THE GROOVED DEFECT OF THE HUMERAL HEAD

A FREQUENTLY UNRECOGNIZED COMPLICATION OF DISLOCATIONS OF THE SHOULDER JOINT

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NCENTIVE for this study was the discovery within a short period of time of two shoulders, each of which presented a large defect or groove in the posterolateral aspect of the head of the humerus (Figs. 3 and 4). The defect was variously interpreted by different consultants as due to infection, metastasis, and post-traumatic osteoporosis. A survey of the standard textbooks on roentgen diagnosis and on orthopedics was of no assistance in differential diagnosis. Accordingly, a detailed study of the literature was made and 119 cases of dislocated shoulder, examined roentgenographically at the San Francisco Hospital between the years 1930 and 1940, were reviewed. This led to a clarification of our original conceptions regarding the nature of this lesion, and identified it *not* as a late result of dislocation of the shoulder, but as a true fracture.

REVIEW OF THE LITERATURE

Inasmuch as shoulder dislocations are the most frequent of all dislocations of the body, this subject has been of medical interest since ancient times. Hippocrates described the symptoms of dislocation of the shoulder and a method of reducing the luxation. Following Hippocrates, little was added to this subject until late in the nineteenth century when progress began to be made in the pathologico-anatomic changes occurring in shoulder dislocations.

In 1861, Flower (8) reported upon 41 shoulder specimens which he had studied after collecting them from all of the pathologic museums of London. He described cases which showed rupture of the tendons inserted upon the greater tuberosity, fracture of the tuberosity, or the presence of a groove excavated on the articular head posterior to the greater tuberosity. Between 1880 and 1903, there were many case reports (Kuster, 1882; Cramer, 1882; Popke, 1882; Loebker, 1887; Schuller, 1890; Staffell, 1895; Francke, 1898; Wendel, 1903), which described the pathologico-anatomic findings in humeral heads resected for the relief of chronic or habitual dislocation (9). In all these cases there was such a similarity in the change found by the various operators that the groove or excavation became known as the "typical defect." A composite description of these resected specimens may be summed up as follows: The defect is located posterior and medial to the greater tuberosity on the posterolateral aspect of the articulating surface of the humeral head. The groove is navicular or wedge-shaped and its average measurements are 2.5 cm. in length (cephalocaudad), 1.5 cm. in width, and 0.75 cm. in depth. The defect is demarcated from the surrounding normal bone by sharp or vertically projecting walls, which in the larger defects stand at a right-angle to each other. The spongiosa bordering the defect is thicker than elsewhere and is covered with a glossy, smooth connective tissue layer. No fragment avulsed from the humerus is to be seen (Fig. 1).

Since more conservative methods have displaced resection as a method of treatment for habitual shoulder dislocations (4, 5, 10), the defect is frequently not discovered as a result of operation, especially if the anterior approach and extracapsular methods are used. However, x-ray studies, if properly made, will reveal the defect.

In 1906, Perthes (13) described the roentgenologic appearance in two cases and in 1914 Schultze (15) published the results of the first carefully studied series of cases. However, it was not until 1925 that Pilz

(14) first demonstrated the fact that the success or failure of the x-ray examination is dependent upon the technic used.

ETIOLOGY

The mechanism of anterior dislocations of the shoulder have been well described by numerous authors (1, 9, 10, 16). In brief: With the arm abducted and internally rotated, trauma is transmitted along the longitudinal axis of the humerus, forcing the head inferiorly. The head is forced out of the glenoid fossa by external rotation and against the anterior rim of the glenoid. In many instances the force of impaction is sufficient to fracture off all or a portion of the greater tuberosity, or, more rarely, the neck of the humerus is fractured. In other cases, in which the posterolateral aspect of the humeral head and its weakest portion impinges on the glenoid rim, a compression fracture of the spongiosa of the former region occurs. This compressed area is usually of sufficient size to permit detection on the roentgenograms as a so-called "typical defect"; less often it results in but a slight flattening of the contour of the humeral head or in minute infractions which later lead to cystic changes.

There have been many theories offered in the past to account for the defects noted in the resected specimens and roentgenograms. Some of these are as follows: (1) congenital anomaly; (2) osteochondritis dissecans; (3) avulsion fracture with absorption of fragment; (4) aseptic or pressure necrosis following damage to blood vessels of the head; (5) post-traumatic inflammation.

