Shoulder Instability and Pain?

While traditionally shoulder instability has been synonymous with conventional anterior and posterior unidirectional dislocations, a continuum of conditions from the grossly dislocated shoulder to multidirectional instability, and the more subtle forms of anterior subluxation is now recognized. Many of the shoulder problems are seen in overhead throwing and non-throwing athletes and discussion with reference to these athletes assist in the description of mechano-pathology.

Shoulder Stability

The passive stabilizing mechanism of the shoulder includes a combination of osseous and fibrous tissue structures. Individual composition and integrity of these structures create variation in effective restraint. The glenoid fossa is deepened by the fibrocartilagenous labrum located along the periphery, which significantly increases the area of contact between the humeral head and the glenoid. The glenohumeral ligaments as well as the long head of the biceps are attached to the labrum. The inferior glenohumeral ligament complex attaches along the inferior and anterior inferior margin of the labrum. Selective cutting experiments and arthroscopy have demonstrated a hammock-like structure that is essential in supporting the humeral head, especially when the arm is elevated abducted and externally rotated. The middle glenohumeral ligament inserts on the labrum adjacent to the glenoid fossa. It assists in anterior stability and acts as a checkrein to posterior translation. The superior glenohumeral ligament runs anterior to the inferior border of the biceps as it attaches to the superior labrum. It restrains inferior translation of the humerus, prevents superior migration, and helps control posterior stability. Collectively, the capsular ligaments and labrum are called the static stabilizers of the shoulder.

The rotator cuff and long head of the biceps provide dynamic stability of the glenohumeral joint. The rotator cuff consists of the subscapularis anteriorly, supraspinatus superiorly, and infraspinatus and teres minor posteriorly. In addition to providing humeral rotation, their primary stabilizing role is to secure the head of the humerus into the glenoid fossa while the larger deltoid, scapular, and thoracic muscles generate powerful motion to the upper extremity. The long head of the biceps is contained within tenosynovium as it lies within the bicipital groove. It enters the inter-articular portion of the joint along the undersurface of the junction of the subscapularis and supraspinatus. As the upper extremity is placed in external rotation, the biceps has a greater role in arm elevation. It is important that the dynamic action of these stabilizers protect the static restraints.

A coordinated scapulathoracic-glenohumeral movement is also a critical component for normal shoulder function. Optimal positioning of the scapula relative to the glenohumeral joint requires normal function of the rhomboids and upper trapezius muscle.
Researchers have found that the humeral head remains near the center of the glenoid during elevation. A small upward translation occurs during the first 30 degrees of elevation and remains stable as abduction increases. Compromise of the rotator cuff function permits increased upward translation, narrowing the subacromial space.

In the horizontal plane, the humeral head undergoes passive translation when the arm is flexed, extended, rotated, or adducted. Normal kinematics of glenohumeral translation is altered by capsular laxity and contractures.

Posterior head translation occurs when the shoulder is in the "cocked" position for throwers. If anterior instability is present, this posterior translation is diminished, or in some cases, anteriorly translated. The posterior translation in normal shoulders is due to tightening of the anterior capsule in maximum external rotation and extension. By surgically tightening the posterior capsule, Harryman et al had shown that the head had increased anterior and superior translation with shoulder flexion and adduction. Muscular forces did not alter this translation and was labeled as "obligate translation". Changes in normal translation patterns can be responsible for labral injuries. The thrower relies heavily on the dynamic effect of the rotator cuff for joint compression to avoid capsular stretching. Rotator cuff injuries or a breakdown in throwing mechanics jeopardizes the compressive force of the cuff. The larger superficial muscles of the chest wall, scapular, and deltoid can create a shearing effect that further stretches the restraints and increases translation.

The rotator cuff is essential in throwing. Concentric work is performed when the supraspinatus elevates the arm, when the infraspinatus externally rotates into cocking, and when the subscapularis forward flexes the arm. Eccentric work is performed as the subscapularis resists in late cocking and when the supraspinatus and infraspinatus stabilize the shoulder during deceleration and follow-through.

Rapid internal rotation depends upon the rotator cuff for stability'. Loose shoulders are at a greater disadvantage to withstand these stresses. Eccentric overload is a common cause for overuse tendinosis. Postural changes during a throw can reduce the subacromial space. The head-stabilization function of the rotator cuff prevent impingement problems.

