Recurrent transient subluxation of the shoulder

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ABSTRACT: Transient subluxation of the shoulder may cause the so-called dead-arm syndrome, which is characterized by a sudden sharp or "paralyzing" pain when the shoulder is moved forcibly into a position of maximum external rotation in elevation or is subjected to a direct blow. This syndrome also may occur during throwing, repetitive forceful serving in tennis, or working with the arm in a strained position above shoulder level. Sixty shoulders with the dead-arm syndrome, apparently caused by transient subluxation of the shoulder, were treated and analyzed after follow-up periods ranging from two to sixteen years.

Two groups of patients with this syndrome were identified. The patients in Group I had the sensation that subluxation was occurring when they used the arm in elevation; in Group II, the patients were not aware of slipping out or instability of the shoulder. Both groups had similar mechanisms of injury, similar symptoms and physical findings, comparable pathological lesions at operation, and similar results after the same surgical treatment.

A Bankart procedure was performed in thirty-two shoulders in which a Bankart lesion was found, and a modified Bankart repair (capsulorrhaphy) was done in the remaining eighteen in which the labrum was intact. The results in the fifty shoulders treated surgically were 70 per cent excellent, 24 per cent good, and 6 per cent fair. Ten shoulders were treated by non-surgical means.

In twenty (54 per cent) of the thirty-seven shoulders in which the superior aspect of the musculotendinous cuff was examined, a large opening in the capsule was noted in the interval between the supraspinatus and subscapularis tendons below the superior glenohumeral ligament. This opening may be a factor in anterior instability of the shoulder.

After an injury or excessive use of the shoulder, a patient (frequently an athlete) may begin to complain of persistent inability to use the arm forcefully in the overhead position. He or she may state that the arm "goes dead" or is "lame" when a hard throw or a tennis serve is attempted. This report compares two groups of patients with this syndrome due to subluxation of the shoulder: one group in which the patients were aware of the subluxation, and the other in which the patients recalled no sensation of displacement of the humeral head. The diagnosis was not made easily when the patient was not aware of any subluxation.

The shoulder is in a vulnerable position when the arm is elevated above shoulder level, especially when it is forced into excessive external rotation and extension. It is in this position that the shoulder commonly is injured in athletics; it also can be injured in this position in activities not involving forceful contact, such as excessive throwing or serving in tennis. After such an injury, the patient no longer is able to throw, serve hard in tennis, swim with an overhead stroke, or work with the arm above shoulder level. When the arm is externally rotated in abduction and extension, or when an attempt is made to throw, the patients have a sudden sharp or "paralyzing" pain, the limb is weak or "goes dead", and they may lose control of the extremity and drop the objects they are holding or throwing. After these episodes the pain quickly subsides, but the limb may feel sore and weak for several hours. The pain
may radiate from the anterior to the posterior aspect of the shoulder and down the arm to the hand, mimicking nerve-root pain.

A wide variety of pathological conditions about the shoulder can cause this syndrome, which often is referred to by patients as a "dead arm". In addition to recurrent transient subluxation of the shoulder, the cause of symptoms may be thoracic outlet syndrome, brachial plexus stretching, cervical disc disease, rotator cuff tear, or vascular insufficiency.

Beginning in the late 1960's, transient subluxation of the shoulder was discussed informally by orthopaedic surgeons who were interested in shoulder problems. Blazina and Satzman focused specific attention on the syndrome in their report in 1969. There are excellent descriptions of subluxation of the shoulder in the two editions of Bate-man's monograph on the shoulder. Recently, Rockwood, DePalma, Morton, O'Donoghue, LeClerc, Protzman, and Neer and Foster reported on the cases of patients with transient subluxation of the shoulder. With the exception of some of the patients reported by Bateman, all patients included in the published studies were aware that the shoulder momentarily left the joint.

