Displaced Proximal Humeral Fractures: PART I. CLASSIFICATION AND EVALUATION

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Displaced Proximal Humeral Fractures

Part I. Classification and Evaluation*

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Most proximal humeral fractures respond satisfactorily to simple conservative treatment. It is only the occasional displaced fracture or fracture-dislocation that demands special treatment and judgment; yet existing classifications are inadequate to identify these lesions. Failure to portray the specific fracture under consideration has led to confusion in the literature and difficulty in establishing guidelines for treatment. This paper describes a classification that has been found not only adequate for sorting lesions for analysis of results but also helpful in correlating the roentgen appearance and type of fresh fractures.

Material and Method

A study was made of the anatomy of 300 displaced proximal humeral fractures and fracture-dislocations, selected at random from those treated by closed reduction under anesthesia or surgery at the New York Orthopaedic Hospital—Columbia-Presbyterian Medical Center between the years 1953 and 1967. The ages of the patients ranged from twenty-two years to eighty-nine years and averaged 55.6 years. Treatment consisted in closed reduction under anesthesia in 162, open reduction in seventy-five, with removal of the humeral head on five occasions 8, and prosthetic replacement 10,16,17 in sixty-three patients. Roentgenograms of the fracture made before treatment were studied and the precise relationships of the major segments were charted. Operative findings and photographs of those treated surgically were correlated with the roentgen appearance. As distinct anatomical categories became evident, the classification was evolved.

Deficiencies in Existing Classifications

Traditional classifications according to the level of the fracture 2,11 are of little assistance in depicting the type of displaced fracture because two levels were frequently involved (Fig. 1). As Codman observed, fractures at the humeral neck separate one, two, or three of the four major segments from the rest: the segments are the head, the lesser tuberosity, the greater tuberosity, and the shaft. Fracture of both tuberosities produces a lesion that can be termed either an anatomical-neck fracture or a surgical-neck fracture because both levels are implicated. This leads to

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inconsistencies in the literature, as is shown by variations in the reported incidence of each level of fracture as interpreted by different observers. Furthermore, a classification based merely upon the level of the fracture permits a non-displaced lesion to be grouped with a serious displacement.

Classification according to the mechanism of the injury also fails to portray

Fig. 1

Drawing illustrating the rotator interval, a ligamentous area between the tendons of the supraspinatus and subscapularis, and the four major fragments of proximal humeral fractures: (1) head, (2) lesser tuberosity, (3) greater tuberosity, and (4) shaft. Retraction of both tuberosities tears the rotator interval and involves both the surgical-neck and anatomical-neck levels.

Fig. 2-A

Figs. 2-A and 2-B: Anteroposterior roentgenograms of a malunited fracture depicting the fallacy of the terms abduction fracture and adduction fracture.

Fig. 2-A: With the humerus internally rotated the head appears to be in valgus position, the adduction fracture.

Fig. 2-B: With the same humerus externally rotated the head appears to be in varus position, the abduction fracture.

The apex of the angle is, as in this case, usually directed anteriorly and not in the scapular or coronal planes.
The anatomical classification. Each of the four major segments shown in Fig. 1 is considered. Group I includes all proximal humeral fractures, regardless of the number of lines of cleavage, in which no segment is displaced more than 1.0 centimeter or angulated more than 45 degrees. Group II, the anatomical-neck fracture, is a displacement of the head segment, with or without hairline tuberosity components. Group III, the surgical-neck fracture, is a displacement of the shaft segment with the rotator cuff intact. Group IV, the greater tuberosity displacement, occurs as a two-part and, with an impacted surgical-neck fracture, as a three-part lesion. Group V, the lesser tuberosity, occurs as a two-part and, with an unimpacted surgical-neck fracture, as a three-part lesion. Groups IV and V blend as the four-part fracture in which both tuberosities are displaced. Group VI, the fracture-dislocation, implies damage outside the joint space, anteriorly and posteriorly, and segment distribution is important in estimating the circulation of the head. The articular surface fractures, in which portions of the head are dislocated, are the impression fracture and the head-splitting fracture.

the type of lesion. The terms abduction fracture and adduction fracture are misleading because the apex of angulation usually is directed anteriorly, occasionally in some other plane, but rarely in the coronal or scapular planes. Anterior angulation can produce the roentgen appearance of either the abduction fracture or the adduction fracture, depending on the position of rotation of the humerus (Figs. 2-A and 2-B).