When the rotator cuff is compromised, the head can migrate superiorly and create secondary problems. In addition, anterior instability compromises the clearance below the anterior edge of the acromion. Secondary impingement has been identified as a common problem in throwers. The long head of the biceps has activity based on motion occurring at the elbow. Peak activity occurs during follow-through, decelerating the extending elbow and pronating forearm. The role of the biceps in anteriorly and superiorly stabilizing the head of the humerus remains controversial. Reports of tendon hypertrophy are common when rotator cuff function has been compromised.

The pectoralis major, latissimus dorsi, and subscapularis function as powerful internal rotators during the acceleration phase. The serratus, trapezius, and rhomboids position the
glenoid in the optimal position for shoulder stability. During follow-through, the trapezius decelerates scapular protraction. The interplay of the scapular rotators with the rotator cuff maximize efficiency in the energy transfer required to throw a baseball.

In summary, throwing requires:
(1) Concentric work to position and move the arm,
(2) Eccentric work to stabilize the shoulder,
(3) Effective depression of the humeral head to avoid impingement in the overhead position, and
(4) Normal stability to prevent secondary impingement.

Shoulder Instability:

Translation in the shoulder is hard to assess objectively, since wide variations exist. Laxity does not equate to shoulder instability. Translation is used to describe the amount of excursion of the humeral head relative to the glenoid when stress is applied. Shoulder instability is defined as loss of comfort and function of the joint because of unwanted gleno-humeral translation. It is the excessive symptomatic displacement of the humeral head as it relates to the glenoid fossa. Anterior translation should not exceed 25% of the glenoid surface and posterior and inferior translation should be less than 50%. As a translation becomes symptomatic, subluxation exists. The subtleties of this syndrome make this distinction difficult. Subluxation is when there is symptomatic translation of the humeral head on the glenoid without complete separation of the articular surfaces (i.e. partial loss of joint congruency), often with spontaneous return to the normal relationship. Multidirectional instability requires the presence of 2 or 3 of the following instability: inferior, anterior or posterior instability. Dislocation occurs when there is a complete separation of the articular surfaces without immediate, spontaneous relocation.

Posterior instability is a common problem in throwers. It may be uni-directional or in a predominant direct in a patient with multi-directional instability. Unlike anterior subluxation, posterior subluxation can be well tolerated until secondary complaints of infraspinatous tendonitis and parascapular muscular strains become apparent.

In contrast, it may be difficult to pinpoint the initial event in cases of anterior subluxation or multidirectional instability. It is more likely that problems result from the repetitive forces involved in throwing or racquet sports. When these stresses are applied at a rate that exceeds that of tissue repair, progressive damage to the stabilizing structures of the shoulder can occur. With persistent stress of the gleno-humeral joint through continued throwing, the static restraints may become increasingly attenuated, placing greater demands on the dynamic stabilizers. The cumulative effect over time may be increased anterior translation of the humeral head.

The shoulder is subjected to great strains during the generation and release of kinetic energy during a pitch. In susceptible shoulders, the static stabilizers including the labrum and capsular ligaments struggle to contain the torque placed on the shoulder. As a result,
the humeral head translates, stretching the capsule and frequently, abrading the labrum. This process of shearing begins as a subtle microscope measurement and may increase until frank instability occurs. *If the static stabilizers are injured, the rotator cuff must use additional tension to control and limit translation. Fatigue due to eccentric overload complicates the thrower's shoulder, and overuse tendinosis results. Breakdown of technique places additional stresses on the rotator cuff, limiting its ability to reverse early pathologic processes.*

*A relationship exists between shoulder instability and rotator cuff impingement. As the static stabilizers are stretched, increased translation occurs in the glenohumeral joint. The rotator cuff fatigues while attempting to limit translation, and tendinitis results. Tensile changes are noted as tendon fibers fail along the undersurface of the cuff. During arm elevation and rotation, the rotator cuff can no longer control the humeral head, and anterior-superior head migration occurs. Further breakdown in muscular control reduces scapular rotation, permitting the acromion to limit forward flexion. The impingement syndrome, once believed to be common, is now recognized as a secondary process. The primary process of the anterior humeral head subluxation and protraction of the scapula reduces the subacromial space. Correction of the primary pathology is essential for resolution of the thrower's problems. Secondary pathology will most likely improve or resolve if the underlying problem is corrected.*

**Impingement Syndrome:**

Shoulder Pain is a typical symptom of shoulder instability. Pain is also the most common reason for presentation. The physician should try to establish the onset location, and duration of this pain. It is helpful to have the patient demonstrate at what phase in shoulder motion the pain is made worse. Pitchers and throwers are familiar with changes made in their throwing mechanics that might have been associated with the onset. Other patients may deny pain but describe discomfort associated with fatigue. Lack of endurance may be a secondary complaint due to poor compensatory effort. Further questioning regarding other injuries is important as well. Low back and lower extremity injuries can lead to faulty mechanics affecting the shoulder.

