ANATOMY of the SHOULDER

Ed Mulligan, PT, DPT, OCS, SCS, ATC

FUNCTIONAL ANATOMY

- sternum
- clavicle
- scapula
- ribs
- vertebrae
- ilium
- humerus

CLAVICLE

- shaped like an italic “f”
- acts as a strut to the UE to resist compressive forces
- medial portion moves the least
- main function is stability

SCAPULAR ANATOMY

- thin, flat triangular shape provides a concave surface that can glide easily over the convex thorax with at least 17 muscles that originate or insert

What is the clinical significance of multiple muscle attachments?

Upper Trap
Levator Scapulae
Rhomboid Major
Rhomboid Minor
Middle Trap
Lower Trap
Serratus Anterior
Pec Minor

Deltoid
Supraspinatus
Infraspinatus
Teres Minor
Subscapularis
Teres Major
Biceps
Triceps
Coracobrachialis
SCAPULAR FUNCTIONS

• increases the positions available for the hand in space by varying the original position of the proximal humerus
• provides stability for the upper extremity during functional activities of the hand

Integrated, functional movement emanating from proximal to distal

SHOULDER ARTICULATIONS

- sternoclavicular
- acromioclavicular
- scapulothoracic - functional
- glenohumeral

sternoclavicular joint

- only skeletal articulation between upper extremity and axial skeleton
- synovial sellar articulation
- Articular surfaces lack congruity
  - 1/2 of the large round head of the clavicle protrudes above the shallow sternal socket

sternoclavicular joint

- Disc
  - completely separates joint
  - attaches to cartilage of 1st rib and capsule
- Capsule - very lax
- Ligaments
  - provide stability
  - interclavicular - costoclavicular - sternoclavicular
    (posterior sternoclavicular is strongest)
sternoclavicular joint ligaments

- Proximal Surface
  - sternal clavicular notch
  - shares cartilage with 1st rib
  - convex vertically (cranial/caudal)

- Distal Surface
  - medial clavicle
  - larger surface with thick fibrocartilage
  - concave AP
  - convex vertically

sternoclavicular joint motion

... longitudinal rotation

- When the convex vertical surface of clavicle moves:
  - caudally - shoulder elevates
  - cranially - shoulder depresses

- When the concave AP surface of clavicle moves:
  - anteriorly - shoulder protracts
  - posteriorly - shoulder retracts

ACROMIOCLAVICULAR JOINT

- synovial gliding joint with lax capsule and strong ligamentous support
- Distal Surface
  - acromion (flat or slightly convex)
- Proximal Surface
  - clavicle (flat or slightly concave)
  - clavicle faces inferiorly, posteriorly, and laterally

Acromioclavicular Ligaments

- Acromioclavicular
  - limits 91% of AP translation
- Coracoclavicular
  - limits 77% of superior translation
  - Conoid (medial) is vertically oriented and creates clavicular rotation when taut
  - Trapezoid (lateral) is more horizontally oriented and resists acromion form sliding under the clavicle
Acromioclavicular Ligaments

Coracoacromial
- triangular shape from base at lateral border of coracoid which moves up, laterally, and posterior to the top of the acromion process

Structural Influences
- Prominent coracoid process
  - Impingement of subscapularis between coracoid and lesser tuberosity
- Os acromiale
  - Unfused anterior acromial epiphysis
- Hooked acromion
  - Osteophytes, calcific deposits
  - Morphology Variants

Acromion Morphology and its Relationship to Rotator Cuff Tears

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<tr>
<th>Type</th>
<th>Description</th>
<th>Acromial Shape Frequency (%)</th>
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Bigliani, Orthop Trans, 1986

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No evidence of change with aging but acromial spurring does and SA space encroachment does decrease with age

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<td>42-43</td>
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<tr>
<td>III</td>
<td>Hooked</td>
<td>26-40</td>
<td>73</td>
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Bigliani, Orthop Trans, 1986

Recent Contradictions in the Literature

- Acromial slope (in all planes) is not useful in classifying patients with shoulder pain and should not be considered a source of pathological change - Moses, et al., J Magn Reson Imaging 2006
- 3D imaging could not adequately distinguish between normals, SIS, and RC tears and osseous acromial impingement is not a primary cause of RC disease - Chang, et al., Radiology 2006

Scapular Location

- Tipped 10° forward and 30° anterior to the frontal plane
- Medial border of scapulae essentially parallel to the vertebral

Scapular Motion

- 3 Rotations
- 2 Translations
Scapulothoracic Joint Motion

Three Axes of Rotation
- AP upward-downward rotation
- Vertical scapular winging (IR/ER)
- Frontal scapular tipping or tilting

Two Translations
- Elevation - Depression
- Protraction - Retraction

Scapular Contributions to Glenohumeral Elevation
- Upward Rotation
- Internal Rotation
- Posterior Tilt

SCAPULAR MOBILITY

RANGE of MOTION
- Up/Downward Rotation: 10-12 cm displacement of inferior angles or 60°
- Protraction/Retraction: 15 cm of movement
- Elevation/Depression: 12 cm of movement