A knowledge of the mechanism of shoulder dislocations and of the pathologico-anatomic changes present in this lesion (3, 6, 10, 12, 16) makes the above theories untenable. Furthermore, there is sufficient evidence, especially roentgenographic, to prove that such defects do occur immediately following a single injury to a shoulder previously proven to be normal. Malgaigne (11), prior to 1880, conjectured that such might be the case. Eve (7), in 1880, reported the first proven case. His

patient died twelve hours after a train accident in which one shoulder sustained an injury. On examination of the humeral
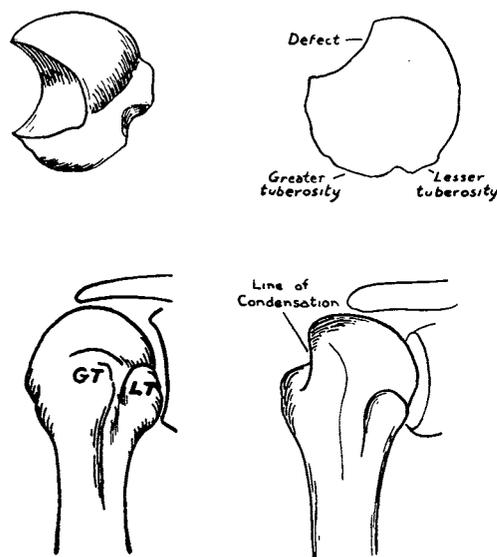

Fig. 1 (*upper*). Diagrams of profile and cross-section views of grooved humeral heads resected for habitual dislocation (*from Kuster and Cramer*).

(*Lower left*) Diagram of an x-ray of a normal humerus in internal rotation.

(*Lower right*) Diagram of an x-ray of a humerus in internal rotation, showing defect.

head a deep groove of recent origin was found on the posterolateral aspect of the head of the humerus. Hermodsson (9) states that his studies have shown that in many instances the defect occurred at the time of the first dislocation and did not change appreciably later, in spite of additional luxations. He reports 18 cases in which the defect was demonstrated before reduction was attempted. One of his cases was roentgenographed one hour following a fall from a motorcycle, and though the patient had replaced the dislocation a large defect was found. Roentgenograms of another individual taken during March, 1930, following a fall showed no damage, but on re-examination of the same shoulder following a dislocation in May, 1930, a defect was noted. We have a very similar case in our series (Fig. 4). Films taken of the left shoulder for comparison at the time of a disorder of the right were negative. Examination two months later, immediately after a subcoracoid dislocation of the

left humerus, showed a definite defect. Therefore, after a review of the literature and a study of our own cases, we are con-

Figures for the incidence of compression fractures producing the "typical defect" in the head of the humerus are rare, most
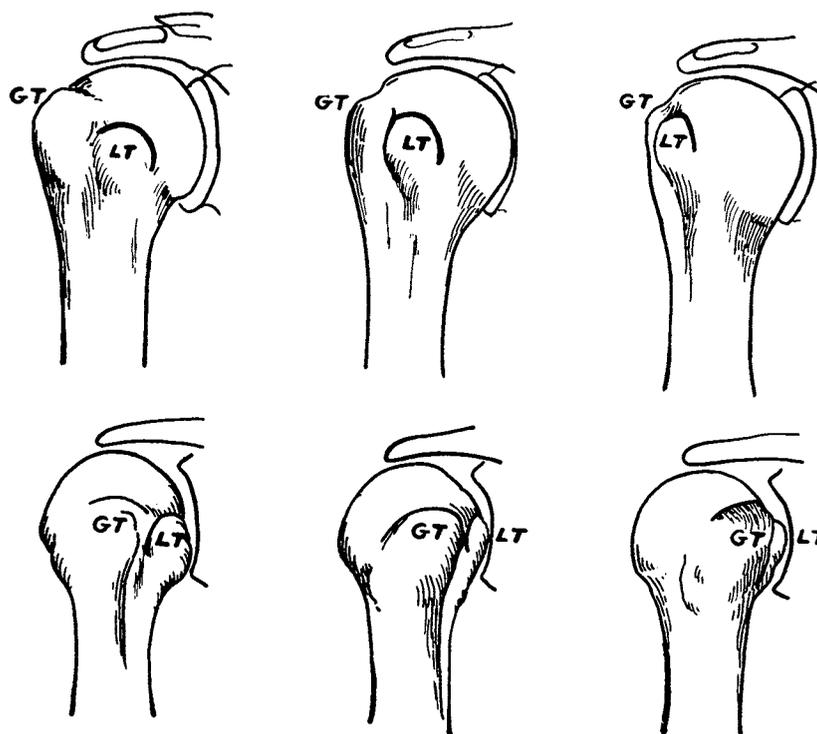

Fig. 2. Diagrams of x-rays of the humerus in increasing degrees of rotation to illustrate the fact that only in marked internal rotation is the posterolateral aspect of the humeral head seen in profile.

(*Upper*) External rotation of humerus: (*left*) slight rotation; (*center*) moderate; (*right*) marked.

(*Lower*) Internal rotation of humerus: (*left*) moderate rotation; (*center*) marked; (*right*) very marked.

vinced that the "typical defect," and probably also the cystic changes present in a few cases, are the result of *compression fractures* of the comparatively soft bone comprising the posterolateral portion of the head of the humerus.

INCIDENCE

About 95 per cent of shoulder dislocations are anterior in position. The following classification of the varieties of anterior displacements is the one that we prefer: (A) Subglenoid; (B) Anterior or axillary; (C) Subcoracoid. The subcoracoid position of the head is the third or last stage in anterior displacements of the humerus, nevertheless it is the most frequently seen variety, outnumbering by more than three to one the subglenoid type.

reports being of but one or two cases. A few authors have reported their results from roentgenologic investigations of a series of habitual dislocations of the shoulder.

