Introduction and Classifications

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10.1 Introduction

Proximal humeral fractures are very common and incidence is very different considering the age.

In children, they are less than 1% of all the fractures, but as they never required a treatment with reverse shoulder arthroplasty, they will not be treated in this chapter.

Incidence rate of proximal humeral fracture in adults rates from 4 to 5% of all fractures, and in patients older than 40 years, they account for over 75% of humerus fractures [1, 2].

Women have a much higher incidence than men, probably because of postmenopausal osteoporosis, whereas in patients younger than 50 years, the main cause of this kind of fracture is a high-energy trauma [3, 4].

Classification should help orthopedic surgeons to characterize a problem, to suggest a prognosis, and to offer the optimal treatment for a particular pathology.

Understanding the particular fracture pattern in each case is complicated, especially when poorly positioned radiographs are the only available studies. Most well-accepted classification systems were developed based on radiographs complemented by intraoperative findings.

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10.2 Historical Classifications

As in other districts, many different classifications have been proposed, starting with Kocher's classification based on different anatomic levels of fracture: anatomic neck, epiphyseal region, and surgical neck [5].

This classification is quite simple and reproducible, but do not consider the presence of fracture at multiple levels, the degree of fracture displacement, and the present of dislocations.

In 1934 Codman presented a modification of Kocher's classification, based on the epiphyseal region of the proximal humerus, and identified four possible fracture fragments: greater tuberosity, lesser tuberosity, anatomic head, and shaft [6].

10.3 Neer Classification

This classification was used till 1970, when Neer proposed his classification that is still the most used in clinical practice [7] (Fig. 10.1).

This system is based on the anatomic relationship of the four main anatomic parts (greater tuberosity, lesser tuberosity, proximal shaft, and humeral head) and on the grade of displacement of the fragments.

In this classification the main issue is the presence of displacement of one or more segments and not only the presence of a line of fractures.

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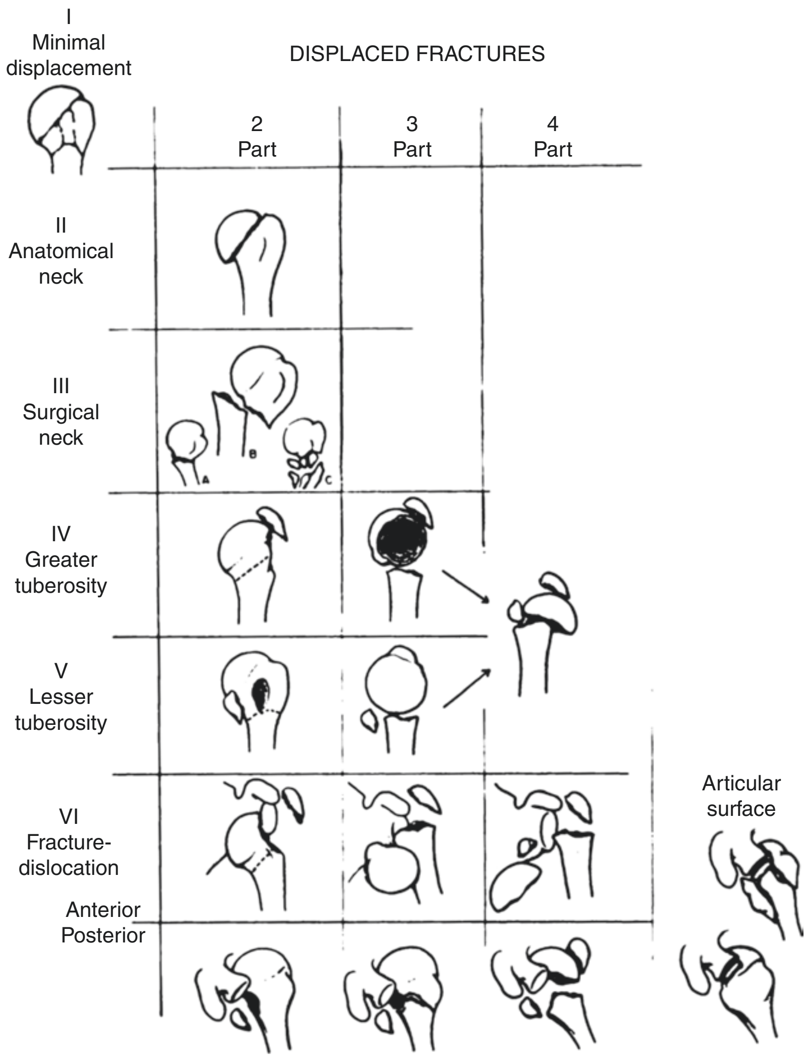

