7 OVERVIEW OF CLASSIFICATIONS OF SCAPULAR FRACTURES

Since the time of Petit, the classification of scapular fractures has experienced a long historical development. Yet, all the authors more or less respected the basic anatomical parts of the scapula, i.e., scapular body, neck, glenoid and processes [4, 5, 14, 54]. The first step in the development of a classification was identification of individual fracture patterns. This process lasted throughout the whole 19th century and was based primarily on autopsy findings. Description of individual cases was precise, reflected the reality, and often also included the respective injury mechanism. At the beginning of 20th century, radiological examination began to spread gradually as the basic element of the diagnostic protocol. However, its interpretation was not always exact [4, 5, 28, 31] as verification of a correct interpretation of radiological diagnoses by confrontation with intraoperative findings was considerably limited due to predominance of non--operative treatment of scapular fractures. The situation began to change as late as in the 1970s and the 1980s, as a result of the growing number of patients treated operatively [29, 44, 61]. It was during that period, that the first reports of the use of CT examination of scapular fractures began to appear [38].

The majority of the classification schemes currently in use were developed as late as in the 1990s [1, 19, 20, 24-27, 45, 51], but they were preceded by several, currently less-known classifications [17, 22, 31, 47, 57, 58]. Two types of classifications can be found in the recent literature. The first type deals with the whole complex of scapular fractures [1, 19, 20, 51-53, 61], while the other type analyzes only certain types of injury to the scapula, particularly glenoid fractures [8, 9, 32-34, 39], scapular neck fractures [6, 7, 26], scapular body fractures [10] and fractures of the processes [11, 21, 25, 27, 49, 50]. Despite all the progress achieved as a result of modern diagnostic procedures, there is still no generally accepted comprehensive classification of scapular fractures.

HISTORICAL OVERVIEW OF CLASSIFICATIONS OF SCAPULAR FRACTURES

At the beginning of 20th century, there appeared a number of outstanding studies, the most comprehensive of which was the Tanton's publication [58].

TANTON CLASSIFICATION

Tanton [58], in 1915, was the first to publish a well-conceived, detailed overview of various fracture patterns, which may be taken for the first comprehensive classification scheme. Although this classification is almost unknown today, it is surprising how the author described in detail individual types and subtypes of scapular fractures, including mechanisms of injury. Tanton based his scheme both on his profound knowledge of the literature available at that time, more specifically descriptions and illustrations of various scapular fracture patterns, and on his own broad experience. He distinguished between two major groups of scapular fractures, namely fractures of the anterior (lateral) angle and fractures of the scapular body.

Fractures of the anterior angle included those involving the glenoid and anatomical neck (Fig. 7-1) and a group of *juxta-articular fractures*, i.e., those of the surgical neck, of the coracoid and of the acromion. Glenoid fractures were divided by Tanton into partial (anterior, inferior) and total fractures. In fractures of the surgical neck, he focused on the importance of the integrity of the coracoacromial and coracoclavicular ligaments. In fractures of the coracoid, he distinguished between fractures of its base and those of the beak. In fractures of the acromion, he described those of the apex, intraarticular fractures involving the AC joint, and fractures of the base.

Fractures of the scapular body were classified by Tanton into four groups. The first group comprised fractures of the supra- and infraspinous fossae. Based on the course of the fracture line, he distinguished between vertical, transverse, and comminuted fractures. The second group included fractures of the inferior angle, the third group fractures of the superior angle and the fourth group fractures of the scapular spine.

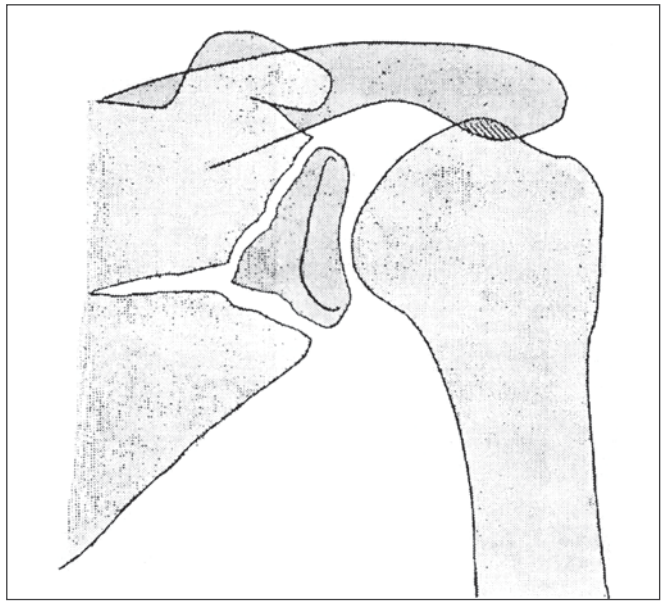

Fig. 7-1 Fracture of the anatomical neck according to Tanton [58].