TABLE I.—CASES OF HABITUAL DISLOCATION OF THE SHOULDER, STUDIED ROENTGENO-
GRAPHICALLY

Investigator	No. Cases Studied	No. Defects Found	Percentage of Incidence
Schultze	24	5	20
Boicev	31	11	35
Pilz	21	15	71
Bazy	7	7	100
Hermodsson	23	23	100

Pilz and Hermodsson have correctly shown that the percentage of defects found will be greatly influenced by the

thoroughness of the x-ray examination. Hermodsson found 24 out of 40 cases of recent or "fresh" dislocations in which defects could be demonstrated by his ordinary or routine shoulder examination, including views with the arm in internal rotation. Nine additional cases (of the 40) were shown to have defects, by the use of his specially devised tangential projection, thus changing the frequency of occurrence in this group from 60 to 82 per cent.

Small cyst-like areas in the posterolateral aspect of the humeral head have been described by a few investigators. It has been claimed by some that the changes are due to slight compression fractures sustained at the time of dislocation, or to

nutritional changes following the luxation. The number of such cases reported is small and figures as to incidence have not been given.

Most authorities place the frequency of recurrent or habitual dislocations of the shoulder (that is, instances in which there is more than one dislocation of the same shoulder) at from 10 to 15 per cent.

ROENTGENOGRAPHIC FINDINGS

Compression fractures of the humeral head, unless quite large, will frequently be overlooked unless the x-ray studies are made with the possibility of such in mind. A stereoscopic anteroposterior examination with the arm adducted and in external rotation is *not* adequate to demonstrate the

Fig. 3.   Case 1 (*upper left*).   Nov. 8, 1937.   Subcoracoid dislocation of the right humerus; view in external rotation shows no groove.
  (*Upper center*) June 27, 1938.   X-ray made following re-dislocation, with the humerus rotated slightly externally reveals a slight flattening of the superior-lateral contour of the head.
  (*Upper right*) Sept. 22, 1938.   Following correction of the third dislocation, a large groove is visible when the humerus is in marked internal rotation.
  (*Lower left*) Oct. 11, 1938.   The right humerus in external rotation, routine projection, showing no visible defect.
  (*Lower center*) Oct. 11, 1938.   The left humerus in internal rotation for comparison with the right; no groove present.
  (*Lower right*) Oct. 11, 1938.   The right humerus in marked internal rotation; this projection clearly reveals the large defect which was "hidden" in the routine view.   (This case presented through the courtesy of J. Minton Meherin, M.D.)

defect in many instances. An anteroposterior projection made with the arm in *marked* internal rotation is essential, and in a small percentage of cases the defect will be disclosed only by means of a tangential view of the posterolateral aspect of the humeral head. With marked internal rotation, the posterolateral aspect of the head is viewed in profile so that the length and depth of the compressed area may be evaluated (Fig. 2). The tangential view is necessary to measure the width; this view is obtained by placing the film on the top of the shoulder while the tube is lateral to and below the elbow, the arm being internally rotated.

The x-ray characteristics of such compression fractures are as follows:

1. The defect is located on the posterolateral portion of the humeral head; only when very large does it extend into the greater tuberosity.

2. In external rotation all that may be noted is a slightly increased rarefaction of the region medial to the lateral contour of the greater tuberosity, except in the case of extremely large defects, when a slight flattening of the contour may be noted. Both of these changes are easily overlooked, especially if a view of the opposite shoulder is not available for comparison.

3. With the arm in internal rotation there is:

(A) Flattening of the contour of the articular surface or, in larger defects, an indentation, excavation, or groove on a level with the greater tuberosity, and

(B) A sharp, dense line running downward from the top of the humeral head, parallel to the axis of the shaft

and somewhat lateral to the mid-line. This "line of condensation" is a special sign and is the result of the compression or compaction into a narrow medial border of the spongy bone previously occupying the space of the defect (Fig. 1). Pilz believes that one may judge the size of the defect present by a measurement of this line.

(C) The floor of the defect (best seen in the tangential view) also shows a dense compacted border.

4. An avulsed fragment from the humerus is practically never present. There may be a small chip from the inferior portion of the glenoid rim of the scapula.

The size of the compressed areas varies considerably; however, from a study of our material, we believe that there is a definite correlation between:

(A) The size of the head of the humerus and the size of the defect;

(B) The size of the head of the humerus and the length of the line of condensation;

(C) The size of the defect and the length of the line of condensation (Table II).

The average case in which a typical defect is present shows the length of the line of condensation to approximate one-half the diameter of the widest portion of the head. The size of the defect may become larger following repeated dislocations; in a few cases the size has diminished as a result of partial filling in of the defect with new bone (Fig. 3).