In some patients who have had a similar mechanism of injury to the shoulder followed by the symptoms of a dead arm, the exact cause remains obscure. In 1964, one of us (C. R. R.) first appreciated that a patient can have transient subluxation of the shoulder and the accompanying disability but not realize that the shoulder is subluxating or popping out. Since then it has become evident that the vague nature of the pain has led to misdiagnosis and, at times, to poorly selected treatment. If the patient does not appreciate that the shoulder is going out of the socket, often the physician is confused by the patient's disabling and persistent shoulder problem. Physicians should be familiar with the symptoms and physical findings associated with subluxation of the shoulder so that the proper diagnosis is made whether or not the patient is aware of subluxation.

Clinical Material

Fifty-eight patients with sixty shoulders with the dead-arm syndrome were treated and followed by one of us (C. R. R.) at the Massachusetts General Hospital during a sixteen-year period. Two patients had bilateral shoulder involvement. Twenty-six patients with twenty-seven symptomatic shoulders stated that the shoulders "left the joint and popped back in" (Group I). Thirty-two patients with thirty-three symptomatic shoulders were not aware that subluxation had occurred (Group II). Fifty of the sixty shoulders required surgical treatment (in forty-eight patients), twenty-three in Group I and twenty-seven in Group II.

All sixty shoulders were followed for two to sixteen years after operation or after the completion of treatment by an exercise program. The average age of the patients at the time of operation was twenty-six years, with a range of sixteen to forty-nine years. There was no statistically significant difference in age between the patients in Groups I and II. Male patients predominated; there were fifty-one male and seven female patients. Forty-two of the involved shoulders were on the right and eighteen, on the left. Seventy-four per cent of the involved shoulders were on the dominant side.

Mechanism of Injury

Thirty-five (58 per cent) of the sixty shoulders (seventeen in Group I and eighteen in Group II) had been subjected to forceful external rotation in positions of abduction and varying amounts of hyperextension during activities such as basketball (when the elevated arm was forced into hyperextension during a lay-up) or football (when a lineman attempted to hold back an on-rushing opponent with the outstretched arm). Another seventeen (28 per cent) of the sixty shoulders (six in Group I and eleven in Group II) had been injured by a direct blow. The remaining eight shoulders (four in each group) had become symptomatic after excessive throwing and hard serving in tennis.

Of the injuries to the shoulder, 85 per cent occurred during sports activities such as football, baseball, basketball, hockey, tennis, skiing, boxing, and karate, while the other 15 per cent occurred when the patient fell from a height or sustained a direct blow.

Physical Examination

All sixty shoulders showed a positive apprehension test. This test can be carried out when the patient is either in a standing (Figs. 1-A and 1-B) or in a supine position. As the shoulder is moved passively into maximum external rotation in abduction and forward pressure is applied to the posterior aspect of the humeral head, the patient suddenly becomes apprehensive and complains of pain in the shoulder. The humeral head could be subluxated forward manually in twelve shoulders. Of the fifty-eight patients, 30 per cent were categorized as being loose-jointed since they had excessive hyperextensibility of multiple joints such as the fingers, elbows, and knees; the remaining 70 per cent had normal or average joint tightness.

The diagnosis of transient subluxation was not dependent on the actual demonstration of subluxation during the physical examination or during fluoroscopy but was made primarily on the basis of the history and physical examination. We did not exclude patients from this series because they did not recall that the shoulder had slipped out or left the socket.

In the differential diagnosis of subluxation of the shoulder, or the dead-arm syndrome, one should be careful to exclude: (1) thoracic outlet syndrome, including vascular compromise; (2) injury or stretching of the brachial plexus; (3) cervical disc disease; (4) impingement syndromes of the shoulder with or without a rotator cuff tear; (5) lesions of the long head of the biceps tendon; and (6) injury of the acromioclavicular joint.
In the apprehension test, the arm is rotated externally in a position of abduction while anteriorly directed pressure is applied to the posterior aspect of the humeral head. This maneuver produces sudden pain and weakness in the arm if there is anterior subluxation of the shoulder.