Fig. 10.1 The Neer classification of proximal humeral fractures [7]

A segment was considered displaced if it angulated more than 45 degrees from its anatomic position or if it's displaced more than 1 cm.

The most common fracture (85% of all proximal humeral fractures) is a one-part non-displaced or minimally displaced fracture even if these fractures have multiple fractures lines, because the fragments don't fulfill the criteria for displacement as stated by Neer [8].

Displaced fracture includes two-part fractures, characterized by displacement of one of the four-fragment, three-part fractures, in which there is a displacement of two fragments, and four-part fractures, where there is a displacement of all four segments.

So we could have four different two-fragment fractures (anatomic neck, surgical neck, greater tuberosity, or lesser tuberosity), two different three-fragment fractures (greater tuberosity and shaft or lesser tuberosity and shaft), and one four-fragment fracture.

Neer also introduced fracture dislocations which are displaced fractures (two-, three-, or four-part fractures) associated with anterior or posterior dislocations: so we could have six different types of fracture dislocations.

In the end Neer also introduced articular surface fractures dividing them into two types: impression fractures and head-splitting fractures.

Neer classification is the most widely used classification system for proximal humerus fractures [9]; however reliability of this classification has been discussed in many studies.

Radiographs of 50 proximal humerus fractures [10] were reviewed by an orthopedic shoulder specialist, an orthopedic traumatologist, a skeletal radiologist, an orthopedic resident in fifth year of training, and an orthopedic resident in second year of training.

These exams were reviewed two times at 6 months of interval, and the results showed a "moderate" level of reliability and the mean intra-observer reliability was 0.65.

This point is really important because a fracture could be classified as minimally displaced or as a three-part fracture by two different orthopedic surgeons leading to two different treatments [11].

10.4 AO Classification

The AO group proposed another classification based on risk of osteonecrosis due to modification of vascular supply (Fig. 10.2).

The fractures of the proximal humerus are divided in three types: extraarticular unifocal, extraarticular bifocal, and articular; each of these groups is further divided into three different groups based on presence of impaction and associated dislocation.

Type A fractures are extraarticular unifocal and A1 are the tuberosities fractures, A2 are impacted metaphyseal fractures, and A3 are nonimpacted metaphyseal fractures.

Type B group includes extraarticular bifocal fractures involving both tuberosities with a concomitant metaphyseal fracture or glenohumeral dislocations: B1 fractures are the fractures associated with an impacted metaphyseal fracture, B2 are nonimpacted metaphyseal fractures, and B3 are fractures associated to a glenohumeral dislocation.

Type C fractures are articular and involve vascular isolation: C1 are fractures with slight displacement, C2 are fractures impacted with marked displacement, and C3 are fractures associated with dislocation.

Each subgroup is divided in three different options according to alignment, degree, and direction of the displacement.

The risk of avascular necrosis is rare in type A, low in type B, and high in type C.

This classification seems to be more complex compared to the Neer classification, even if it should allow a more detailed guideline for treatment, but its interobserver reliability has not shown it to be better than Neer's classification [12].