Cystic changes are usually easily discernible because of their macroscopic size (diameters of from 2 to 12 mm.) and well delimited borders of increased density. They are localized in the posterolateral

TABLE II.—MEASUREMENTS OF OUR MATERIAL USED IN ESTABLISHING CORRELATION BETWEEN SIZE OF HEAD, SIZE OF DEFECT, AND LENGTH OF LINE OF CONDENSATION

Size of Defect	Length of Line of Condensation			Diameter Widest Part of Head			
	2 cm.	3 cm.	4 cm.	4 cm.	5 cm.	6 cm.	7 cm.
Small 5 cases	5 cases	1 case	0 case	2 cases	2 cases	1 case	1 case
Medium 16 cases	5 cases	7 cases	2 cases	0 case	5 cases	6 cases	2 cases
Large 4 cases	0 case	0 cases	5 cases	0 case	1 case	2 cases	3 cases

portion of the humeral head and occur just beneath the articular surface. They sometimes appear to communicate with the joint space.

DIFFERENTIAL DIAGNOSIS

Occasionally a grooved defect in the humeral head may be confused with a fracture of the greater tuberosity. This will seldom, if ever, occur if a thorough x-ray examination is made, because the location of the two lesions is different and a fragment can usually be made out in cases of fracture of the tuberosity. If the greater tuberosity fragment unites with its base in a somewhat displaced position or is partially absorbed before union takes place, the contour of the greater tuberosity will show some irregularity of outline (Fig. 7, *upper*). The tuberosity fragment may not unite, in which instance it is absorbed; the resultant appearance is that of a very flattened tuberosity or as if the tuberosity had been sheared off (Fig. 7, *lower*).

In posterior dislocation of the humerus an area of absorption has been noted on the anterior aspect of the articular surface of the head (17). In this case the location will serve as a differential guide.

An apparent groove is sometimes noted in certain projections of the shoulder in humerus varus. However, a thorough study including projections in other planes will reveal no true defect.

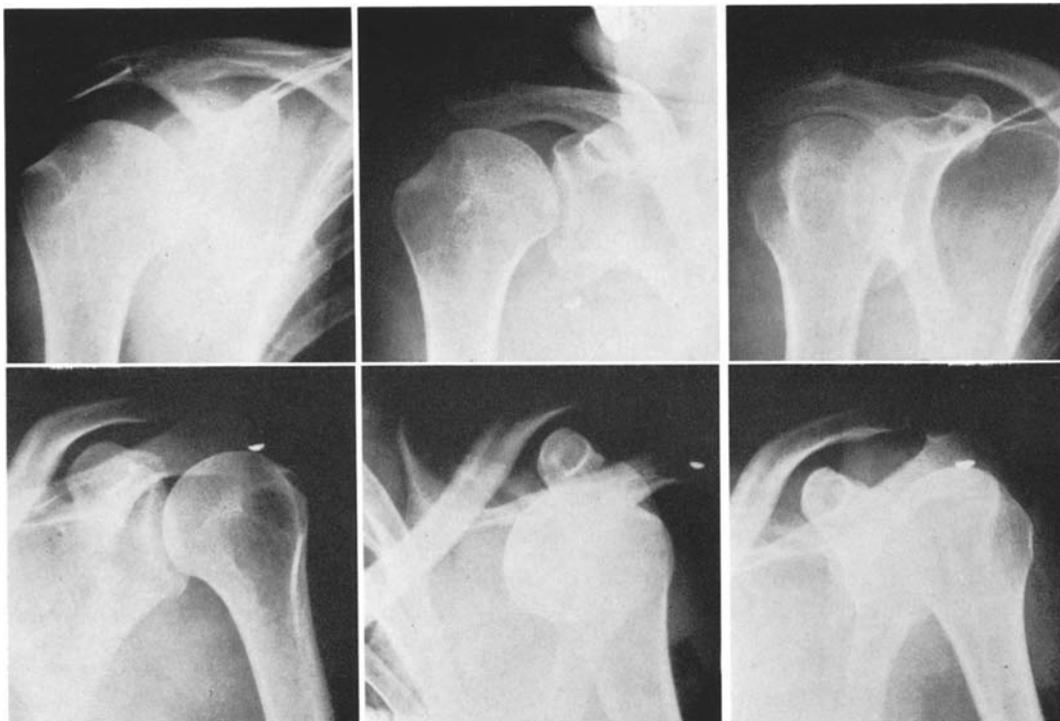In caries sicca and in Charcot's osteoarthropathy of the shoulder there may be

Fig. 4. Case 2 (*upper left*). Nov. 28, 1938. The right humerus in external rotation; no groove visible.
(*Upper center*) Sept. 21, 1938. The right humerus in external rotation immediately after correction of a subcoracoid dislocation; only an experienced observer would detect the suggestion of a compression fracture.
(*Upper right*) Sept. 22, 1938. The same humerus taken a day later but in marked internal rotation with the large defect and line of condensation very obvious.
(*Lower left*) Nov. 28, 1938. The left humerus in internal rotation; negative—taken only for comparison with right.
(*Lower center*) May 11, 1939. The left humerus following first dislocation; no defect visible in this projection.
(*Lower right*) May 11, 1939. The same humerus following reduction and with the humerus in marked internal rotation; a deep groove and dense line of condensation are made out.

changes at certain stages which will simulate the changes following a compression fracture. A complete clinical and laboratory examination will make an accurate differentiation possible.