As pointed out by others, a true axillary radiograph or a modified axillary radiograph (the so-called West Point view) should be made routinely. Although minor variations of the glenoid fossa were observed in some of the shoulders in this series, no specific study was made to determine whether anteversion or retroversion of the glenoid was present.

We did not make arthrograms routinely in these patients. Arthrography had been performed on eleven of the sixty shoulders by other physicians. We reviewed these studies but did not find that they were helpful. Laxity of the anterior part of the capsule was demonstrated in a few.

Previous Diagnoses and Treatment

Thirty-three (55 per cent) of the sixty shoulders had been diagnosed as having some condition other than subluxation when they first were seen by us. Eight of these thirty-three shoulders were in Group I and twenty-five were in Group II (Table II). The presenting diagnoses were: a pinched nerve in nine, bursitis or tendinitis of the rotator cuff in eight, impingement of the greater tuberosity and in one there was irregularity of the anterior glenoid rim. We did perform arthroscopy in one patient, but this did not help us in arriving at the diagnosis, which was made in every patient on the basis of the history and physical examination.

Previous Diagnoses and Treatment
against the acromion or coracoacromial arch in four, biceps tendinitis in four, subluxation of the long head of the biceps tendon in three, a ruptured cervical disc in three, and thoracic outlet syndrome in two shoulders. Thus, a neurological diagnosis had been made in twelve patients (20 per cent); cervical myelography had been carried out in two; and three others had had electromyograms. Eight patients had been seen by a neurologist in consultation in an attempt to find the cause of radiating shoulder pain. The frequency of incorrect prior diagnoses in Group II reflects the difficulty of making the diagnosis when the patient is not aware of any displacement of the humeral head.

Non-operative treatment had included injections, systemic anti-inflammatory drugs, physical therapy, ultrasound, diathermy, and, in five patients, manipulative treatment.

Surgical procedures had been performed previously on seven patients. These included decompression of the shoulder (sectioning of the coracoacromial ligament and anterior acromioplasty) in three patients (all in Group II), tenodesis of the long head of the biceps tendon in three (two patients in Group II), and a Bristow procedure in one (Group I).

Treatment

Non-Operative Treatment

All patients with the clinical diagnosis of anterior subluxation of the shoulder were treated initially with specific resistive exercises. These included resisted internal rotation, external rotation, and abduction of the shoulder to strengthen the muscles of the rotator cuff which stabilize the head of the humerus. This program, which was continued for three to four months, decreased the pain and disability in eight of the sixty shoulders to the extent that an operation was not required. Two shoulders, both with recognizable subluxation, continued to be symptomatic but were not treated surgically.

Surgical Treatment

Of the fifty shoulders that were operated on, thirty-two (64 per cent) had a standard Bankart procedure and eighteen (36 per cent) had a modified Bankart procedure or capsulorrhaphy.

The Bankart procedure was performed in the same way as previously described for recurrent anterior dislocation of the shoulder. We emphasize the advantage of complete muscle relaxation during anesthesia and the importance of a careful layer-by-layer exposure of the shoulder down to the rim of the glenoid. The shoulder is approached through the deltopectoral interval. The coracoid process is osteotomized routinely to release the attached short head of the biceps and coracobrachialis tendons, and thus to lessen the pull on the musculocutaneous nerve. The osteotomy also gives adequate exposure to allow examination of the attachment of the superior part of the rotator cuff to the head of the humerus. The subscapularis tendon is dissected carefully from the anterior part of the capsule as far medially as the glenoid rim. The arm is externally rotated and the capsule is opened by a vertical incision, parallel and one-half centimeter lateral to the anterior glenoid rim. When a Bankart lesion is present, the capsule