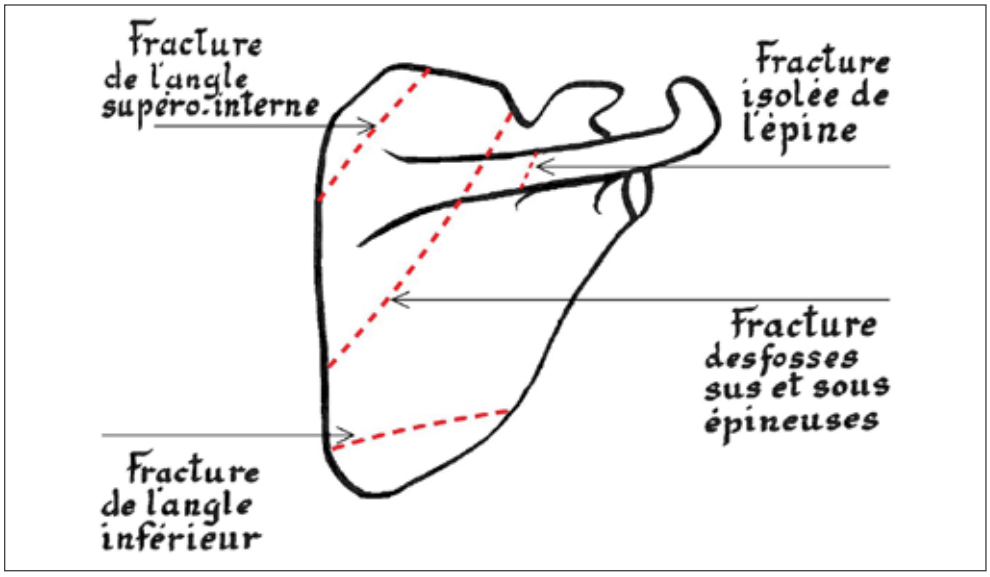

Fig. 7-2 Division of scapular body fractures according to Decoulx. Modified after [17].

DECOULX CLASSIFICATION

Decoulx et al. [17] based their classification, published in 1956, on Tanton's concept. They analyzed a group of 26 patients and divided scapular fractures into three main groups:

- **Scapular body fractures** (fractures of the superior angle, inferior angle, supra- and infraspinous fossae, isolated fractures of the scapular spine) (Fig. 7-2);
- **Apophyseal fractures** (fractures of the coracoid and the acromion);
- **Fractures of the superolateral angle** (fractures of the glenoid, i.e., its anterior or posterior rim, the whole glenoid fossa, the anatomical neck, or the surgical neck) (Fig. 7-3, Fig. 7-4).

This classification was adopted by other French authors [15, 18, 60].

TSCHERNE AND CHRIST CLASSIFICATION

Tscherne and Christ [61], in 1975, divided scapular fractures into five basic types:

1. **Fractures of processes** (acromion and coracoid),
2. **Fractures of the scapular body**, including the medial (superior) and inferior angles,
3. **Fractures of the scapular neck**,
4. **Fractures of the glenoid fossa**,
5. **Combined and comminuted fractures**.

Although the authors did not deal with details, their basic classification scheme reflects with high accuracy the actual situation when assessing scapular fractures.