*The shoulder pain is usually the result of impingement of the rotator cuff tendons due to recurrent anterior positioning of the humeral head with recurrent 'silent subluxation'. This aggravated by the eventual weakening of the rotator cuff muscles.*

Other causes of shoulder pain must be excluded, including acromioclavicular joint problems, avascular necrosis of humeral head, cuff tear, early degenerative joint disease, loose bodies, snapping scapula, suprascapular nerve injury.

The rotator cuff is vital to normal shoulder function. It depresses the humeral head and compresses the glenohumeral joint during arm elevation. Larger muscles such as the deltoid create an upward-shearing stress during elevation. The shoulder needs an effective fulcrum to prevent compromise of the subacromial space. The cuff is dependent on intact static stabilizers and scapular rotators. *If the glenohumeral joint static stabilizers*
fail to contain the head, the rotator cuff must substitute by eccentrically contracting. Elevated muscle loads often lead to early fatigue, eccentric overload, and inflammation. Scapular malposition places the glenoid at a disadvantage, and the rotator cuff is overstressed to complete the throwing motion. Lack of forward protraction stresses the anterior cuff and capsule in early acceleration and posterior cuff during follow-through. Poor mechanics often result from this inflammation, and compensatory mechanisms are attempted. Strains due to eccentric overload result in overuse tendinosis.

Overuse injuries are most common in the supraspinatus muscle and tendon. This portion of the cuff has the greatest role in head depression during shoulder abduction. In a healthy shoulder, this can adequately maintain the subacromial space, preventing impingement. With fatigue, the shoulder can no longer resist superior translation. Intrinsic changes within the tendon and cuff deterioration occur.

Biceps overload can also complicate throwing. This occurs either as a result of elbow eccentric deceleration or as an adjunct to shoulder stabilization. Overuse tendinitis of the long head of the biceps is most noticeable in the follow-through phase. During this phase both elbow extension and pronation require forceful deceleration. In addition anterosuperior shoulder stability is assisted with biceps activity. Both activities place stress on this muscle-tendon unit.

Infraspinatus tendinosis can occur in a thrower. This tendon, along with the teres minor and posterior deltoid, externally rotates the shoulder.

The pectoralis major and latissimus dorsi muscles assist the subscapularis with internal rotation. Inequality in strength of internal and external rotation can upset the balance.

As the throw continues during follow-through, there is increased activity in the posterior cuff as deceleration of the arm occurs. Weakness of external rotators makes it difficult to decelerate properly, leading to fatigue, and can progress to tissue damage. Appropriate conditioning is essential to prevent this syndrome.

Hence impingement syndrome is the rotator cuff degenerative process caused by exterior wear on the undersurface of the subacromial arch. In throwers, the eccentric overload leads to fiber failure. A superior migration of the humeral head results, compromising the subacromial space. Cyclic cuff failure and secondary impingement create changes within the rotator cuff and subacromial bursae.

Pathology:

Neer has classified three progressive pathologic stages, beginning with edema and hemorrhage within the bursae and supraspinatus and occasionally the biceps. Thickening and fibrosis comprise stage 2 and eventually lead to tendon failure or stage 3. Individuals who stress their arms repetitively overhead are at a greater risk of developing
impingement. Although the natural history is not available, the stages of degeneration are generally believed to be progressive.

One theory for secondary impingement is occult instability. The shoulder is stabilized by static and dynamic restraints. The position of abduction and external rotation during throwing stresses these restraints. If this stress exceeds the rate of tissue repair, the static restraints become attenuated. This laxity permits abnormal anterior head translation.

Shoulders with anterior subluxation compensate with increased rotator cuff activity. As the anterior restraints stretch further, subluxation results in the cocking and acceleration phases. The rotator cuff fatigues, and tensile injury causes further dysfunction. The humeral head can no longer be depressed effectively, and compromise of the subacromial space results.