The standard Bankart procedure is used when the capsule and labrum are avulsed from the glenoid rim. Three drill-holes are made in the anterior glenoid rim (1). Three sutures are used to reattach the lateral flap of the capsule to bone (2). Once the sutures are tied, four of the six ends of the tied sutures are passed through the medial flap of the capsule as shown (3) and are tied to one another as indicated to form a double-layered reinforcement at the site of repair (4).
An anterior shoulder capsulorrhaphy is performed when a Bankart lesion is not present. Since the capsule and labrum are not avulsed from the glenoid, they are used to anchor the sutures at the rim of the glenoid when reefing the anterior and inferior parts of the capsule. The sutures are passed through the medial flap of the capsule deep to the labrum, through the lateral flap of the capsule and back under the labrum and through the capsule, where they are tied (1). Four of the six ends of the sutures then are tied to one another as in the Bankart procedure (2), and the free margin of the medial flap is sutured to the underlying lateral flap with interrupted sutures to produce a double-layered reinforcement as indicated.

is reattached to the glenoid rim through three holes made in the anterior part of the glenoid — at one, three, and five o’clock for the right shoulder, and at seven, nine, and eleven o’clock for the left shoulder (Fig. 2). During repair, overlapping of the cut margins of the capsule from the inferior aspect of the capsule up to the top of the glenoid is performed to strengthen the repair (Fig. 2, 4). If there is a defect between the superior and inferior glenohumeral ligaments, it should be repaired when the subscapularis is reattached to its original insertion. Several sutures are placed to bring the adjacent edges of the supraspinatus and subscapularis tendons together over the humeral head.

If a Bankart lesion is not present, a modified repair or capsulorrhaphy is performed (Fig. 3). Since the labrum still is attached to the glenoid, it can be used to anchor the sutures. Three sutures are passed from outside in through the medial flap of the capsule, deep to the labrum, then through the lateral capsular flap first from inside out and then from outside in, and finally from inside out through the labrum and medial flap of the capsule. These three sutures, tied as shown in Figure 3, reef the anterior part of the capsule in a double-breasted manner along the anteroinferior rim of the glenoid and ensure a strong repair. In closing, after reattaching the subscapularis muscle, the coracoid process is reattached using double strands of zero-gauge cotton sutures, two passed through a hole in the center of the coracoid and two, through the coracodromial ligament. This repair is secure enough to allow early motion of the shoulder.

The postoperative management is similar to that used after repair of a recurrent anterior dislocation of the shoulder10. A sling is used for two to three days only, after which the limb is free. Exercises and use of the limb are increased gradually. Patients are instructed to use the hands anterior to the coronal plane of the body for six weeks. A folded towel placed behind the elbow when the patient is recumbent maintains slight flexion of the shoulder during the first week. Pendulum exercises are begun within one week after operation. We found that early motion eliminated the need for physical therapy to regain motion. Many patients returned to light work within four to six weeks with the extremity free. By three months, the patients were swimming, rowing, and taking part in light sports. By six months, a complete range of motion is expected and contact sports and heavy labor are permitted.

Surgical Pathology

We classified the Bankart lesions into three types (Fig. 4): Type I, avulsion of the capsule and cartilaginous labrum from the anterior part of the glenoid rim with or without eburnation of the rim; Type II, avulsion of the anterior part of the capsule, the labrum, and a fragment of the glenoid rim, the width of the fragment being less than one-eighth of the transverse width of the glenoid; and Type III, avulsion of the anterior part of the capsule, the labrum, and a fragment of the rim of the glenoid greater than one-eighth of the transverse width of the glenoid.

Bankart lesions were found in thirty-two (64 per cent) of the fifty shoulders (Table III). There were seventeen Type-I, ten Type-II, and five Type-III lesions. It is of interest that in our series half of the shoulders in which a Bankart lesion was found were in Group II. This group included the patients who gave no history of subluxation and complained only of pain and weakness of the shoulder.