It also is confusing to find that opinions differ 1,6,9,10,20 as to what constitutes a fracture-dislocation. The glenohumeral-joint capsule is large enough to contain two humeral heads and when there is muscle atony or when one of the tuberosities is detached, the articular surface of the humerus can easily be subluxated or rotated out of the glenoid cavity. This has led to such terms as fracture-subluxation 7,21, rotary
dislocation, and impacted fracture-dislocation. However, these terms fail to specify the type of rotatory displacement in a specific lesion. Indeed, the role of muscle attachments in producing displacement has received surprisingly little attention.

The Four-Segment Classification

The classification adopted is based, not on the level of the fracture nor on the mechanism of injury but on the presence or absence of displacement of one or more of the four major segments. Since all minimally displaced fractures pose analogous problems in treatment and prognosis, it seems logical that they be grouped together, regardless of the number of fracture lines. Displaced fractures require more accurate identification in order to depict both the effect of muscle attachments on free fragments, as well as the circulatory status and continuity of the articular surface. The classification illustrated was formed to identify the types of displacement that were actually encountered (Fig. 3).

Group I. Minimum Displacement

This group includes all fractures, regardless of the level or number of fracture lines, in which no segment is displaced more than 1.0 centimeter or is angulated more than 45 degrees. This group constitutes over 85 per cent of proximal humeral fractures. These lesions present similar problems in management. The fragments are usually held together by soft tissue or are impacted, permitting early functional
exercises; however, a brief period of immobilization may be required before the head and shaft rotate as one.

**Group II, Articular-Segment Displacement**

Pure displacement at the anatomical neck without separation of one tuberosity or both is quite rare. This lesion can escape notice unless a good anteroposterior roentgenogram of the upper end of the humerus is obtained (Fig. 4-A) and may lead to disability because of malunion or avascular necrosis (Figs. 4-B and 4-C).

**Group III, Shaft Displacement**

This fracture occurs just distal to the tuberosities at the level of the surgical neck and is displaced more than 1.0 centimeter or is angulated more than 45 degrees. Although fissure fractures may be present proximally, the rotator-cuff

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**Fig. 5-A**

Figs. 5-A, 5-B, and 5-C: Anteroposterior roentgenograms illustrating the three types of shaft-segment displacement seen in Group-III fractures.

Fig. 5-A: Angulated fracture, same malunion as in Figs. 2-A and 2-B, showing maximum abduction.

**Fig. 5-B**

Fig. 5-B: Non-contact fracture with the shaft displaced medially by the pectoralis major and the head held in neutral rotation by the intact rotator cuff.

**Fig. 5-C**

Fig. 5-C: Comminuted fracture, twisted by placing the arm across the chest in a sling.
Fig. 6-A through 6-E: Original anteroposterior roentgenograms illustrating Group-IV and Group-V fractures.

Fig. 6-A: Group-IV two-part fracture. The greater tuberosity is displaced but the head remains in normal position, with or without an undisplaced surgical-neck component.

Fig. 6-B: Group-IV three-part fracture. The greater-tuberosity displacement is associated with an unimpacted surgical-neck fracture which permits the head to be internally rotated by the subscapularis so that the articular surface faces posteriorly.

attachments are intact and hold the head in neutral rotation. The head is only slightly abducted unless tilted by an overriding shaft. Epiphyseal fractures are of this category. Three types are seen in adult patients.

