Rotation Before Elevation

- Anatomy and mechanics of movement
- Component movements of elevation
- Muscle function and dysfunction
- Evaluation of rotation
- Treatment using rotation
- Complex Movements – Elevation and reaching behind

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The Complex Mechanics of Shoulder Movement

- Rotation Before Elevation
- FORCE Couples
  - Two forces moving in opposite directions that creates a non linear movement = rotation
  - Glenohumeral (modified)
  - Scapula sesamoid bone

Shoulder Movement of the Glenohumeral = Force Couple

Scapula-G-H Rotational – Force Couple
**How Much Rotation?**

- Brems and Browne patients need a minimum of 35 degrees to 45 degrees of external rotation in order to maintain functional overhead movements and avoid subacromial impingement.
- Browne et al demonstrated that external rotation is required during arm elevation in any plane anterior to the scapula and internal rotation is required during arm elevation in any plane posterior to the plane of the scapula.

**Clinical Outcomes Restoring Rotation**

- Vermeulen reported that the loss of glenohumeral joint mobility in adhesive capsulitis is probably due to capsular adhesions, which limit external rotation of the head of the humerus.
- Mao demonstrated that restoring passive external rotation showed the reappearance or enlargement of the axillary recess and smoother capsular margins. Increased extensibility of the axillary recess is important in restoring active elevation.

**Rotation Clinical Importance**

- Shortening the anterior capsule 7 mm resulted in tightening of the capsule. Tightening of the anterior capsule resulted in loss of external rotation, which is the area that is most restricted in patients with adhesive capsulitis of the shoulder.
- Cyriax described a capsular pattern in the shoulder that is specific to adhesive capsulitis. He described the movement with the greatest percentage of limitation was passive external rotation, followed by elevation in the frontal plane (abduction).

**Patients have less pain with Rotation**

- It has been recognized that an “obligatory” axial external rotation of the humerus is necessary to clear the greater tuberosity from the acromial arch and to accommodate the retroverted articular surface of the humerus to gain an optimum position for glenoid contact and stability.
Testing/Mobilizing Soft Tissue Restrictions More
Specific Differential Diagnosis

- External Rotation in Frontal plane
  - Zero degrees Abd
  - 30E subscapularis
  - 45E - 50 middle GH ligament - coracohumeral ligament
  - 90E Inferior G-H ligament-superior band


- 36 cadaver shoulders embalmed
- Relative soft tissue contributions to limiting external rotation at the G-H joint.
- Dissections of Subscapularis, Shoulder capsule, Superior, middle and inferior G-H ligaments.
- At Zero degrees of abduction subscapularis most significant restriction in ext. rot.
- 45 degrees Abd middle G-H ligament
- 90 degrees Abd superior band of the inferior G-H ligament checked external rotation

A Cadaveric Study of Strain on the Subscapularis Muscle

- External rotation at 30° to 60° of glenohumeral elevation, abduction, flexion, and horizontal abduction can significantly stretch the lower fiber group of the subscapularis muscle.

- External rotation at 30° of glenohumeral elevation is considered to be the possible stretching position.

- In external rotation at 30° of glenohumeral elevation, significantly large muscle strain on the lower fiber group and positive muscle strain on the upper and middle fiber groups were observed simultaneously.

- External rotation at greater than 60° of glenohumeral abduction is supposed to be inadequate as a stretching position for the subscapularis muscle.

Passive ER Test in Zero Abd, 30E, 45E-90E
Stress to the Anterior Capsule, Ligaments, Subscapularis, Bigliani

30 degrees of add with external rotation – Subscapularis/ middle glenohumeral ligament and the anterior superior fibers of the inferior glenohumeral ligament

45-60 degrees of add with external rotation – Superior / Middle fibers of the capsule, coracohumeral ligament

Passive test Internal rotation

Inferior G-H ligamentous complex

Joint Active Systems - Shoulder

Stress-relaxation – static progressive – JAS Bonutti Clin Ortho Rel Research 1994
Static progressive stretch

Donatelli et al – Static progressive stretch-stress relaxation and mobilization in treatment of Adhesive Capsulitis.
Ortho Research Society Annual Meeting - Poster Presentation 2000
Biomechanics Journal Feb 06

Posterior Capsule Strain Measurement using cadaver specimens
Izumi, Tomoki et al , AJSM 2008

30E abduction in the Plane of Scapula (30E) & internal rotation
Superior & Middle fibers of posterior capsule

30E flexion internal rotation posterior capsule
Muscle Strength Testing the G-H rotators in the POS

- Length tension of the rotator cuff and shoulder abductor is optimal - Exercise and testing
- Capsule is untwisted
- Stretching/ mobilization
- Joint Congruity is optimal
- Joint stability
- Johnston Brit J Surg 1937 “A Plea” the true abduction range