Excessive laxity of the anterior part of the capsule was present in thirteen shoulders (26 per cent). The degree of laxity was estimated by the amount of redundancy in the
capsule that remained when the shoulder was externally rotated at operation. It is possible to evaluate the anterior half of the capsule only when the subscapularis tendon has been dissected off the capsule completely. Capsular laxity was the only lesion in eight shoulders.

In the past, little attention has been paid to the anterosuperior part of the rotator cuff of the shoulder (specifically the interval between the subscapularis and supraspinatus tendons) and the subscapular bursa in terms of their relationships to recurrent subluxation and dislocation of the shoulder. This is a rather inaccessible area during an anterior approach, since it is covered by the coracoid process and the coracoacromial ligament. If the coracoid process is osteotomized and the arm is pulled down, the examiner’s finger can be passed up over the adjacent margins of the subscapularis and the supraspinatus tendons to palpate the superior aspect of the shoulder.

In 1973, during a repair for recurrent dislocation of the shoulder, we noticed a very large opening in the superior aspect of the capsule. Since then, we routinely have pulled the arm down and inspected the top of the shoulder capsule during operations for recurrent subluxation or dislocation of the shoulder. Of the thirty-seven shoulders that were operated on in this series in which the superior aspect of the shoulder capsule was explored, twenty had large openings below the superior glenohumeral ligament in the interval between the subscapularis and supraspinatus tendons. When openings were present in the capsule and between the overlaying tendons, we closed them with interrupted sutures. Figure 5 shows a typical example of the large openings that are found occasionally when the coracoid process is divided by osteotomy and the superior aspect of the shoulder capsule is examined.

Other pathological lesions also were found. There were multiple loose bodies in one shoulder. In another, the pectoralis minor tendon inserted onto the greater tuberosity; the tendon was released and reattached on the coracoid. In one patient, the coracobrachialis muscle originated from the rotator cuff rather than the coracoid process.
process. In two shoulders, the glenoid labrum was split longitudinally and the inner portion lay across the joint, resembling a bucket-handle tear of a meniscus in the knee.

In none of the fifty shoulders was there any evidence of instability, subluxation, or other abnormality of the long head of the biceps tendon. DePalma, Warren et al., Rockwood, Neer, and Samilson also found no abnormalities of this tendon in their patients in this age group with transient subluxation of the shoulder.

**Results**

At follow-up, the results were evaluated in terms of function and pain (subjective) and of stability and range of motion (objective). Using the grading system shown in Table IV, the results were graded excellent (90 to 100 points), good (70 to 89 points), fair (40 to 69 points), or poor (39 points or less). Before treatment, fifty-six (93 per cent) of the sixty shoulders were graded poor and four (7 per cent), fair.

Of the ten shoulders that were treated with exercises, only five were graded excellent; three shoulders, good; and two shoulders, fair at two to six years (average, 3.1 years) after treatment. Since all shoulders initially were treated with exercises, it could be said that fifty-two (87 per cent) of the sixty shoulders did not improve to a satisfactory level with exercises.

The results in the fifty shoulders that were treated with surgical procedures, after follow-ups ranging from two to sixteen years (average, 4.1 years), were: thirty-five (70 per cent), excellent; twelve (24 per cent), good; and three (6 per cent), fair (Table V). The results in the thirty-two shoulders that had well defined Bankart lesions (which were reconstructed with the standard Bankart repair) were: twenty-five (78 per cent), excellent; six (19 per cent), good; and one (3 per cent), fair. The results in the eighteen shoulders without a Bankart lesion (in which a capsulorrhaphy was performed) were: ten (56 per cent), excellent; six (33 per cent), good; and two (11 per cent), fair. The five shoulders with a severe fracture of the glenoid fossa that were treated with a Bankart repair all had an excellent result.

The presence of a Hill-Sach’s lesion did not affect the result adversely. There were two shoulders with a severe and three with a moderately severe Hill-Sach’s lesion. All five had excellent results. Of the nineteen shoulders with a mild Hill-Sach’s lesion, eight had an excellent result; ten, good; and one, a fair result.