The combination of anterior subluxation and the curvature of the anterior acromion compresses the subacromial space. Further compensation by the parascapular muscles causes malposition of the scapula, further narrowing this zone.

This pattern of tendinosis demonstrates both interarticular and extra-articular damages. With increased translation, the anterior capsular ligaments are stretched. The labrum is abraded anteriorly and, possibly, torn from the glenoid. Undersurface tears of the rotator cuff are common. As this impingement progresses, the subacromial space changes as well. Bursal thickening and exterior cuff wear are present. Late changes to the acromion and coracoacromial ligament can develop with time.

**Symptoms and findings**

The swimmer typically complains of pain on the anterior or lateral aspect of the shoulder, characteristic of rotator cuff tendinosis. If supraspinatus is involved, pain can radiate to the area over the inferior part of the deltoid and lateral aspect of the elbow, but also to other areas on the upper extremity depending on the part of the rotator cuff involved. Some swimmers report a snapping sensation either during the recovery phase or at mid pull-through, probably due to chronic inflammation of the bursa.

Neer & Welsh\textsuperscript{vi} described four phases of swimmer's shoulder:

1. Phase I - pain only after heavy workouts;
2. Phase II - pain (not disabling) during and after workouts;
3. Phase III - disabling pain during and after workouts that interferes with the swimmer's performance; and
4. Phase IV, shoulder pain that prevents competitive swimming.

In the last phase, pain at rest and sleep disturbances are seen. The classification is practical for the purpose of clinical evaluation and as a guideline during rehabilitation programs. In order to prevent the condition from progressing to an advanced stage, the characteristics of phases I and II should be known to any competitive swimming coach.
Two impingement tests bring the rotator cuff into collision with the coracoacromial arch with subsequent pain.

(1) In Neer's test the greater tuberosity as well as the anterior part of the rotator cuff is jammed against the anterior-inferior surface of the acromion. The test is performed with the swimmer sitting. The examiner is standing behind with one hand on the scapula in order to prevent scapular rotation. The other hand raises the arm in forced forward elevation. The test is positive if anterior or lateral shoulder pain occurs.

(2) Hawkins' test is performed with the subject sitting or standing. The shoulder is flexed to 90° in the scapular plane. A positive test is noted if anterior or lateral shoulder pain arises after a forcible internal rotation of the shoulder.

Both tests must be supplemented with the lidocaine injection test. Hawkins' test seems to require the least patient compliance. If mobility is restricted, abduction and external rotation might be slightly impaired, but usually only in late phases (III and IV). If the biceps tendon is involved there will be a point tenderness over the bicipital groove and pain during resisted supination of the forearm, with the elbow flexed to 90° (Yergason's test).

The swimmer is then examined for concomitant instability. There are a number of different tests to evaluate glenohumeral instability. They all have in common that they are much dependent on patient compliance, and their sensitivity and specificity have been very sparsely evaluated. The most commonly used tests are as follows:

1. The apprehension test is positive if apprehension results from passive resisted external rotation of the glenohumeral joint, with the arm at 90° or 135° of abduction, while the examiner pushes the humeral head anteriorly with a thumb. If the test is positive, anterior instability is suspected.

2. The relocation test is positive if posterior relocation of the humeral head relieves pain after a positive apprehension test performed with the patient supine.

3. The drawer test as described by Hawkins & Bokor demonstrates anteroposterior instability. The test is performed with the patient sitting relaxed on a chair or preferably on a couch, with the shoulder in neutral rotation. One hand fixes the acromion and the other hand grasps as proximal on the humerus as possible. The humeral head is then gently translated in anterior and posterior direction. The laxity is graded from 0 to 3 in both directions. Some authors prefer the patient supine with or without a slight abduction of the shoulder. With the patient supine there is a risk of misinterpretation of the anterior laxity, since the humeral head in this position will tend to slide posteriorly before examination is started.
4. Test for inferior instability is performed with the sulcus test, either by downward traction of the arm or by downward pressure while the arm is abducted at 90° and neutrally rotated. The sulcus test is found to be positive in many asymptomatic subjects. In order to exclude pathological inferior instability, the sulcus sign must disappear when the shoulder is externally rotated 30°. General joint hypermobility is evaluated using the Carter & Wilkinson's criteria (5°).