Arthritis deformans, atrophy (senile or following rupture of the external rotator tendons), osteomalacia, and rachitis might, at times, be confused with small compression fractures or with the cystic changes following dislocations. The differential diagnosis depends upon the history of preceding trauma, bilateral nature of the systemic disorders, and the sharply localized site of the compression fractures.

REVIEW OF OUR CASES

We have reviewed 119 shoulder dislocations seen at the San Francisco Hospital between 1930 and the Summer of 1939. It has been only during the last six months of this interval that the x-ray examinations have been adequate to rule out positively the possibility of a small defect or fracture. While we attempted to have all of the 119 individuals return for a thorough follow-up x-ray examination, we were able to obtain such studies on only a relatively small percentage. These facts undoubtedly account for the low incidence of

grooved defects of the humeral heads found in our series of cases.

CASE REPORTS

Case 1. G. S., 61-year-old male, with no history of previous trauma, fell in a ditch on Nov. 8, 1937; a right subcoracoid dislocation was corrected. He redislocated the same shoulder while turning in bed on June 27, 1938, and again on Sept. 22, 1938. X-ray examinations of June and September revealed a large (4 cm. in length) defect in the posterolateral aspect of the right humerus (seen only in internal rotation). The left shoulder was negative at all examinations.

The serial studies show an increasing sclerosis of the walls of the groove, also a slight filling in of the defect between September and October, 1938. It is probable that such large grooves as were exhibited in this case explain some of the failures of capsulorrhaphy (18). (See Figure 3.)

Case 2. J. S., 37-year-old male, chronic alcoholic; history unreliable. Entered the hospital on Nov. 28, 1938, complaining of pain and limited abduction of right shoulder. X-rays made at this time were negative for dislocation, but showed a moder-
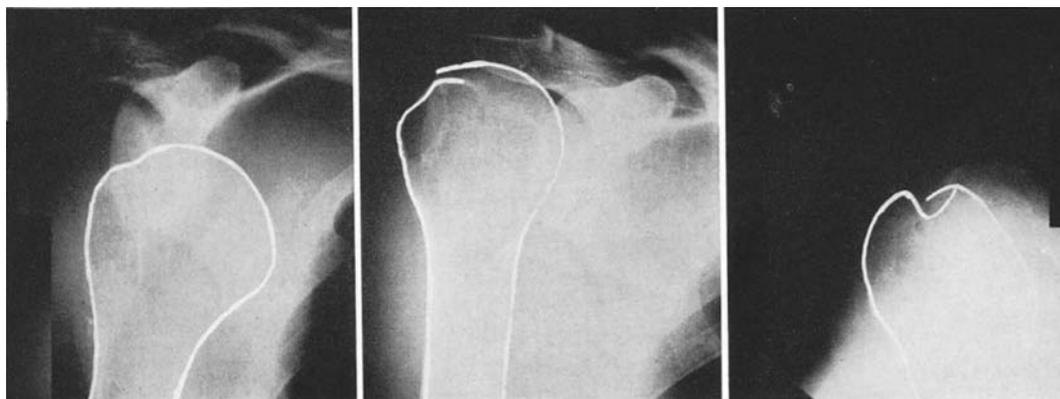

Fig. 5. Case 3 (*left*). Feb. 1, 1938. The right humerus following original injury; subcoracoid dislocation but defect cannot be seen.

(*Center*) Feb. 2, 1938. The following characteristics of the typical defect are present: deformed contour and washed-out appearance of the posterolateral aspect of the humeral head, a fairly dense line of condensation, and no visible fragment.

(*Right*) Feb. 2, 1938. Tangential view of the posterolateral portion of the humeral head showing the groove as the result of the compression fracture. *Note.*—The bicipital groove has much the same appearance but is situated anteriorly and usually is smaller.

ate sized defect. The same shoulder was dislocated in an automobile accident on Feb. 21, 1939. Films made the following day in internal rotation revealed a large groove with sharp line of condensation. The right shoulder was again dislocated in March and in May, 1939. All x-ray examinations revealed the large defect but an operation on this shoulder in May failed to disclose any defect, presumably due to the anterior approach and small size of the operative field (18). (See Figure 4, *upper*.)

The original x-rays of the left shoulder taken for comparison on Nov. 28, 1938, were negative. Examination following a subcoracoid dislocation of the left humerus on May 11, 1939, revealed a deep groove in the posterolateral portion of the humeral head and medially a well defined line of condensation. This defect was undoubtedly due to the recent injury of May 11. (See Figure 4, *lower*.)