Thirty-three of the shoulders operated on (in thirty-three patients) were on the dominant side. Of these patients, twenty-one (64 per cent) were able to return to forceful throwing and were not limited in sports or work. An additional seven patients could use the shoulder with the arm overhead, including playing tennis, but were unable to pitch a baseball. Of the thirty-three patients operated on, one returned to pitching for a large state university, relieved of the so-called dead arm which he had had for two years. Two patients who were professional tennis instructors returned to playing. One professional ice hockey player returned to full play in the National Hockey League. Of the fifteen patients whose non-dominant shoulder was operated on, thirteen (87 per cent) had no limitations in sports or work and returned to all the activities that they had participated in before injury. The remaining two patients were ambidextrous.

Of the eight patients operated on whose injury was produced by hard pitching, four were graded excellent—they could pitch and throw hard—and four had good re-
The results in the patients in Groups I and II who were treated surgically were similar. Of the twenty-three shoulders in Group I, sixteen were rated excellent and seven, good. Of the twenty-seven shoulders in Group II, nineteen were rated excellent; five, good; and three, fair.

Analysis of the Fair Results

Two of the patients with fair results were treated with exercises and had little improvement, but their disability was not severe enough to warrant an operation.

In three patients, surgical treatment produced a fair result. One had been diagnosed previously as having the thoracic outlet syndrome. He was not aware of the subluxation of the shoulder (Group II), but he had a positive apprehension test. At operation, a moderately sized opening in the capsule was found below the superior glenohumeral ligament, in addition to a Type-I Bankart lesion. A Bankart procedure was carried out and the opening was closed. At follow-up the patient had a negative apprehension test but felt discomfort in the testing position; he had a 25 per cent loss of both abduction and external rotation and was moderately limited in activities that required use of the arm above shoulder level.

The other two patients with fair results, also in Group II, did not have a Bankart lesion and therefore were treated by capsulorrhapsy. One had an excellent result for two years until he tried heavy overhead lifting which caused repeated strain of the shoulder. Thereafter he remained limited in above-the-shoulder work and activities. The other patient had a good result for one year, but when he was examined after two years the shoulder was rated as having a fair result. The patient had been in an accident in which he was thrown from an automobile against a tree, and he sustained a new injury of the shoulder.

Complications

There were no infections or serious complications in the series. In one shoulder a postoperative hematoma developed, necessitating evacuation and closure, but the wound healed with no sequelae. One patient had postoperative thrombophlebitis of the cephalic vein which resolved uneventfully in ten days. There were no non-unions of the coracoid process. No shoulder had a recurrence of anterior subluxation after surgical treatment.

One patient had posterior subluxation of the shoulder after successful repair of the anterior part of the capsule. This twenty-two-year-old man previously had had a Brshtow procedure which failed, with loosening of the screw and non-union of the transferred coracoid process. A second procedure had been carried out in which the screw and coracoid process were removed and tenodesis of the long head of the biceps tendon was performed. At exploration, a Type-I Bankart lesion was identified and repaired. Thereafter the patient’s shoulder was stable anteriorly with good function for two years, but then he began to have posterior subluxations. At the time of writing, he was being treated with an exercise program.

Late Radiographic Changes of the Glenohumeral Joint

Radiographic evidence of mild degenerative changes in the humeral head and glenoid rim was found in only one shoulder at follow-up five years after operation. These changes had been present to a lesser degree preoperatively. The patient’s initial injury had been a severe blow to the shoulder which appeared to have been a factor in the joint changes. The postoperative radiographic findings in this study paralleled those observed in shoulders treated with the Bankart procedure for recurrent anterior dislocation of the shoulder, in which no significant degenerative changes of the joint were found in 124 patients who were followed for one to thirty years.