10.5 LEGO System and HGLS Classification

Hertel [13] more recently developed a "binary system" (LEGO system). Emphasis was given to the location of fracture planes, rather than the nature of the fractured fragments. The system pictorially represented the four parts of the proximal

Fig. 10.2 The AO classification of proximal humeral fractures (https://www2.aofoundation.org)

humerus (head, greater and lesser tuberosities, and shaft) using LEGO blocks (Lego Group, Billund, Denmark). The absence of a bond between any of the four parts represents the location of a fracture plane. For a full fracture description, five yes-or-no questions had to be answered concerning the five basic fracture planes: (1) Is there a fracture plane between the head and greater tuberosity? (2) Is there a fracture plane between the greater tuberosity and shaft? (3) Is there a fracture plane between the head and lesser tuberosity? (4) Is there a fracture plane between the lesser tuberosity and shaft? (5) Is there a fracture plane between the greater tuberosity and lesser tuberosity? Thinking in fracture planes, not in fracture fragments, represented the change of paradigm. A number was then assigned to each fracture permutation (Fig. 10.3).

In addition, the following accessory criteria were determined (Figs. 10.2, 10.3, and 10.4): length of the posteromedial metaphyseal head extension; displacement of the shaft with respect to the head (the maximal displacement was measured between the posteromedial edge of the head and the posteromedial shaft fracture line); whether the shaft is displaced medially or laterally; displacement of the tuberosities (maximum displacement of either the greater or the lesser tuberosity); amount of angular displacement of the head, varus, or valgus; whether there is a glenohumeral dislocation (anterior or posterior); whether there is a head impression fracture (anterior or posterior); and whether there is a head-split component (>20% of head involvement) with one or two intraarticular fracture planes (Figs. 10.4 and 10.5).

The main purpose of this classification was to predict humeral head perfusion in proximal humeral fractures in order to identify the optimal treatment; the results were that specific fracture plane combinations (types 2, 7, 8, 9, 10, and 12) were associated with impaired head perfusion and that additional elements, such as the length of the posteromedial metaphyseal head extension and the integrity of the medial hinge, were the key elements for occurrence of vascular disruption.

However, despite validating this system well with intraoperative direct observation, the numerical coding of individual fracture patterns was considered difficult to remember and therefore likely to contribute to categorization error and poor reliability.

So, this classification was modified adopting an alphabetic-based “pictogram” that clearly

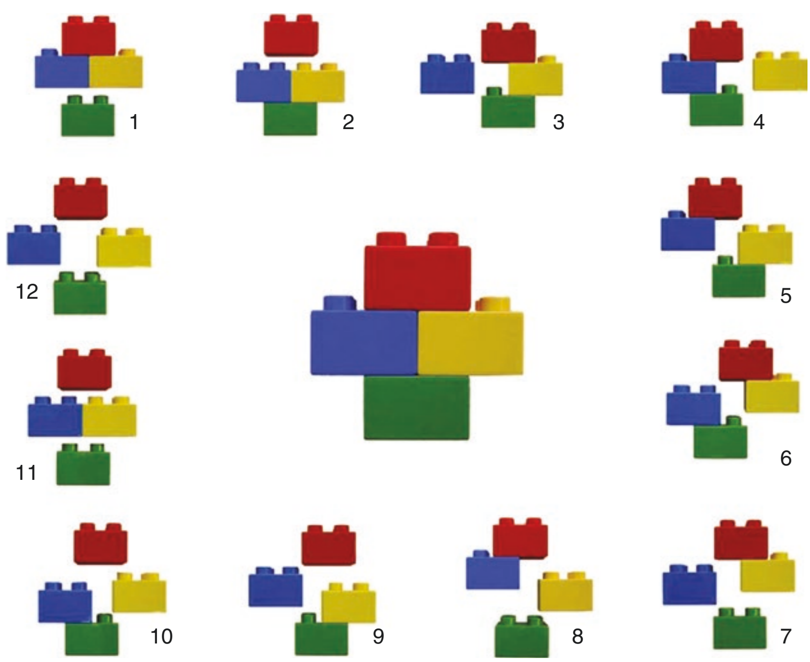

Fig. 10.3 The LEGO system classification of proximal humeral fractures (Ref. [13])