Subscapularis and Surrounding Muscles

Research

- Torque production between Scaption and other body plane movements
- Greenfield and Donatelli Am J Sports Med 1990 – Significant increase in strength of the external rotators in the POS – 30 degrees anterior to the frontal plane
- Tata et al., J Ortho Sports PT 1993
  Better Ratio of ext/int at 35 deg anterior
- Soderberg et al., J Ortho Sports PT 1997 No difference from sagittal, frontal, neutral, POS 45 degrees anterior to the frontal plane
Ratio Of Rotator Cuff Muscles

- Average strength of the external to internal rotators approximately 60-65%
- Ellenbecker JOSPT 1997 demonstrated that in professional baseball pitchers the external to internal rotator ratio was 70%.
- If the external to internal rotator ratio is less than 50% a muscle imbalance is present that could effect function. Especially in overhead throwing athletes.

Forces During Elevation

- Muscle forces produce parallel and perpendicular forces to the GH joint
- The RC muscles = a parallel force to the GH joint = compression and depression
- The Ant Deltoid produces a perpendicular force to the GH joint = shear (Max shear 60 deg)

Muscle Forces Changing Acromial Pressure

- **Muscle reducing acromial pressure:**
  - Biceps 10% (6 shoulder 34% dec)
  - Rotator Cuff 52% dec without supraspinatus (type III acromion)
- **Muscle increasing acromial pressure:**
  - Supraspinatus – superior shear forces
  - Deltoid abduction force inc. 17% and the average pressure under the acromion increased 12% without the effect of the external rotators and subscapularis (internal rotation increased pressure 33%)

Rotator Cuff Fatigue & G-H Kinematics in Patients without Shoulder Dysfunction

- Deydre et al. Journal of Athlete Training 2008
- Fatigue protocol was indicated by a 54% reduction in prone horizontal abduction strength average prefatigue strength was 7.15 kg postfatigue 3.16kg average time to fatigue was 84.2 seconds.
- Blackburn et al. determined that abduction in the prone position with the thumb up position isolated the supraspinatus, infraspinatus and teres minor muscles
Results

- Increase in superior migration of the humeral head during arm elevation increases with rotator cuff fatigue in individuals without shoulder dysfunction.
- Average subacromial space is between 2mm and 14mm (~6.7mm).
- The magnitude of superior migration may represent a 6% to 40% reduction in subacromial space.

Strength of the Glenohumeral Rotators Equals Function in the Shoulder

- Wooden, Donatelli et al. JOSPT 1992

Improving Strength of Shoulder Rotators in Teenage Baseball Pitchers

- Isokinetic 500 degrees/sec
- Isotonic mode 80% Max effort thru out the range of rotation
- Results: Isotonic group significant increase in throwing velocity and external rotation strength
- Ave. increase in speed 2-3mph
- Wooden et al. JOSPT 1992

Tennis serve velocity changes with strength training on Isokinetic device

- 3 groups (control, eccentric, concentric)
- Isokinetic training was used 90-210 deg. Per second
- Significant concentric and eccentric gains were obtained in both groups
- Increase serve velocity average 11mph
- Monte et al, 1994
Shoulder Strengthening

- Bench and Reach
- Bent Over Row
- Lat Pull down

Lower Trap Lift

Mid Trap Lift and RC
Scapular Rotators
- Upper traps
- Lower traps
- Serratus
- Levator scapulae
- Middle Traps and Rhomboids (stabilize)

Scapula Kinematics

**Scapular Dysfunction**

S.I.C.K.
- Kebaestse et al Arch of Phys Med Rehab 1999 – Thoracic posture effects position of the scapula and G-H ROM
- Warner et al Clin Ortho ’92
- Asymmetry of the scapula is 32-57% of shoulder instability & impingement
- Wadsworth & Bullock-Saxton Int J Sports M ’97
- Serratus recruitment delayed in impingement

**Scapula Rotators Effect on Increasing GH Forces**
- Weakness of scapula retractors will result in excessive protraction and narrow the subacromial space *McQuade et al. Clin Biomech 95*  *Kibler Am J Sports Med 1998*

**Scapular Dyskinesia**
- Factors affecting scapular position and control
  - Weakness of Scapular muscles
    - Lower Traps
    - Rhomboids/Mid Traps
    - Serratus Anterior
  - Tightness of Pectoralis Minor
  - Tightness of Subscapularis
  - Tightness of Posterior Capsule
Scapula Rotators
- Biomechanical analysis of scapular rotators during arm abd. In the POS
- Scapula rotators 80-140 greater moment arm than the Deltoid and the supraspinatus

Rotation of the Scapula
- Increased tension on the conoid and trapezoid ligaments resulting in axial rotation of the clavicle.
- Clavicle forms a double curve creating a crankshaft effect
- Rotation produces elevation at the AC end to allow the scapula to rotate the last 30 deg