Discussion

Most reports in the literature on recurrent subluxation of the shoulder have discussed the cases of patients who were aware that their shoulders slipped out when they experienced associated sharp pain and weakness of the limb. In this report we have emphasized another category of patients, those who are not aware of the instability of their shoulders. In these patients, when the shoulder is forced into a position of excessive external rotation combined with abduction or with hyperextension, or is subjected to a direct blow, a sharp paralyzing pain is felt rather than any sensation of the shoulder slipping out. Since these patients do not complain of the telltale symptom of subluxation, diagnosis and correct treatment are very difficult in this group.

Eleven per cent of the sixty shoulders in this series had been treated previously by unsuccessful surgical procedures. This is understandable, since routine examination, arthrography, and arthroscopy are not diagnostic and the findings on regular radiography are only suggestive.

The most dependable criteria for the diagnosis of a dead arm due to unrecognized subluxation of the shoulder are the typical history of injury, characteristic symptoms, and the consistent finding of a positive apprehension test. The mechanism of injury is usually forced external rotation in abduction and hyperextension or a direct blow, but the cause also may be due to excessive throwing or serving in tennis. The typical symptoms are a sudden sharp pain in the shoulder and loss of control of the arm when it is in the position used in throwing, serving in tennis, or swimming the crawl stroke. The consistently positive apprehension test, whether carried out with the patient standing with the arm elevated and externally rotated or with the patient lying supine with the arm supported in this position by the examiner, presumably is due to stress on the anterior part of the shoulder capsule caused by displacement of the humeral head forward from the glenoid.

The patients in Groups I and II had similar pathological findings at operation. This similarity supports the
hypothosis that the underlying lesion in the majority of patients in Group II is transient subluxation of the shoulder. It is possible, however, that some patients in Group II did not, in fact, have recurrent subluxation of the shoulder as the primary lesion. This is suggested by the higher incidence of fair results in Group II, the slightly better results in the shoulders with a well defined Bankart lesion compared with the shoulders in which no lesion was found, and the improved results in the shoulders with a moderate or severe Hill-Sach’s lesion compared with the shoulders with a mild lesion. These results underscore the difficulty in making the correct diagnosis in all patients in Group II.

It should be emphasized that when evaluating patients with the dead-arm syndrome it is most important to exclude other conditions that may cause similar symptoms, such as the thoracic outlet syndrome, brachial plexus injury, tears of the rotator cuff, and subacromial bursa. Unexplained pain in the anterior aspect of the shoulder in baseball pitchers with a symptom complex similar to that described in this report has been attributed to subdeltoid adhesions.

An interesting finding in this study was the defect in the anterosuperior part of the shoulder capsule. A large opening below the superior glenohumeral ligament in the interval between the subscapularis and supraspinatus tendons was found in twenty of the thirty-seven shoulders in which the superior aspect of the shoulder capsule was explored. DePalma, Moseley and Overgaard, and Bost and Inman described variations in the subscapular bursa and glenohumeral ligaments. Moseley and Overgaard believed that a deficiency of the middle glenohumeral ligament was the anatomical basis for recurrent dislocation in certain patients. In our series, the incidence of a large opening in the capsule between the superior and inferior glenohumeral ligaments was 54 per cent in the shoulders operated on for transient subluxation in which a search was made for this lesion. DePalma et al. found the incidence of this opening to be 9 per cent in normal shoulders.

A large opening in the shoulder capsule below the superior glenohumeral ligament appears to be a significant lesion in anterior instability of the shoulder. We do not know whether congenital absence of the middle glenohumeral ligament is a predisposing factor in anterior subluxation of the shoulder or whether injury to this portion of the capsule leaves an opening. A possible explanation for enlargement of the opening in the capsule is that as the humeral head subluxates or dislocates forward, the subscapularis tendon and underlying capsule are free to move forward with the humeral head, whereas the supraspinatus tendon and superior part of the capsule are restrained by the coracoid process. The same mechanism could rupture the coracohumeral ligament, which normally prevents excessive external rotation or displacement of the humeral head. We are undertaking further study to determine normal variations in the shoulder bursae and capsular restraints and their relationships to shoulder instability.