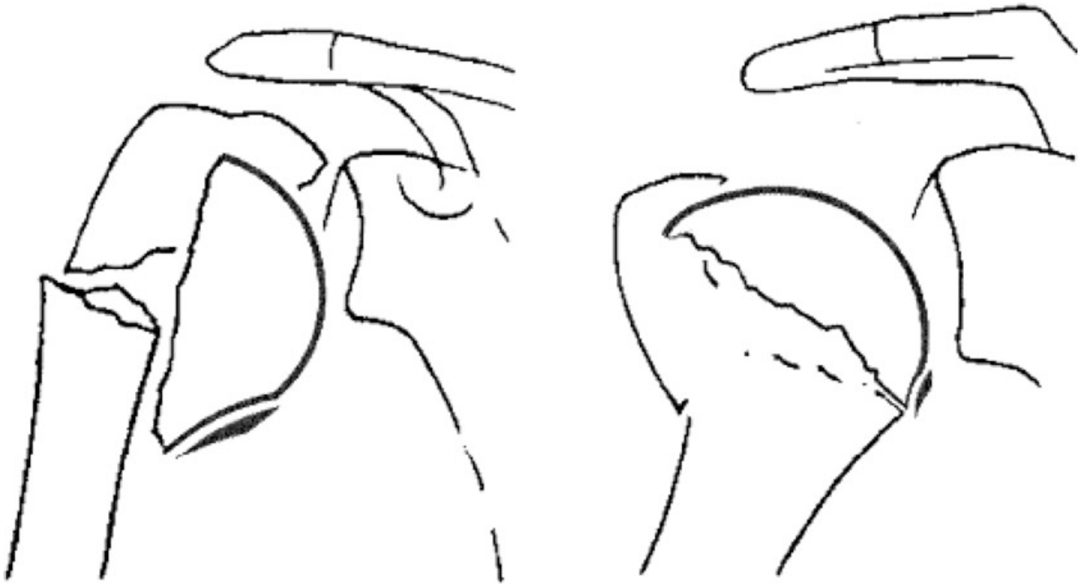

Fig. 10.4 First additional criterion: length of the medial metaphyseal head extension. The longer the extension, the more likely the head is perfused. Hertel, R., Hempfing, A., Stiehler, M., & Leunig, M. (2004). Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. *J Shoulder Elbow Surg, 13*, 427-33