Case 3. C. N., 54-year-old male, fell, injuring his right shoulder; no history of previous injury to this arm. The fall occurred on Jan. 15, 1938, but it was not until Feb. 1, 1938, that he entered the hospital for medical attention, at which time x-rays revealed a moderate sized

TABLE III.—INCIDENCE OF THE COMPLICATIONS OF ANTERIOR DISLOCATIONS OF THE SHOULDER FROM A STUDY OF THE X-RAYS OF 119 CASES SEEN AT THE SAN FRANCISCO HOSPITAL, 1930–1939

Dislocations which were recurrent	15	12%
Dislocations which were uncomplicated	27	24%
Dislocations complicated by:		
(1) Compression fracture	33	27%
(a) Typical defect	25	21%
(b) Cystic changes	8	6%
(2) Fracture greater tuberosity	44	37%
(a) and fracture humeral neck	2	2%
(b) and fracture glenoid rim	8	7%
(3) Fracture glenoid rim	18	10%

Recurrent Dislocations

11 showed compression fractures	74%
2 showed fracture greater tuberosity	13%
2 showed no complication	13%

Age Incidence

Ages	1–15	16–30	31–45	46–60	61–75	76 and over
Cases	3	10	18	56	27	5

Sex Incidence

Males	Females
64	55

groove in the humeral head; the line of condensation can be fairly well made out on the original films. The tangential view clearly shows the lesion. It is our belief that the compression fracture was in all likelihood sustained at the time of the fall in January (Fig. 5).

Case 4. I. S., 50-year-old male, struck his left shoulder against a table while wrestling. He went to a doctor two weeks later, at which time a dislocation was corrected (June 20, 1932). He re-dislocated this shoulder on Jan. 14, 1933, on Aug. 7, 1933, and again in January, 1934. The serial x-ray studies show a gradual increase in the cystic changes located in the posterolateral portion of the humeral head following each subsequent dislocation (Fig. 6, *upper*).

Case 5. G. H., 52-year-old male, sustained a subglenoid dislocation in April, 1938. X-rays made immediately following the reduction exhibited a little flattening of the contour of the posterolateral aspect of the articular surface of the humeral head, probably due to a slight compression fracture. Because of slight limitation of function, he had further x-rays made in July and in October; these showed the development of cystic changes in the posterolateral portion of the head of the humerus (Fig. 6, *left lower*).

Case 6. B. R., 68-year-old male, dislocated (subcoracoid) his left shoulder in February, 1936. It was immediately reduced. A check-up examination early in March showed rather marked cystic changes in the posterolateral portion of the humeral head, especially for such a short interval of time between the injury and the appearance of these changes. This finding favors a compression fracture origin rather than one due to nutritional changes (Fig. 6, *right lower*).

Case 7. T. L., 44-year-old male, fell against a garbage can on Feb. 6, 1937. A subcoracoid dislocation with a comminuted fracture of the greater tuberosity was treated (Fig. 7, *upper left*). Two years later an examination revealed that the fracture had united, but a portion of

the greater tuberosity had been absorbed and the contour of the tuberosity was quite irregular; also, there was a deepened sulcus at the anatomic neck (Fig. 7, *upper right*). A comparison of the end-result in this case with the changes seen following a compression fracture of the posterolateral portion of the humeral head (as, for ex-

ample, in Case 1) should enable one to state the nature of the original injury in each instance.