Conclusions

1. Recurrent anterior subluxation of the shoulder is characterized by sudden paralyzing pain and weakness of the arm when the elevated and abducted shoulder is in maximum external rotation.

2. Recurrent transient subluxation of the shoulder can be a cause of the dead-arm syndrome.

3. While many patients are aware of a momentary slipping-out of the shoulder, an equally large number of patients are not aware of subluxation.

4. Patients in this latter group have a specific clinical entity that can be very difficult to diagnose correctly. A careful history and physical examination are important. A positive apprehension test is the most consistent physical finding.

5. Deficiency in the shoulder capsule below the superior glenohumeral ligament in the interval between the subscapularis and supraspinatus tendons is probably a factor contributing to anterior subluxation of the shoulder.

References


A Biomechanical Study of Normal Functional Elbow Motion

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ABSTRACT: We studied thirty-three normal patients, eighteen women and fifteen men, for normal motion and the amount of elbow motion required for fifteen activities of daily living. The amounts of elbow flexion and forearm rotation (pronation and supination) were measured simultaneously by means of an electrogoniometer. Activities of dressing and hygiene require elbow positioning from about 140 degrees of flexion needed to reach the occiput to 15 degrees of flexion required to tie a shoe. Most of these activities are performed with the forearm in zero to 50 degrees of supination. Other activities of daily living (such as eating, using a telephone, or opening a door) are accomplished with arcs of motion of varying magnitudes. Most of the activities of daily living that were studied in this project can be accomplished with 100 degrees of elbow flexion (from 30 to 130 degrees) and 100 degrees of forearm rotation (50 degrees of pronation and 50 degrees of supination).

CLINICAL RELEVANCE: These data, not previously recorded, may be used to provide an objective basis for the determination of disability impairment, to determine the optimum position for elbow splinting or arthrodesis, and to assist in the design of elbow prostheses. The motion needed to perform essential daily activities is obtainable with a successful total elbow arthroplasty.

The normal motion of the elbow and forearm has been investigated previously using the standard hand goniometer3. Although experimental techniques have been described2,7,8 the simultaneous study of motion of the elbow and forearm during activity was not practical until the development of the triaxial electrogoniometer. This device is capable of determining simultaneously the amount of elbow flexion-extension and forearm rotation involved in performing simple daily activities.

Materials and Methods

The triaxial electrogoniometer consists of three mutually orthogonal potentiometers attached to a device that is applied to the arm and forearm (Fig. 1). The potentiometers are arranged according to a gimbal system which permits rotation to occur independently about three axes, hence allowing flexion-extension, pronation-supination, and changes in carrying angle to be recorded simultaneously (Fig. 2). Details of the design and application technique of the instrument as well as its use in clinical investigation have been reported9,10.

The components of the goniometer are placed parallel to the humerus and forearm with the elbow in 90 degrees of flexion and the forearm in neutral rotation. The lateral epicondyle is used as an anatomical landmark to approximate the axis of flexion of the elbow. In this study zero degrees is defined as full extension of the elbow. The motion of flexion and extension is performed with the forearm in full supination. Forearm rotation is determined beginning with the elbow at 90 degrees of flexion and neutral rotation defined as the extended thumb being coplanar with the humerus. The device attaches to the distal end of the forearm, thus eliminating any contribution of the carpus or metacarpals to the determination of rotation. The device itself is mechanically accurate to within a fraction of a degree.

The arcs of elbow flexion and forearm rotation are largely independent of goniometer placement. The relative amount of pronation and supination does depend on the definition of the neutral or zero position of the forearm and hence is dependent on the attachment of the goniometer. The device itself is mechanically accurate to within a fraction of a degree. Since no technique of greater accuracy currently is available for comparison, we have not been able to quantify the exact amount of error introduced by placement of the goniometer or soft-tissue interpo-