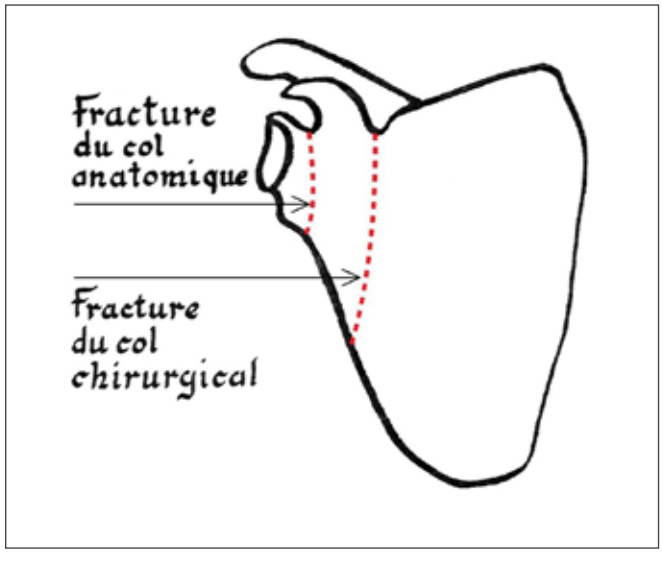

Fig. 7-3 Division of scapular neck fractures according to Decoulx. Modified after [17].

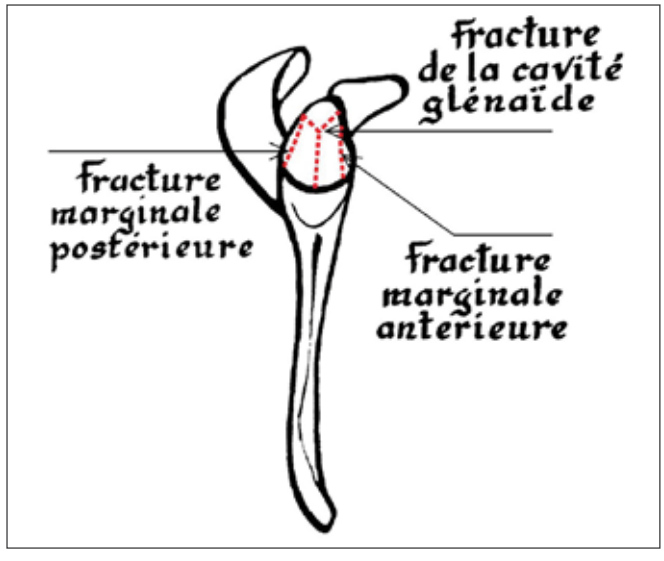

Fig. 7-4 Division of glenoid fractures according to Decoulx. Modified after [17].

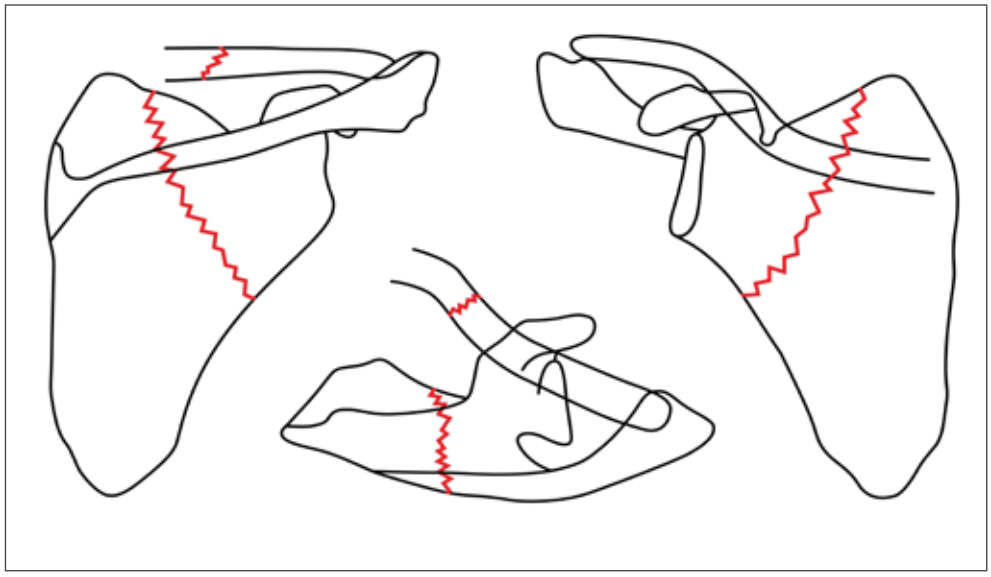

Fig. 7-5 "Fracture transspinale" according to Gagey. Modified after [22].

GAGEY CLASSIFICATION

Gagey et al. [22], in their 1984 classification, distinguished only between two main groups, of **intraarticular** and **extraarticular** fractures.

Extraarticular fractures were divided into *scapular body fractures* and *fractures of the lateral angle*, which included fractures of the anatomical neck or the surgical neck, fractures of the coracoid and of the acromion. Among other things, they discussed, and presented a drawing of, a "fracture transspinale", separating the lateral angle from the scapular body (Fig. 7-5).

