

# Injuries of the Musculotendinous Cuff Of the Shoulder

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INJURY OF THE musculotendinous cuff of the shoulder is relatively common and although it may seem to be of minor order it may cause many months of disability in a person whose livelihood depends on active use of the shoulder.

## ANATOMY

The shoulder joint, whose semispherical humeral head articulates with a small shallow glenoid cavity, has a wide range of motion for dextrous use of the upper extremity. In phylogenetic change from a weight-bearing to a prehensile limb, the shoulder joint has sacrificed stability and strength for mobility. The joint capsule is lax, to allow freedom of motion. The capsule is attached to the periphery of the glenoid cavity of the scapula and to the anatomical neck of the humerus. It is strengthened by ligamentous bands and by tendons of the four short rotator muscles. These muscles arise from the body of the scapula and terminate in flat tendons that blend indistinguishably with the capsule and with each other, forming a structure which has been aptly named *musculotendinous cuff*. The supraspinatus tendon reinforces the capsule superiorly, the subscapularis anteriorly, the infraspinatus and teres minor posteriorly. The acromion process of the scapula and the coraco-acromial ligament form a protective roof over the shoulder joint. Beneath the acromial arch and the upper portion of the deltoid muscle lies the subacromial (subdeltoid) bursa, which affords a gliding mechanism for the musculotendinous cuff as it slides up under the acromion on abduction of the arm. Thus, the floor of the bursa is the musculotendinous cuff and the roof is the undersurface of the deltoid muscle and acromion process. Reaction of the bursa, therefore, commonly accompanies trauma or disease of the adjacent capsule or tendons.

Function of the component parts of the shoulder has been clearly described by Inman, Saunders and Abbott.<sup>5</sup> Elevation of the arm results from the combined action of the deltoid and short rotator muscles throughout the entire range of motion which

• *Injuries of the musculotendinous cuff are frequent and often cause long periods of disability.*

*The cuff is subject to progressive degenerative changes which are visible microscopically in most persons past 30 years of age, and visible grossly in those past 40. The cuff ruptures through areas of degeneration.*

*A great majority of patients recover good shoulder function under conservative treatment.*

*Operation is not urgent. Accurate diagnosis of a complete tear of the cuff cannot be made until the acute phase of injury has passed, and delay in operating does not decrease chances of good results.*

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occurs partially at the glenohumeral joint and partially by rotation of the scapula. After an initial "setting-phase" the ratio of excursion of the glenohumeral to scapulothoracic motion is as two to one, thus producing what Codman<sup>3</sup> described as "scapulohumeral rhythm." All the rotator muscles acting together stabilize the humeral head against the glenoid cavity. Abducting force is exerted by the superior portion of the cuff. The degree of rotation of the arm at any given moment determines which of the rotator muscles is in the superior position and therefore exerting this force. The force is most frequently, but by no means exclusively, exerted by the supraspinatus muscle. Tearing of one tendon may readily be compensated for by rotating the arm so that an intact portion of the cuff is superior. Thus, a rather extensive rupture of the cuff may be present in a shoulder in which there seems to be no loss of abductor power.

## PATHOLOGY

The musculotendinous cuff is subject to progressive degeneration, which is considered to be a physiological aging process accentuated by chronic strain, overuse or repeated minor trauma. In the supraspinatus and subscapularis tendons, which are subject to more strain, more pronounced changes occur. Microscopically visible fraying, hy-

Presented at the Sectional Meeting of the American College of Surgeons, April 7, 1952, in Tucson, Ariz.

alinization and fibrosis are present in most persons after age 30, and are visible grossly in those past 40 years of age. These changes become more pronounced with increasing age and cause weakening of the tendinous cuff. A normal tendon will seldom, if ever, rupture and the fact that a tendon has ruptured is indicative of a degenerative process. Wilson and Duff<sup>9</sup> reported on the pathologic changes of short rotator tendons of the shoulders in a study of 125 cadavers. They noted complete rupture in 22 per cent of subjects over 30 years of age and an increasing incidence in older age groups.

A rupture of the musculotendinous cuff may be classified as "incomplete" when it does not extend through the thickness of the tendon. That occurring on the joint surface was termed by Codman "rim-vent." The tear may be on the bursal side or may occur within the substance of the tendon and not be visible from either surface. A "complete" tear extends through the entire thickness of the tendon, opening free communication from joint to bursa. Tears vary in size and site. The most common lesion is initially a transverse tear with subsequent longitudinal split. This enlarges with ensuing strain or re-injury and separates anteroposteriorly, due to divergent muscle pull. In all tears of the cuff, the essential feature is that tearing occurs through an area weakened by a degenerative process.