Case 8. J. J., 65-year-old male, ten days prior to his entry to the hospital in August, 1937, slipped in a bathtub, striking and dislocating his left humerus and fracturing the greater tuberosity. The dis-
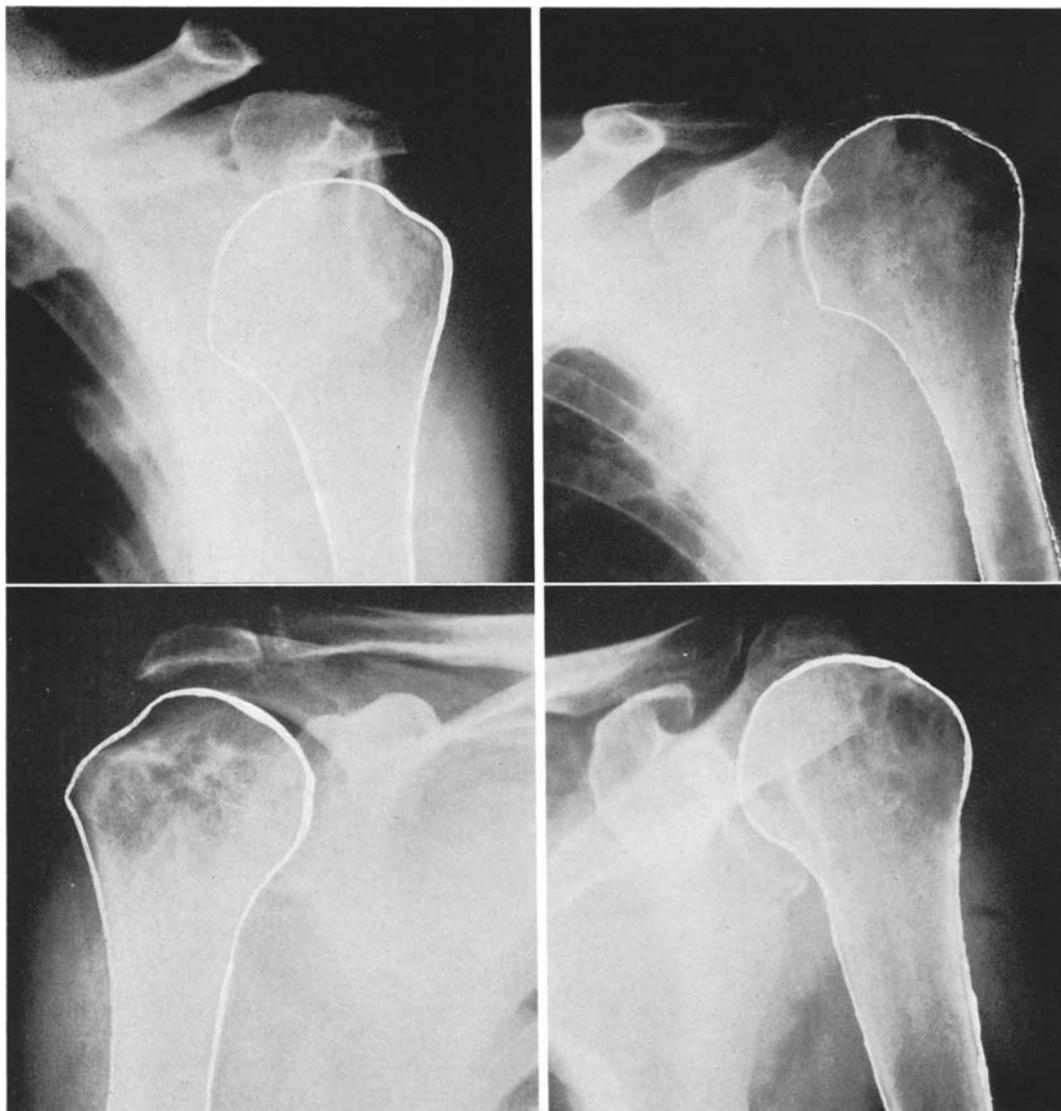

Fig. 6.   Case 4 (*upper left*).   June 15, 1932.   The left humerus following first subcoracoid dislocation; no cystic changes are present.
(*Upper right*).   Jan. 14, 1935.   Re-examination following reduction of fourth dislocation of left shoulder; quite marked cystic changes are observable on the films.
Case 5 (*lower left*).   Oct. 10, 1938.   X-rays made six months after the first and only dislocation show both a shallow groove and rather marked cystic changes, neither of which was present at the examination in April.
Case 6 (*lower right*).   March 2, 1936.   Cystic changes present in the posterolateral portion of the humeral head best disclosed by projection made with the humerus in marked internal rotation.

location was reduced but marked disability followed because of lack of grip and loss of external rotation. X-ray examination made 18 months later shows that the fragment has been completely absorbed and the region of the base of the tuberosity has a sheared-off appearance (Fig. 7, *lower right*).