The angulated surgical-neck fracture is impacted. Residual angulation of more than 45 degrees causes permanent limitation of abduction and elevation (Figs. 2-A, 2-B, and 5-A). The periosteal sleeve is usually intact posteriorly and affords considerable stability when closed reduction is accomplished by traction and elevation of the arm forward beyond the pivotal position.

The separated surgical-neck fracture is one in which the shaft is displaced medially and anteriorly, pulled by the pectoralis major. This fracture is often unstable after closed reduction (Fig. 5-B), and immobilization in a position to relax the pectoralis is helpful. The displacement is made worse by placing the arm in abduction or in a tight sling. Instability and interposition of soft tissue may lead to non-union. Associated neurovascular damage is not uncommon.

The comminuted surgical-neck fracture, in which fragmentation extends distally for several centimeters, often undergoes twist displacement when the arm is internally rotated across the chest, because the tuberosities and head are held in neutral rotation by the intact rotator cuff. Intermediate fragments may be displaced by the pectoralis (Fig. 5-C). This fracture can be adequately aligned by overhead ulnar-pin traction applied in neutral rotation to relax the pectoralis.

Group IV, Greater-Tuberosity Displacement

The greater tuberosity or one of its facets for tendon attachment is retracted more than 1.0 centimeter from the lesser tuberosity. The separation is pathognomonic of a longitudinal tear in the rotator cuff. The tear usually occurs at the rotator interval (Fig. 1), but, when only the posterior part of the greater tuberosity is retracted, the tear occurs posterior to this interval. In the two-part pattern, the articular segment remains in a normal relationship with the shaft, although a minimally displaced fracture of the surgical neck may be present (Fig. 6-A). In the three-part pattern, in addition to the retraction of the tuberosity, displacement at
Fig. 6-C: Group-V two-part fracture. The lesser tuberosity is displaced but the head remains in normal position, with or without an undisplaced surgical-neck component.

Fig. 6-D: Group-V three-part fracture. The lesser-tuberosity displacement and unimpacted surgical-neck fracture permit the head to be externally rotated and abducted by the supraspinatus and external rotators as the articular surface faces anteriorly.

Fig. 6-E

Groups IV and V merge in the four-part fracture. Both tuberosities are displaced and the head presents at the defect in the rotator interval.

...the surgical neck is also present which allows the articular segment to be internally rotated by the subscapularis. This exaggerates the rotator-cuff defect and causes the articular segment to face posteriorly (Figs. 6-B and 7). This is a much more serious displacement. The attached muscles act to prevent closed reduction. Nevertheless, a good source of blood supply to the head remains because soft parts are attached to
the articular segment anteriorly. If this source of blood supply is preserved during an open reduction, the prognosis for survival of the humeral head would appear to be much better than that of the four-part fracture in which the head is detached (Fig. 6-D).

**Group V, Lesser-Tuberosity Displacement**

The two-part lesion occurs as an isolated avulsion or in association with an undisplaced fracture of the surgical neck (Fig. 6-C). Displacement of the lesser tuberosity spreads the anterior fibers at the rotator interval and produces a bone prominence. Neither defect appears to be of clinical importance. In the three-part displacement, however, the displacement at the surgical neck allows the articular segment to be externally rotated and abducted by the supraspinatus and external rotators. This exaggerates the rotator-cuff defect and interferes with closed reduction. The articular surface is made to face anteriorly (Figs. 6-D and 7). At open reduction, articular cartilage is found presenting at the gaping tear in the rotator cuff, a situation which suggests that the head is dislocated, a false fracture-dislocation. However, the head segment retains abundant soft-part attachments posteriorly and adequate blood supply. Open reduction can be readily accomplished by de-rotating the head and approximating the tuberosities and cuff. In the four-part fracture, both tuberosities are retracted and, as in all four-part lesions, the blood supply to the humeral head has been severed. The articular segment is usually displaced laterally between the retracted tuberosities (Fig. 6-E). When the head is displaced laterally and out of contact with the glenoid, the term *lateral fracture-dislocation* is descriptive. However, the pathomechanics seem clearer when this lesion is classified as a severely displaced fracture rather than a fracture-dislocation.