#### SYMPTOMS

Most patients with an acute injury of the shoulder cuff are past 40 years of age—that is, the injury usually occurs after degenerative changes that weaken the cuff and predispose to tearing have taken place. Injury is more common in laborers owing to their exposure to repeated strain which augments degenerative lesions and to acute trauma which precipitates the tear. Injury may be incurred as in a fall on the outstretched arm, or perhaps sudden abductor movement of the shoulder strains the cuff beyond its functional limit, rupture resulting. There is a feeling of something tearing or giving way, associated with acute pain which increases in severity for the first four to seven days, then decreases. The patient is unable to actively raise the arm or to maintain it in abduction. This limitation may be owing either to extensive rupture of the tendon or to protective muscle spasm and reflex muscle inhibition. There is ache in the shoulder, often referred to the point of deltoid insertion or down the arm, and localized tenderness over the site of the cuff lesion. In less severe cases, with preservation of abductor power, there may be a painful jog as the arm is abducted past the horizontal, owing to impingement of the cuff against the acromion.

During the acute phase, it is impossible to evaluate the degree of actual injury to the cuff, and definite diagnosis cannot be made for from two to four weeks. Conservative treatment is therefore indicated initially in all cases. Radiant heat and gentle massage are comforting and allay spasm. In some instances, local injection of procaine may be indicated to give temporary relief. The abduction or "airplane splint" is uncomfortable and ineffectual. Since the scapula rotates freely, especially when the shoulder muscles are in spasm, and the humerus remains in a position of adduction in relation to the scapula, even though the arm be elevated on a splint, splinting neither relieves strain on the cuff nor prevents contracture. The arm should be supported in a sling but complete immobilization is undesirable as it increases discomfort and causes stiffness. Every two or three hours the arm should be removed from the sling for gentle motion (Figure 1). In the initial exercise of "relaxed circumduction" the patient leans well forward and supports himself with the uninjured hand on a chair; then the injured extremity, hanging free, is swung slowly in circles for several minutes (Figure 1, A). As the acute phase begins to subside, more activity is indicated. In the wall climbing exercise (Figure 1, B) the patient stands with his side to the wall, places the tips of the fingers on the injured side against the wall and then moves the fingers in a "walking" motion up the wall to ever higher goals to stretch the shoulder into abduction. Exercises with the use of a staff (Figure 1, C) are valuable, particularly in restoring external rotation. The use of a rope through an overhead pulley (Figure 1, D) is another method of obtaining active exercise and passive stretching of the shoulder in abduction and external rotation with the good arm assisting the injured one.

Some forcing of motion is essential to prevent permanent stiffness of the shoulder, especially as most of the injuries occur in older persons with degenerative capsular lesions. Yet, if motion is forced too vigorously, it will cause increasing pain and muscle spasm, thereby defeating the purpose. The guiding rule is not to force activity beyond the point of mild discomfort. As improvement is made the sling may be left off for longer periods and more vigorous exercise permitted.

The shoulder stiffness that is present soon after injury is owing to muscle spasm, and motion increases as spasm subsides. However, after several weeks of inactivity, adhesions develop. In this stage, passive stretching is indicated. Here again, a nice balance must be reached between ineffectual motion and stretching so vigorous that pain and spasm are increased. Positive stretching should be done by a

