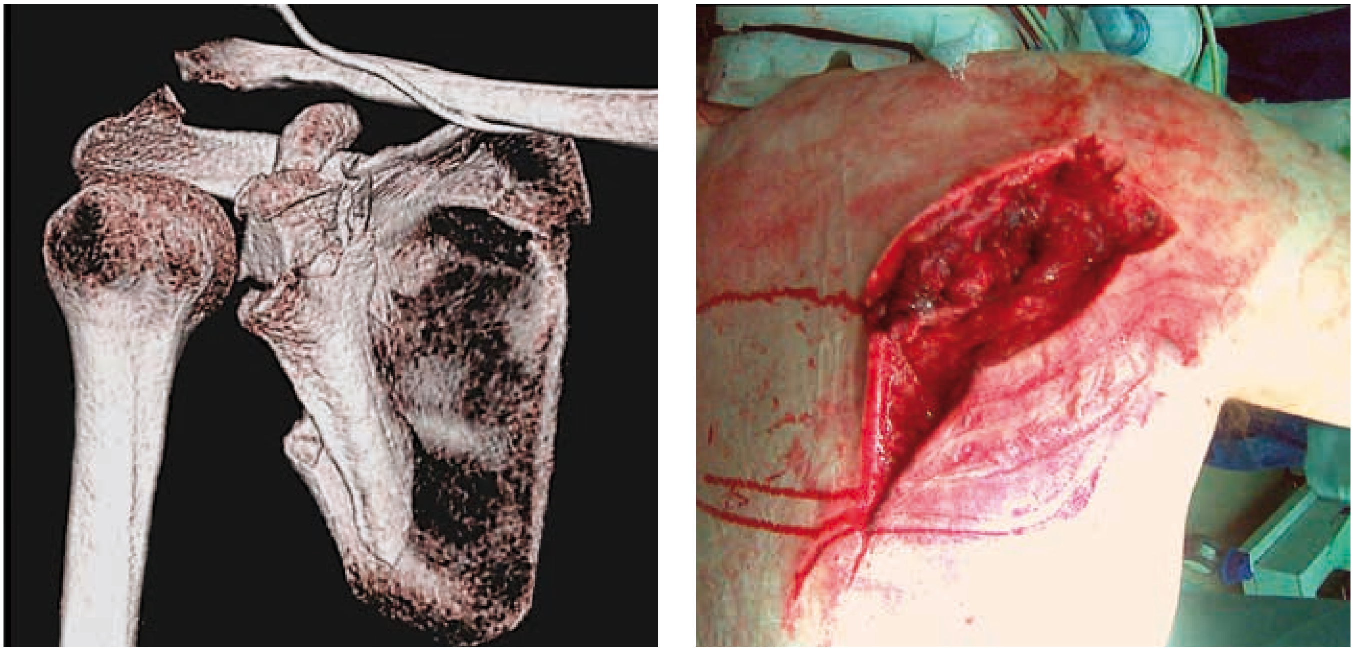

Fig. 4-2 Open complex intraarticular fracture caused by motor vehicle accident.

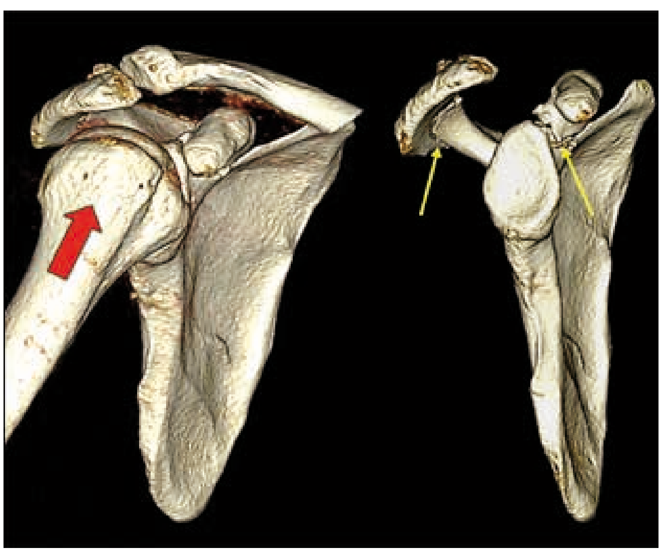

Fig. 4-3 Proximal displacement of the humeral head causing scapular process fractures. The arrows indicate fractures of the scapular spine and the coracoid.

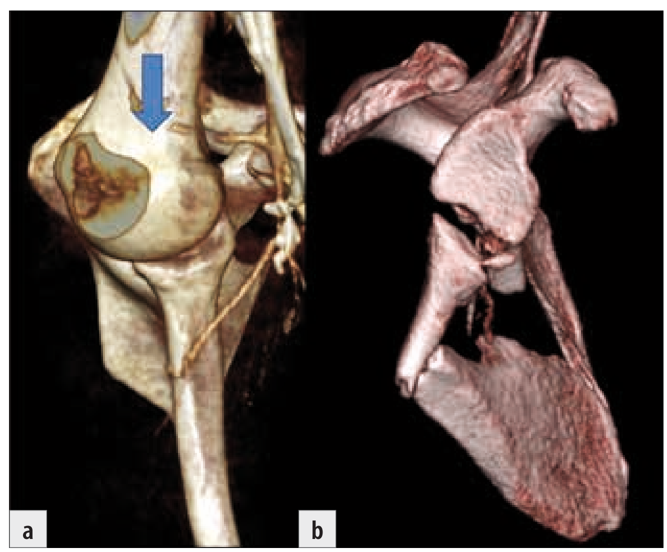

Fig. 4-4 Glenoid fracture with the arm in marked abduction: **a)** the humeral head is driven against the inferior area of the glenoid; **b)** as a result of such an impact, the inferior glenoid separates off, together with the adjacent infraspinous part of the scapular body.

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].