Shoulder Anatomy and Biomechanics

 Movements

- Sagittal plane
  - Flexion (180°)
  - Extension (60°)
- Coronal plane
  - Abduction (180°)
  - Adduction (180°)

 Five Functional Joints

1. Glenohumeral Joint
2. Subacromial
3. Scapulothorasic
4. Acromioclavicular
5. Sternoclavicular

Sternoclavicular Joint

- The only true bony attachment of the upper extremity to the trunk.
- Synovial, saddle shaped joint

Sternoclavicular Joint

- Disc that attaches to the first rib
- Ligaments:
  - Interclavicular Ligament
  - Costoclavicular Ligament (subclavius muscle)
  - Posterior Ligament
  - Sternoclavicular

Sternoclavicular Joint

Three degrees of freedom

Movements in horizontal plane:

- Protraction (30°) limited by costoclavicular and post. capsule
- Retraction (30°) limited by costoclavicular and ant. capsule
Movements in the frontal plane:

Elevation (60°) limited by costoclavicular
Depression (5°) limited by first rib
Axial Rotation created by ligamentous attachments

Acromioclavicular Joint

Synovial sliding joint allows three degrees of movement
There is a disc is present until the second decade.

Acromioclavicular Joint

Ligaments:
Medial - Coracoclavicular; Conoid
Lateral - Trapezoid

Acromioclavicular
Coracoacromial: coracoid process to acromion process
Closed packed position is when the humerus is abducted to 90°.

Biomechanics of Scapular Rotation

Scapulo-thoracic motion occurs as part of a closed kinetic chain involving the:

A-C joint
S-C joint

Subacromial Space
Structures Within Suprahumeral Space
1. Long head of biceps
2. Superior capsule
3. Supraspinatus tendon
4. Upper margins of subscapularis & infraspinatus tendons
5. Subacromial bursa
6. Inferior surface of the A-C joint

Subacromial Space
- Clinical Relevance
  - Avoidance of impingement during elevation of the arm requires
    - External rotation of humerus to clear greater tuberosity
    - Upward rotation of scapula to elevate lateral end of acromion

Subacromial Space
- Primary Impingement
  - Structural stenosis of subacromial space
- Secondary Impingement
  - Functional stenosis of subacromial space due to abnormal arthrokinematics

Glenohumeral Joint
- Synovial ball and socket joint
- Three degrees of freedom
- Stability provided by
  - Passive restraints
  - Active restraints

Glenohumeral Motion
Passive Restraints:
1. Bony geometry
2. Labrum
3. Capsuloligament-ous structures
4. Negative intra-articular pressure

Glenohumeral Ligaments
- SGHL
- MGHL
- IGHL
  - Anterior band
  - Posterior band
  - Axillary band
Capsuloligamentous Structures

Corocohumeral Ligament
- anterior band
- posterior band

Restraints to External Rotation

Dependent on arm position
- 0° - SGHL, C-H & subscapularis
- 45° - SGHL & MGHL
- 90° - anterior band IGHLC

Restraints to Internal Rotation

Dependent on arm position
- 0° - posterior band of IGHLC
- 45° - anterior & posterior band of IGHLC
- 90° - anterior & posterior band of IGHLC

Restraints to Inferior Translation

Dependent on arm position
- 0° - SGHL, C-H
- 90° - IGHLC

Glenohumeral Motion

- Scapular Plane:
  - Flexion/extension - 120°
  - Abduction/adduction - 120°
  - External/internal rotation
  - Horizontal abduction/adduction

Arthrokinematics of the Glenohumeral Joint

Scapular Plane:
Glenohumeral Motion
Concave-Convex ‘Suggestion’

Glenohumeral Motion
Arthrokinematics

Glenohumeral Motion
Capsular Tightness:
Results in abnormal arthrokinematics

Glenohumeral Motion
Normal Arthrokinematics:
Combines rotation and translation to keep the humeral head centered on the glenoid

Scapulohumeral Muscles
Prime Movers:
- Deltoid
- Pectoralis major
- Latissimus Dorsi
- Teres Major
- Biceps
- Coracobrachialis
- Triceps

Scapulohumeral Muscles
Rotator Cuff ms:
- Subscapularis
- Supraspinatus
- Teres Minor
- Infraspinatus
Rotator Cuff Function

• Approximates humerus to the glenoid
• Supraspinatus assists deltoid in abduction
• Subscapularis, infraspinatus & teres minor depress the humeral head

Subscapularis

• Effective restraint to ER with arm at the side
• Ineffective restraint to ER with the arm abducted to 90°

Rotator Cuff Function

• Biceps tendon force increases the torsional rigidity to ER
• No effect on strain of the IGHLC
• Effect lost with a SLAP lesion

Biceps becomes more important as an anterior stabilizer as capsuloligamentous stability decreases

Itio et al, JBJS 1994
Glausman et al, 1988

Force Couples Acting on the Glenohumeral Joint

• Transverse plane – anterior vs posterior RC
• Coronal plane – deltoid vs inferior RC

Rotator Cuff Tear

Supraspinatus

• Essential force couples maintained
• Normal strength & function possible
Rotator Cuff Tear

**Supraspinatus/Posterior Cuff**
- Essential force couples disrupted
- Weakness with ER
- Little elevation possible

**Massive Tear**
- Essential force couples disrupted
- Weakness with IR & ER
- Little active elevation possible

Scapulothoracic Joint

- Trapezius
- Serratus Anterior
- Rhomboids
- Levator Scapulae
- Pectoralis minor
- Subclavius

Scapulothoracic Motion

- Elevation/depression
- Protraction/retraction
- Upward/downward rotation

**Force Couples at Scapulothoracic Joint**

- Serratus anterior produces antero-lateral movement of the inferior angle
- Upper trapezius pulls scapula medially

**Forces Couples for abduction**
- 0-90° Deltoid and supraspinatus
- 90-150° Trapezius (Upper and Lower), Serratus anterior, deltoid
- 150-180° As above plus contralateral spinal muscles
Scapulohumeral Rhythm

- Total elevation
  - 120° at GH joint
  - 60° at ST joint
- 2:1 ratio for GH/Scapula movement
- Most GH motion occurs within the first 90° of humeral elevation
- Scapula movement occurs toward the end of motion.
- SC rotation and elevation also contribute at the end of motion

0-60°
- Anterior deltoid, coracobrachialis, pectoralis major

60-120°
- Trapezius (upper & lower), serratus anterior

120-180°
- Lower trapezius, serratus anterior, contralateral spinal muscles

Scapular Rotation

Phase 1
- Upper & lower portions of trapezius & serratus anterior produce an upward rotatory force on the scapula
- Motion at the A-C joint prevented by the coraco-clavicular ligament
- Rotation of the scapula occurs as elevation of the clavicle occurs at the S-C joint

Phase 2
- Further motion at the S-C joint is prevented by the costoclavicular ligament
- Continued upward rotation of the scapula pulls on the costo-clavicular ligament causing posterior rotation of the clavicle
- Posterior rotation of the clavicle allows further rotation of the scapula

Scapular Rotation

- Necessary to:
  - Enhance glenohumeral stability
  - Elevate acromion to avoid impingement
  - Maintain effective length tension relationship of scapulohumeral muscles