CURRENTLY USED CLASSIFICATIONS

Currently, studies use mostly some of the classifications that were developed in the last decade of 20th century [1, 19, 20, 24, 34, 51, 52].

ADA-MILLER CLASSIFICATION

Ada and Miller [1] published, in 1991, a series of 148 scapular fractures based on an analysis of conventional radiographs, which they divided into four groups (Fig. 7-6):

1. **Fractures of processes** (28 %): IA – acromion fractures, IB – scapular spine fractures, IC – coracoid process fractures,
2. **Fractures of the neck** (27%): IIA – "fractures of the surgical neck", II B – "transspinous fractures of the neck", II C – "fractures of the neck inferior to the scapular spine",
3. **Fractures of the glenoid** (10%): III,
4. **Fractures of the body** (35%): IV.

Note: Individual patterns of scapular neck fractures were distinguished only by an alpha-numerical code (IIA, IIB, IIC), without any explanatory details in the figure legend, or the text of the article. For the sake of clarity, terms that are currently commonly used in the literature for these fracture patterns are added to the codes in inverted commas. The incidence rate of each fracture pattern is given in brackets.

Drawbacks: Ada-Miller classification is not a true classification scheme. It was presented in a single drawing of a scapula showing fractures lines, without any explanatory notes in the text. It deals in greater detail only with scapular neck fractures, which, however, are neither defined nor specified. At the same time, it completely ignores fractures of the anatomical neck of the scapula but, on the contrary, introduces a new pattern of a scapular neck fracture which actually is not a scapular neck fracture (type IIC). Assessment of displacement is also questionable. In terms of operative treatment, the authors consider as relevant a displacement of more than 1 cm and angulation of more than 40 degrees, but they do not mention exactly how they measured these values. The images evidently show displacement of fragments of the lateral border of the scapular body, rather than of a glenoid fragment. In addition, accuracy and reliability of such measurements on radiographs

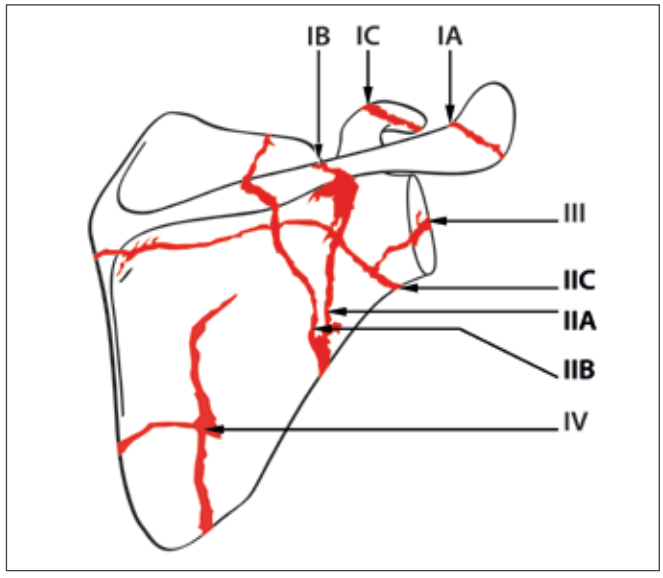

Fig. 7-6 Ada-Miller classification of scapular fractures. Description in the text. Modified after [1].

PITFALLS OF THE CURRENT CLASSIFICATIONS

The above-mentioned classifications presented at their time a significant progress in the knowledge of individual patterns of scapular fractures. However, all of them have a number of more or less common deficiencies.

DEVELOPMENT ON THE BASIS OF RADIOGRAPHS

Except for the OTA/AO classification [53], all the described classifications [1, 20, 24, 51, 52] were based on radiographs and the number of operatively-treated patients was minimal. Ada and Miller [1] examined 148 patients, of whom 8 were operated on. Euler and Rüedi [20] analyzed 153 cases, of whom 18 were treated operatively. Ideberg [34] and Goss [24] did not specify the number of operated-on patients. As a result, in a majority of cases it was not possible to compare radiological and intraoperative findings, to verify the actual fracture pattern and, when appropriate, reflect the need for operative treatment in the classification. Recent studies have shown that radiographic examination alone is inadequate to assess properly the fracture anatomy and pointed out the importance of CT examination [2, 46].