On superficial examination of the appearance of the end-result in this case, one might suspect that the original injury was a compression fracture of the humeral head, but a careful check of the x-ray characteristics found in the latter type of injury will permit a ready differentiation.
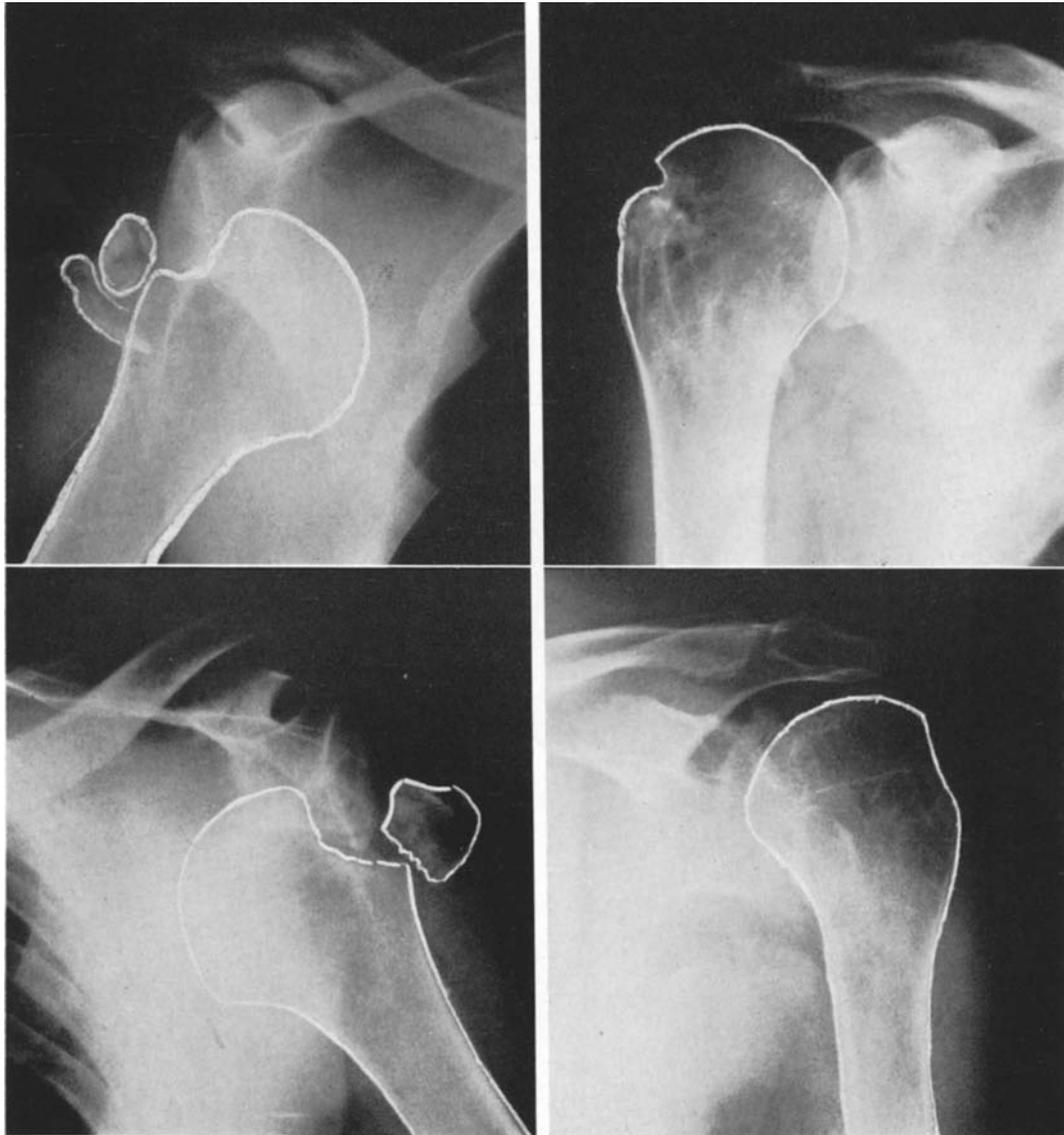

Fig. 7.   Case 7 (*upper left*).   Feb. 6, 1937.   Subcoracoid dislocation and comminuted fracture of the greater tuberosity.
     (*Upper right*) Feb. 8, 1939.   Examination two years later reveals irregular outline of the greater tuberosity and deepened anatomical sulcus.   Compare with Figure 3 for similarities and differences.
     Case 8 (*lower left*).   Aug. 14, 1937.   Subcoracoid dislocation of the left humerus with fracture of the greater tuberosity.
     (*Lower right*) Feb. 14, 1939.   Bone fragment absorbed; base of tuberosity has a sheared-off appearance. Comparison with Figures 3 and 4 demonstrates the difference between the two not uncommon lesions.

SUMMARY AND CONCLUSIONS

1. More than two-thirds of the dislocations of the shoulder are complicated by a bony injury of the humerus or scapula detectable by roentgenographic means.

2. Fractures of the greater tuberosity alone or in combination with fractures of one or more parts of the scapula, most frequently the glenoid rim, comprise the most common group of bony injuries complicating shoulder dislocations in this series.

3. Compression fractures as a result of impingement of the weakest portion of the humeral head, that is, the posterolateral aspect of the articular surface, against the anterior rim of the glenoid fossa are found so frequently in cases of habitual dislocation that they have been described as the "typical defect." If large, such grooved defects may lead to unsatisfactory results following the usual operations for recurrent dislocations.

4. There is ample proof that many of these defects are sustained at the time of the original dislocation and they may be an etiologic factor in recurrent dislocations.

5. Roentgenographic study is the best method of obtaining a true conception of the presence, location, size, and form of the defect.

6. A minimal x-ray examination comprises an anteroposterior projection of the shoulder with the arm in adduction and external rotation and a similar projection with the arm in marked internal rotation. Tangential views often prove useful.

7. The x-ray characteristics of posterior humeral compression fractures are: a wedge-shaped defect of the posterolateral aspect of the head of the humerus, varying from 5 mm. to 3 cm. in length, 3 mm. to 2 cm. in width, and 10 to 22 mm. in depth. A special sign is the sharp, vertical, dense medial border of the groove known as the "line of condensation," the length of which is correlated with the size of the defect.

8. Small cystic changes in the subchondral portion of the posterolateral area of the humeral head are present in a few cases after shoulder dislocations. These are presumably due to small compression fractures but may possibly be due to nutritional changes following damage to minute blood vessels supplying these areas.

9. A more widespread knowledge regarding the possibility of the existence of these lesions should lead to better results in the treatment of shoulder dislocations and disabilities. The determination of a compression fracture defect also is of obvious medico-legal importance.

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