**Group VI, Fracture-Dislocation**

This fracture occurs with a true dislocation which implies ligamentous damage and injury outside the joint, in turn implying a greater threat of pericapsular bone formation. The displacement of the humeral head may be anteroinferior, posterior, or superior; but no instance of superior displacement, associated with a fracture of
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Fig. S-A through S-D: Original anteroposterior roentgenograms illustrating anterior fracture-dislocations, Group VI. Segment distribution is important in estimating the circulation of the head.

Fig. S-A: An unusual two-part surgical-neck lesion with both tuberosities in continuity with the head.

Fig. S-B: Two-part greater-tuberosity displacement, a common injury.

Fig. S-C: Three-part lesion. The lesser tuberosity and its soft-part attachments remain to provide considerable blood supply to the head.

Fig. S-D: Four-part lesion in which the head is detached.

de the proximal end of the humerus, was encountered in this study. In the two-part and three-part fracture-dislocations (Figs. S-A, S-B, and S-C), the blood supply to the humeral head is usually adequate because one of the tuberosities, with soft-tissue attachments, remains in continuity with the articular segment. The lesser tuberosity always remains attached to the humeral head in anterior three-part fracture-dislocations while the greater tuberosity remains to provide circulation to the head in posterior three-part fracture-dislocations. In four-part fracture-dislocations the head is detached (Fig. S-D). Neurovascular symptoms occur more commonly with anterior four-part displacements.

Displaced fractures of the articular surface are classified with fracture-dislocations because, while part of the articular cartilage has been crushed by impact
against the glenoid and stays within the joint space, other fragments of cartilage are extruded from it. The impression fracture is commonly encountered with a posterior dislocation but rarely occurs to a significant extent with an anterior dislocation. When the impression defect is small and the lesion is recognized early, closed reduction is effective. When the impression involves more than 20 per cent of the articular surface, redislocation tends to occur unless the main articular fragment is stabilized, as by transplantation of the subscapularis tendon into the defect in the head. When the articular defect involves more than 50 per cent of the cartilage-covered surface, the joint is unstable and dislocation readily recurs despite transplantation of the subscapularis. A prosthesis may be used at times to render this lesion stable. The head-splitting fracture results from a central impact which may extrude fragments of cartilage both anteriorly and posteriorly. The articular surface is fragmented into many disconnected pieces.

Roentgenographic Appraisal of the Lesion

Recognition of the position and relationships of the four major segments is essential to the application of this system of classification. As in the case of most other fractures, oblique projections can be confusing. It is helpful to obtain two roentgenograms of the upper end of the humerus made at right angles to each other, supplemented when necessary with transthoracic, rotational, and axillary roentgenograms.

It is usually possible to make the two initial projections with the patient erect and the arm in a sling (Figs. 9-A and 9-B). One view of the upper end of the humerus is perpendicular to the scapular plane and the second is parallel to the scapular plane. With this information, and with careful positioning, axillary or rotational roentgenograms of the upper end of the humerus can be made as required. The distance between the greater and lesser tuberosities is used to indicate the severity of tuberosity displacement.
TABLE I
CRITERIA FOR EVALUATION OF RESULTS *

1. Pain (35 units)
   a. None, ignores 35 Extension
   b. Slight, occasional, no compromise in activity 30
   c. Mild, no effect on ordinary activity 25 Abduction (coronal plane)
   d. Moderate, tolerable, makes concessions, uses aspirin 15
   e. Marked, serious limitations 5
   f. Totally disabled 0

2. Function (30 units)
   a. Strength
      Normal 10 External rotation (from anatomical position with elbow bent)
      Good 8
      Fair 6
      Poor 4 Internal rotation (from anatomical position with elbow bent)
      Trace 2
      Zero 0
   b. Reaching
      Top of head 2
      Mouth 2
      Belt buckle 2
      Opposite axilla 2
      Brassiere hook 2
   c. Stability
      Lifting 2
      Throwing 2
      Pounding 2
      Pushing 2
      Hold overhead 2