Carter & Wilkinson's (50) criteria for general joint hypermobility

1. Hyperextension of the elbow > 10°
2. Hyperextension of the knee > 10°
3. Passive apposition of the thumb to volar aspect of the forearm (<0.5 cm)
4. Passive hyperextension of 2nd to 5th fingers >90° or parallel to the forearm
5. Dorsiflexion of the ankle > 45°

If more than 3 criteria are met, the person is judged as generally hypermobile. If all 5 criteria are met, hypermobility is severe.

A person is generally hypermobile if more than 3 criteria are met in this classification.

A concomitant scapulothoracic instability is characterized by an increased lateral scapular glide and a pathological scapulohumeral rhythm. A lateral scapular glide is defined as a significant difference in the distance from the medial border of the scapula to the spinal processes at rest. Scapulothoracic instability is evaluated by observing the scapulohumeral rhythm. The examiner observes the subject from behind as he or she repeatedly slowly abducts and deabducts in the frontal plane. Severe scapulothoracic instability is characterized by obvious asynchrony after few repetitions. Instability is considered light if a palpitation is noted in the rhomboids or the trapezoid muscles during the test.

Other causes of shoulder pain should be excluded, such as acromioclavicular arthritis, cervical spondylosis or traumatic disorders.

Investigations:

Plain radiograms have a limited value in the evaluation of non-traumatic glenohumeral instability. Fluoroscopic evaluation has been shown to confirm the presence of instability or predict subtle instability in patients with undiagnosed shoulder pain.

Jerosch et al have shown that sagittal glenohumeral instability can be quantified by ultrasound. Furthermore, it is possible to assess glenohumeral translation with the Stryker Knee Laxity Tester in un-anaesthetized patients with unilateral instability.

Dynamic electromyographic recordings using intramuscular needle electrodes can reveal deficient function or dyscoordination of the rotator cuff muscles.
Arthroscopy and examination under general anesthesia are recommended in cases not responding to conservative treatment, cases progressing to phase 3 or 4 or cases where glenohumeral instability is suspected. Testing stability under anesthesia excludes muscular defense, and arthroscopy may reveal a variety of associated injuries.

Subacromial bursoscopy allows inspection of the superior aspect of the rotator cuff as well as of pathological conditions within the subacromial arch, such as inflammation of the subacromial bursa.

Superior labral tears and partial tears of the undersurface of the rotator cuff are reported to be a common arthroscopic finding in throwing athletes, but fraying or detachment of the anterior labrum can be seen in swimmers too.

Together with a thorough preoperative evaluation it is possible to place the patients into at least four categories of shoulder problems, each requiring specific treatment:

**Jobe & Glousman's classification of glenohumeral subluxation and associated subacromial impingement**

1. **Group 1: Pure impingement**
   a. Positive impingement sign
   b. Negative apprehension sign
   c. Arthroscope
      - Stable examination
      - Undersurface cuff tear, subacromial bursitis
      - Labrum and glenohumeral ligaments normal

2. **Group 2: Anterior instability and associated impingement (labral-capsular trauma)**
   a. Positive impingement sign
   b. Possible apprehension sign
   c. Arthroscope
      - Unstable examination
      - Undersurface cuff tear
      - Labral damage
      - Humeral-head chondromalacia
      - Subluxation of humeral head

3. **Group 3: Anterior instability and associated impingement (hyper-elasticity)**
   a. Positive impingement sign
   b. Possible apprehension sign
   c. Arthroscope
      - Unstable examination
      - Undersurface cuff tear
      - Attenuated but intact labrum
      - Glenohumeral ligament (capsular laxity)
      - Subluxation of humeral head over labrum

4. **Group 4: Pure anterior instability**
   a. Negative impingement sign
   b. Possible apprehension sign
c. Arthroscope
- Unstable examination
- Normal cuff
- Labral damage and capsular laxity
- Humeral head chondromalacia and subluxation

Group I are subjects with classical mechanical impingement. They have a positive impingement sign, whereas no clinical or arthroscopic signs of instability are present.

Group 2 have anterior instability and associated impingement (secondary impingement).

Group 3 are subjects with general hypermobility and anterior instability, while

Group 4 are subjects with pure anterior instability and no signs of impingement.

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5 Hawkins RJ, Hobeika P, Orthopedics, 1983, 10:1270; Physical examination of the Shoulder