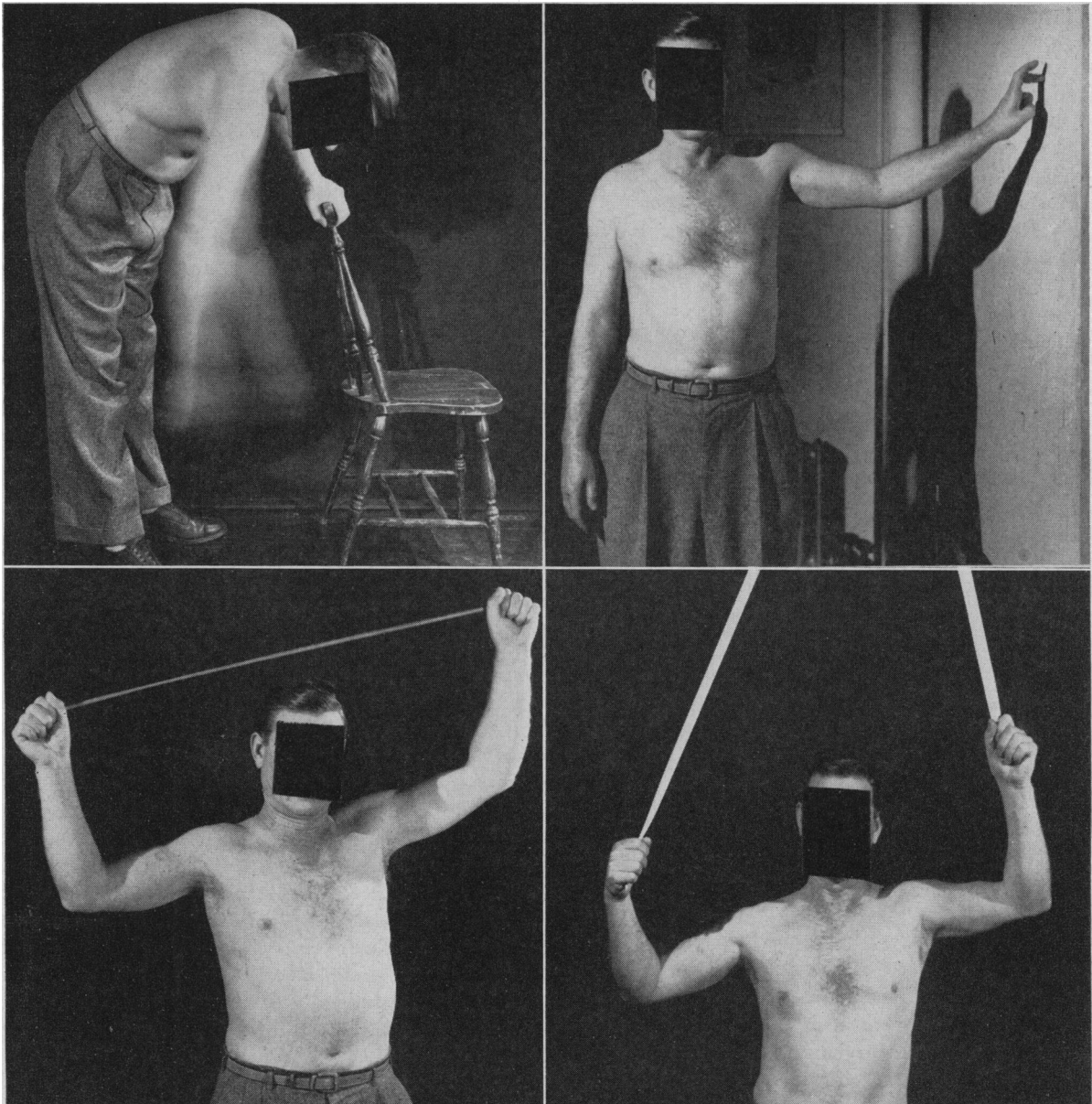


Figure 1.—*Upper left*: “Relaxed circumduction.” This is the initial exercise. The affected extremity hangs free, and is slowly swung in circles for several minutes. *Upper right*: “Wall-climbing exercise.” The fingers of the affected extremity creep up the wall to an ever higher goal, stretching the shoulder into abduction. *Lower left*: Exercise with a staff, particularly valuable in restoring external rotation. *Lower right*: Exercise with rope through an overhead pulley affords active exercise and passive stretching. The good arm assists the affected one.

physical therapist under the direction of a physician, and the amount of force used should be dictated by the patient's response. Adequate stretching will cause the shoulder to hurt at the time, but not to ache afterward. Stretching under anesthesia is thoroughly condemned, for without the sensation of pain as a guide the shoulder is frequently harmed rather than helped by the procedure which may cause further tearing of the capsule, hemorrhage, edema, spasm and pain.

When the acute phase has subsided, it becomes possible to determine the condition of the cuff by the functional tests of active shoulder abduction and by the patient's ability to maintain abduction after the arm has been passively elevated by the examiner, the latter being the more informative test. Pain without demonstrable weakness when strain is thus imposed on the cuff suggests a small or an incomplete rupture. If the patient is unable to maintain the arm in abduction, extensive rupture is indicated. Complete

loss of function indicates that there has been massive avulsion of the entire cuff.

In a large majority of instances, there is a gradual return of active abductor power and decrease in pain. In that case, only conservative treatment is necessary. Operation should not be considered as long as satisfactory progress is being made under conservative treatment (as long as eight to ten weeks). Small tears heal without loss of function, and even larger ones may not cause so much restriction of motion that the patient is seriously handicapped. Age and station in life must also be considered: An elderly or retired man may accept considerable permanent loss of function, whereas a younger working man who has pronounced weakness of abduction and is not improving should have the benefit of surgical repair. An example of adaptation to partial disability is illustrated in Figure 2. A man, aged 70, fell while going upstairs, threw out his right arm to protect himself and felt sudden sharp pain in his shoulder, associated with loss of ability to elevate the arm. When the patient was re-examined six years later, it was noted that he had subconsciously learned to externally rotate the arm when elevating it and was not aware that he had lost much abductor power, although obviously there was extensive tear of the cuff.