3. Range in Motion (25 units)
   Flexion (sagittal plane)
   180 None 10
   170 Mild 8
   130 Moderate 4
   100 Marked zero to 2
   80
   less

   Total points 100 units

* Excellent, above 80 units; satisfactory, 80 units; unsatisfactory, 70 units; failure, below 70 units

Evaluation of Results

Assessment of the results of treatment depends not only on an accurate definition of the specific lesion under discussion but also on an objective interpretation of functional recovery. The criteria for good, fair, and poor results have varied with each author and have been difficult to compare. An objective system that can be generally accepted for the future judging of long-term results is needed.

The numerical rating method employed in our clinic for several years is shown in Table I. This system is based on 100 units. Pain, the most important consideration to the patient, is assigned 35 units. The result in any patient with significant pain is graded a failure. Functional range, more important in the shoulder than in most joints, is accorded a greater unit value than strength and anatomy. The results in 117 patients with three-part and four-part fractures have been rated by this method and are reported in the succeeding article.

Discussion

Existing classifications of fractures of the proximal part of the humerus are oversimplified and inadequate. It is essential to the understanding of the more
complex shoulder injuries that fractures of a similar type be grouped together and separated from the more serious or less serious lesions. Any proponent of a method of treatment who fails to take this into account is likely to add confused reports to the already perplexing literature. Yet, since displaced fractures are relatively uncommon, it is desirable that comparable data be gathered from a number of sources in order to obtain answers to therapeutic questions.

It is generally agreed that fractures with minimum displacement, regardless of the level or number of fracture lines, can be satisfactorily treated by early functional exercises. These lesions can be separated as one large group. Most two-part displacements, with the exception of the greater tuberosity and of certain unstable fractures of the surgical neck, can be adequately controlled by closed means. The real problems arise in the case of three-part and four-part displacements and in the fractures with massive defects in the articular surface.

Three-part fractures present the problem of marked anatomical distortion. Some of the tendons causing rotatory displacement are accompanied by vessels to the articular segment. It may appear most difficult to restore good anatomical relationships by closed means, yet necrosis with resorption of the head rarely occurs. In this group, it would seem important in the future to compare the results of closed treatment with those of open reduction. What degree of imperfection in reduction is acceptable? If open reduction yields better results, how can the technique and the method of fixation be improved?

In four-part fractures the circulation to the head is destroyed. Can the disconnected articular segment enter into bone union and survive or will it disintegrate? What are the relative merits of prosthetic replacement compared with those of other open or closed procedures in which the articular fragment is retained?

Articular crushing in large impression fractures and head-splitting fractures can be logically treated by prosthetic replacement. Other techniques may be developed in the future. But regardless of the method of treatment, if we are to make orderly progress, it is essential that the lesion under consideration be clearly defined and the result considered objectively.

One further deterrent to progress in the treatment of complicated fractures of the shoulder has been the prevalent misconception that these injuries occur in very elderly patients who do not require optimum results. Occasionally this is true, but as the exception rather than the rule. The patients in my series had an average age of fifty-five years and the majority were in their most productive years.

Summary

On the basis of roentgenographic appearance and anatomical lesions in 300 displaced fractures and fracture-dislocations of the proximal end of the humerus, a new classification was made of these injuries. Existing classifications were found to be inadequate to describe the lesion encountered. The new classification was based on the presence or absence of displacement of each of the four major segments: articular surface of the humeral head, greater tuberosity, lesser tuberosity, and shaft. Careful roentgen examination was found necessary to apply this system, including anteroposterior and lateral roentgenograms of the proximal end of the humerus made vertical to and parallel with the scapular plane. A numerical rating scale for evaluating the results of treatment is described because, in addition to a clear definition of the lesion, objective criteria for rating results are essential for future progress in the treatment of the more complex shoulder injuries.

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