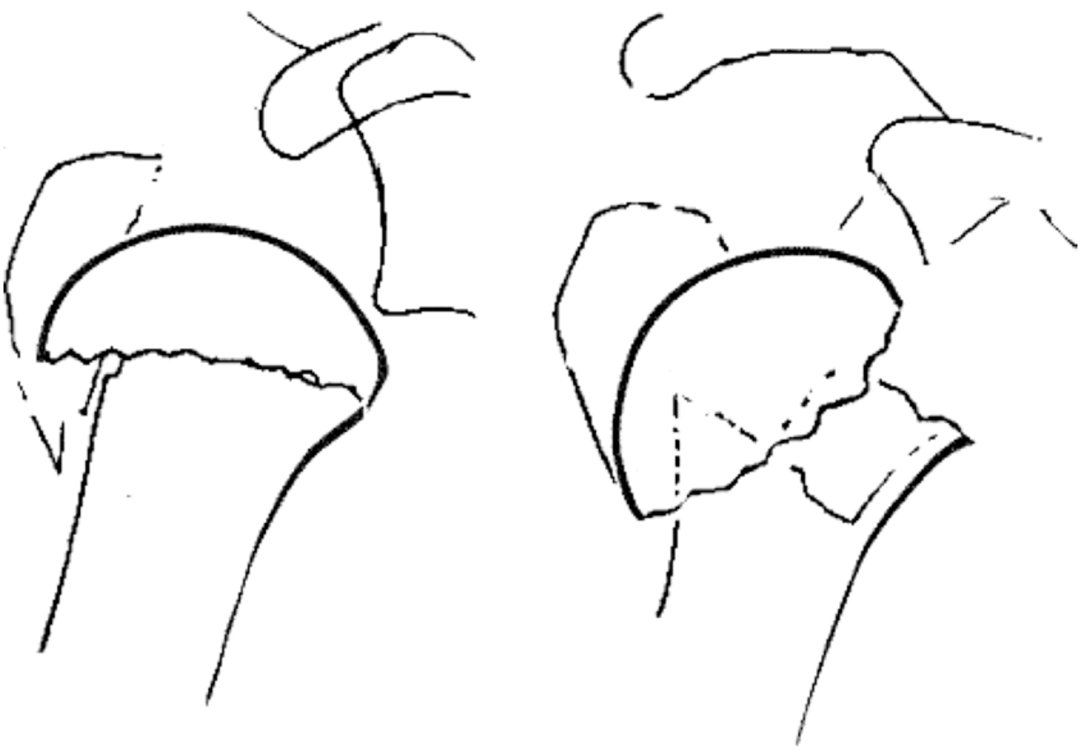

Fig. 10.5 Second additional criterion: integrity of the medial hinge. Integrity of the hinge is a predictor of both ischemia and practical feasibility of reduction. Hertel, R., Hempfing, A., Stiehler, M., & Leunig, M. (2004). Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. *J Shoulder Elbow Surg, 13*, 427-33

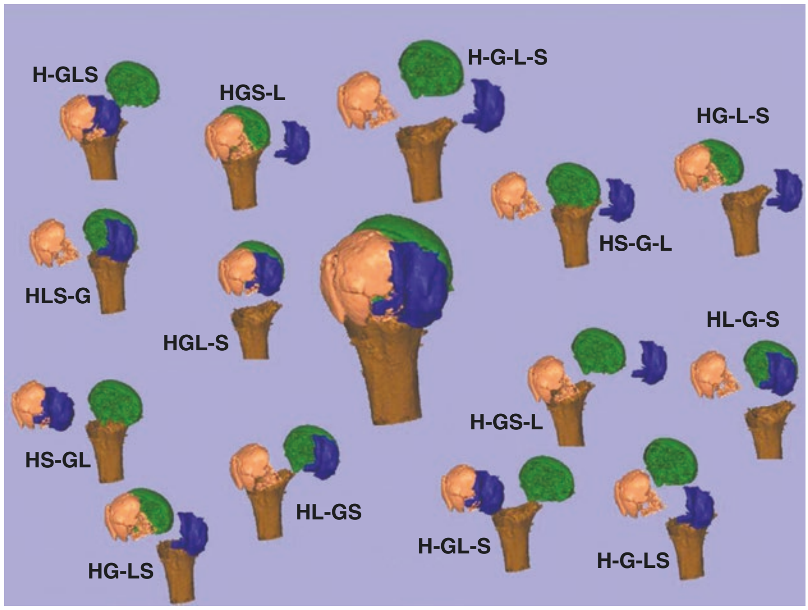

Fig. 10.6 HGLS classification. Sukthankar AV, Leonello DT, Hertel RW, Ding GS, Sandow MJ. J Shoulder Elbow Surg 2013, 22 e1–e6

defines the four anatomic parts of the proximal humerus and the location of a fracture plane(s) between these parts. This system is named the HGLS classification (Fig. 10.6).

In this classification, the proximal humerus is divided into four topographic parts: head (H), greater tuberosity (G), lesser tuberosity (L), and shaft (S). The line of fracture is symbolized by a hyphen (–) and represents a cortical interruption between two parts regardless of displacement and angulation. So a fracture of the greater tuberosity is documented as HLS-G and a fracture of the surgical neck (with tuberosities attached to the humeral head) is documented as HGL-S and so on.

In case of dislocation, a prefixed "d" must be inserted before H; furthermore, calcar length (so important for prediction of humeral head ischemia) is identified by bracketing the letter "c" followed by the length of the intact calcar segment in mm.

Comparing Neer, AO, and HGLS classifications, it seems that HGLS classification has a better intra- and interobserver reliability [14].

As previously stated, the aim of a classification should be to characterize the problem and offer the optimal treatment.

If the first issue has been satisfied by Neer and, more recently, by Hertel, the second one is still pending because even if the reliability of the classification system is quite high, there is not a unique treatment according to the classification itself.

In fact, whatever is the system used, the treatment may be different: analyzing 229 displaced humeral fractures classified with the most utilized system (Neer and AO), only 58.8% of the four-part Neer fractures and 67.7% type-C AO classified were surgically treated [15].

Maybe it could be due to the different cultures of each surgeon and/or the unpredictability of the outcome either of the conservative or surgical treatment [16].

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