Suction Cup – Matsen
Central Position of Humeral Head
- G-H joint compressive force of the head of the humerus into the socket expels the synovial fluid to create a suction that resists distraction.
- Negative articular pressure is produced by the limited volume of fluid
- Compressive load produced by dynamic action of muscle contraction

Central Position
Provides Passive & Dynamic Stability
**Assessment**
- Scapula position
- Capsular mobility testing passive rotation ROM 7 positions – Anterior capsule – external rotation
  - Zero Degrees Abd, 30E Abd POS – 45-90E Abd, 90E Abd
  - Posterior Capsule – internal rotation
  - 30Eabd & 30E POS
  - 30E extension & 30E abd
  - 90E flexion – Sleeper stretch position
- Test RC strength
- Test Scapula strength
- Role of the Biceps as a stabilizer – assisting central position
Role of the Biceps

- The long and short head of the biceps at 60 and 90 degrees of abduction and external rotation is an important stabilizer by increasing torsional rigidity (Itto et al. JBJS 93)
- The long head of the biceps during internal & external rotation (b & c) ant/post - producing compressive forces restraining the translations of the humeral head (Abboud & Slocum Clín Ortho Rev. Rex 2002)

Dynamic Stability of GH

- Deltoid and the Rotator cuff muscles produce shearing, compressive, and depressive forces to the GH joint
- These forces will vary as the muscles' alignment change.
- A larger superior shearing force will produce impingement
- A larger compressive force will center the humeral head on the glenoid creating dynamic stability

Patient Cases – Stiff and Painful Shoulder

**Treatment**

- LLPS into external – internal rotation with heat
- LASER to the Trigger points
- Mobilizations in the barrier
- Passive ROM into rotation
- Strengthening the G-H and Scapula Rotators

Rotator Cuff Tear/ Fx Humerus

Dominance of the Deltoid over the rotator cuff and dominance of the upper trapezius over the lower trapezus

Common movement impairment in frozen shoulder patients
Super Pulse Laser – Multi-Radiance Medical
In the Treatment of Muscle T.P.

- Super pulsing produces higher peak power leading to higher energy densities (more photons delivered) without thermal buildup in cells and tissues
- Speeds up the transformation of photons into biochemical energy and encourages depth of penetration up to 5 inches

The Pain Clinic, Vol. 18, No. 1 (2006)
There was no difference in the relief of pain when comparing Laser to Trigger point injections (6 month FU)
VAS, Verbal pain scale; pressure gage

Low Load Prolonged Stretch With Heat
Lentell JOSPT 1992

Treatment of Sports Hernia and Subscapularis – Hip Flexor TP

Sports Hernia

Subscapularis Trigger Points

Low Load Prolonged Stretch With Heat

Passive External rotation/ Active Elevation before after

800-373-0955
Total Shoulder Replacement

LLPS / External Rotation POS

Exercises / Scapula Rotators

Passive External Rotation / Active Elevation POS
Rotation = Elevation

RC Tear / Rotation=Elevation

Mobilization Posterior Capsule

AP glides
Fulcrum technique

Low Load Passive Stretch
External and Internal Rotation in the POS
30E abduction and POS
Posterior capsule superior/middle fibers
Subscapularis and middle anterior fibers
Low Load Prolonged Stretch - Wedge

- External / Internal Rotation stretch

Before Passive Elevation & ER After
3 weeks post surgery

Phases of Elevation
- Initial Phase 0-60 degrees active elevation
- Middle or critical phase 60-140 degrees active elevation
- Final Phase 140-180 degrees of active elevation
Initial Phase
- 0-30 humeral head moves superior by the action of the supraspinatus 3mm to position the head of the humerus in a central position on the glenoid – Important for stability
- 0-60 SC joint mobility
- Ratio 4.29:1 AA:SR Arm abduction to scapula rotation
- 3.29:1 GH:ST - G-H joint movement to Scapula-thoracic joint movement

Middle (Critical) Phase
- Maximum forces at the G-H joint 60-90
- Shearing forces of the Deltoid
- Weight of the arm
- 80-140 degrees greatest relative amount of scapula rotation
- 130-150 clavicular elevation at the AC is complete

Middle Phase
- Arthrokinematics Superior/inferior glides 1.5mm – Poppen and Walker
- 1.71:1 AA/SR
- 0.71:1 GH/ST
- Rotation-Rotation-Rotation important component movements of the G-H, scapula, and the clavicle

Final Phase
- Disassociation of the humerus from the scapula
- Good extensibility of the subscapularis, teres major
- 4.5:1 AA/SR
- 3.5:1 GH/ST
Summary

- The most complex movements of the shoulder are elevation and reaching behind.
- Restrictions in the above complex movements represent a dysfunctional force couple and limitations in the capsule and periarticular structures that surround the Glenohumeral articulation.
- Assessment of rotation will help determine where the restrictions are and then it will be possible to develop a specific treatment plan to improve the rotational component movements of the shoulder.