#### SURGICAL TREATMENT

McLaughlin<sup>7</sup> and DePalma<sup>4</sup> both observed that the results of operation done long after injury are as good as those obtained by operating early. They noted also that if repair is adequate the size of the tear does not materially affect the end result. Therefore, an adequate trial of conservative treatment should be given and operation decided upon only if the condition seems static and if there is so much persistent pain and disability that the patient desires operative exploration.

A simple deltoid splitting incision is inadequate for cuff repair and it endangers the circumflex nerve which runs forward transversely through the muscle. The anterior exposure through the deltoid-pectoral junction augmented by partial reflexion of the deltoid origin gives adequate visualization for most procedures in the shoulder, although the acromion process partially obscures the cuff. McLaughlin's modification of the saber-cut incision affords the best view of this region. In this procedure the skin incision crosses the shoulder in the suspender line, just lateral to the acromial clavicular joint and extends forward 3 to 5 centimeters. For preliminary exploration, the anterior end is developed first. The deltoid muscle is exposed and the fibers split not more than 4 centimeters. This is done in the anterior portion of the muscle so that if any

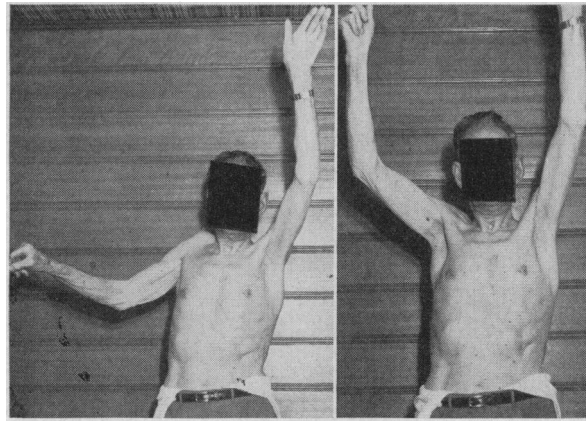


Figure 2.—*Left:* Typical appearance of a patient with a large complete tear of the superior (supraspinatus) portion of the cuff. This picture, taken six years after injury, shows maximum degree of active abduction as the arm is raised from the side in a position of neutral rotation. *Right:* This picture, taken on the same day, shows the greater range of active abduction the patient obtained by raising the arm in complete external rotation. In this position an intact (subscapularis) portion of the cuff was in the superior position. The patient had acquired this maneuver subconsciously and was not aware that he had lost much abductor power.

nerve fibers are cut there will be minimal muscle atrophy. The cuff may then be inspected by rotating the arm, and minor procedures can be carried out without further exposure. More extensive exposure is necessary, however, for most cuff repairs; and it is accomplished by extending the skin incision backward to the posterior deltoid muscle. The acromion process is exposed and osteotomy between the acromial-clavicular joint and the tip of the acromion carried out. The amount of bone excised depends on the exposure needed. The excised portion of the acromion may be discarded and its removal obviates impingement of the repaired cuff against the acromion. If the interior of the joint is to be inspected, the capsule is split longitudinally, preferably in the interval between the supraspinatus and subscapularis tendons.

Ordinarily, surgical treatment is not necessary in cases of incomplete tearing. Sometimes, however, persistent pain caused by mechanical impingement of the lesion against the acromial arch may dictate operation. Alleviation can be accomplished by partial removal of the acromion process and repair of the capsular lesion. Usually the capsular lesion can be excised and the defect closed by direct suture.

Occasionally it is possible to carry out direct suture of a simple split in the cuff, but in most cases a plastic repair is necessary. A common error is to try to close an elliptical defect by abducting the arm and attempting a direct end-to-end suture. This is doomed because it violates surgical principles and ignores the basic pathologic factors of the lesion.

In planning surgical repair, three principles must be remembered. First, the tear is through an area of degeneration of the tendon which must be excised back to healthy tissue. Second, the lesion is a combination of transverse and longitudinal tear which spreads by muscle pull. Third, tissue must not be sutured under tension. In McLaughlin's method of repair, a continuous silk suture is used in a shoelace manner to close the defect from side to side as much as possible without tension. Then the distal end is reinserted into the humeral head only as far distally as it will reach without tension with the arm at the side. An area of exposed cartilage of the humeral head is removed and the edge of the cuff is attached to the bone by passing silk sutures through drill holes.

Postoperative care should be under the direct supervision of the operating surgeon, as only he knows the pathological condition of the torn cuff and the strength of the surgical repair. Until the wound is healed, balanced suspension traction affords adequate protection and permits gentle active exercise. Then all immobilization except a sling is discontinued and the patient put on a course of graduated exercises (beginning with relaxed circumduction, then "finger walking" up a wall and the like, as previously described) and is encouraged to

use the arm for light activities. Active abduction against gravity is not permitted for about a month, or until the surgeon believes that the tendon has firmly reunited.

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