In his study of 1992, Goss [24] stated that "*The relevance of 3D CT reconstructions is yet to be determined*". By contrast, Mayo et al. [45], in 1998, evaluated positively the contribution of 3D CT reconstructions and were followed by other authors [2, 8, 46]. To date, most authors have recognized the importance of CT examination, including 3D CT reconstructions, for diagnosis, measurement of fragment displacement and the choice of a proper treatment option. This was validated, for instance, in diagnosing fractures of the surgical neck of the scapula. Comparison of radiographs, 3D CT reconstructions and intraoperative findings has clearly shown that a majority of fractures, interpreted with the use of radiographs as a scapular neck fracture, were actually transverse two-part fractures of the infraspinous part of the scapular body [12].

NUMBER OF ANALYZED CASES

A majority of the discussed classifications distinguish between 4 to 5 basic types of scapular fractures that are further subdivided. Any relevant classification requires a certain minimal number of analyzed cases.

An example may be glenoid fractures. Ideberg et al. [34] analyzed 100 glenoid fractures. Goss [24], who revised their classification, did not specify his number of cases. Mayo et al. [45] based their amendments to the Goss classification on only 27 operated-on patients, and the AO studies of glenoid fractures on 46 [35] and 53 [59] cases, respectively.

Highly questionable is also the markedly unequal distribution of individual types of glenoid fractures. Ideberg et al. [34] recorded in their series of 100 fractures 85 fractures of the anterior rim (Type 1). The remaining types 2, 3, 4 and 5 accounted for only 15% of all cases. In the AO studies dealing with glenoid fractures [35, 59] 38 of 46 glenoid fractures and 31 of 53 glenoid fractures, respectively, were classified as articular rim fractures.

DRAWBACKS OF SCHEMES OF FRACTURE LINES

In a number of classifications, fracture lines are drawn only on the anterior surface of the scapula [24, 34, 51, 52]. Thus, it is not possible to determine the course of a fracture line in relation to the scapular spine. This relates to scapular body fractures, but primarily the so-called transverse glenoid fractures, specified in the Ideberg's [34], Goss' [24] and Mayo's [45] classifications as type-5 (V).

Another misleading aspect is oversimplification of the shape of the scapula, primarily of the relationship between the superior glenoid rim and the coracoid base (Fig. 7-15, Fig. 7-16). In reality, the coracoid arises directly from the superior pole of the glenoid, or the upper surface of the neck is reduced to a small notch only several millimeters deep. Some classifications [24, 34, 51, 52], however, show the coracoid shifted markedly medially, thus considerably elongating the upper surface of the anatomical neck of the scapula. As a result, the scheme of fracture lines passing through this region and, consequently, the shape of individual fragments do not correspond to anatomical reality.

NON-EXISTENT FRACTURE PATTERNS

The existence of a number of fracture patterns is controversial. An example may be the AO classification of 2007 [52]. The course of fracture lines is rather the author's fiction than a description of the actual state (Fig. 7-17). This was aptly expressed by Armitage et al. [2] in assessment of the OTA classification: "*…they do not reflect the patterns that we found with the use of three-dimensional computed tomography*". An example may be the central fracture of the glenoid fossa without involvement of its rims, descri-

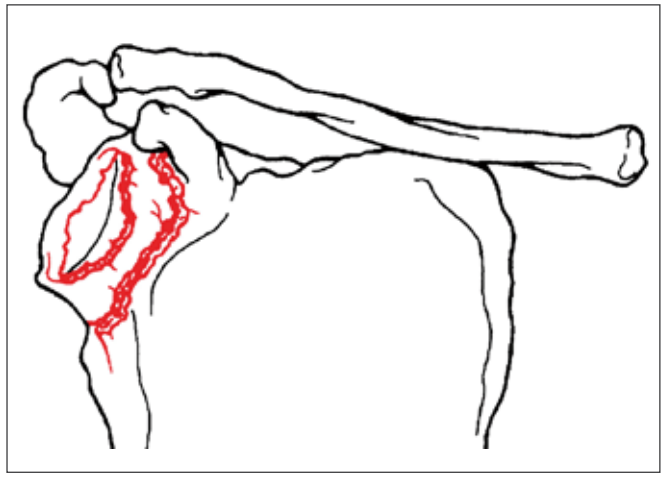

Fig. 7-17 OTA/AO classification – "extraarticular glenoid neck, comminuted". Modified after [52].