Glenohumeral Joint Anatomy
- "golf ball" (humeral head) on a "tee" (glenoid fossa)
- Surface area of humeral head 3-4 times larger than fossa and faces medially, posteriorly, and superiorly

Glenohumeral Joint Anatomy
- Humeral head at 130-150° angle to shaft of humerus
- Humerus retroverted 20-30° with respect to flex-extension axis of elbow
glenoid fossa shape

- pear shaped and shallow
- broader inferiorly than superiorly
- 5° posterior and superior inclination

5° superior inclination to provide buttress to inferior subluxation

5-10° retroversion to provide buttress to anterior subluxation

5° superior inclination to provide buttress to inferior subluxation

5° superior inclination to provide buttress to inferior subluxation

Glenohumeral closed pack position

“testing position”
the point in the ROM where there is perfect fit, maximal articular contact, and concurrent ligamentous tension

90° Abduction and Ext Rotation

Glenohumeral resting position

“treatment position”
the point in the ROM where there is perfect fit, maximal articular contact, and concurrent ligamentous tension

Resting position allows for better lubrication, less frictional forces, and more freedom of movement for spin, glide, and roll

50-70° elevation in the scapular plane with mild ER

39° of abduction in the scapular plane or 45% of available abduction range

Hsu, et al, JOSPT, 2002

Glenohumeral Arthrokinematic Motion

Forward Elevation
- humeral head slides inferiorly, rolls posteriorly, and spins into IR
- slide and spin more pronounced than the roll

Abduction
- humeral head slides inferiorly, rolls superiorly, and spins into ER

External Rotation
- anterior slide and posterior roll of humeral head
- the rotator cuff dynamically steers the humeral head during elevation motions

joint geometry vs. ligamentous tension

Is arthrokinematic motion strictly determined by joint morphology? or Does ligamentous tensions influence arthrokinematics?
**Glenoid Labrum Anatomy**

- Fibrocartilage ring attached to the rim of the glenoid
- Primary site of insertion of ligaments - capsule
- Inner surface covered with synovium
- Outer surface continuous with capsule and periosteum of scapular neck

**Glenoid Labrum Anatomy**

- Increases depth of fossa to 5mm AP and 9mm superior to inferior from 2.5 mm without the labrum
- Glenoid contact with humeral head = 1/3 without labrum; 2/3 with labrum
- Chock block function

**Glenohumeral Capsule Anatomy**

- Attaches medially to the glenoid fossa beyond the labrum and circumferentially moves laterally attaching to the humeral neck up to 1/2” down the humeral shaft
- Twice the surface area of the humeral head; lax with inferior recess
- Very loose and redundant; will allow 2-3 cm of joint surface distraction

**Shoulder Shirt Sleeve Analogy**

- Sleeve Size Dictates
  - Shoulder Mobility
  - Restrictions in Range

**Coracohumeral Ligament**

- Moves downward and laterally from the base of the coracoid to insert onto the greater tuberosity
- Fills the space between the subscapularis and supraspinatus
- Functions to counteract the force of gravity and checks end range ER, flexion, and extension
Rotator Cuff Interval

- Combination of CHL and SGHL
  - Prevents inferior translation
    - Stretched in CVAs allowing inferior subluxation when RC inactive
  - Limits ER when arm in dependent position
  - Contracted with adhesive capsulitis

Glenohumeral Ligaments

- Three distinct, thickened portions of the capsule on the anterior aspect of the joint
  - Superior Glenohumeral Ligament
  - Middle Glenohumeral Ligament
  - Inferior Glenohumeral Ligament Complex

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<th>INSERTION</th>
<th>FUNCTION</th>
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<tr>
<td>Superior</td>
<td>12:00 glenoid</td>
<td>lesser tuberosity</td>
<td>Prevent inferior displacement</td>
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<tr>
<td>Middle</td>
<td>anterior glenoid</td>
<td>anterior aspect of anatomical neck</td>
<td>Limits ER up to 90° of Abduction</td>
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<tr>
<td>Inferior</td>
<td>ant-post-inferior glenoid</td>
<td>anterior aspect of anatomical neck</td>
<td>Prevents anterior subluxation in upper ranges of Abduction</td>
</tr>
</tbody>
</table>

Dependent Position

45° Abduction

90° Abduction
**Shoulder Stability Concepts**

**Static Mechanisms**
- Bony
- Ligamentous
- Joint Pressures/Volumes

**GHJ has very little inherent bony stability**
- Normal translation of humeral head on glenoid is 50% anterior and posterior
- Should not be more than 6 mm translation from center of rotation during shoulder motion

**Glenohumeral Joint Analogy**
- Concave on convex
- Convex on concave

**Circle concept of instability**
- Increased translation is possible with injury to one side of the joint
- Dislocation requires injury on both sides of the joint

**Static Shoulder Stability**
- Joint pressures and volumes
- Negative atmospheric pressure contributes to shoulder stability
- Adhesion/cohesion: joint surfaces stick together, allowing motion but not separation (ex: two slides that stick together with a drop of water)
- Limited joint volume contributes to shoulder stability
GHJ intra-articular joint pressure

- magnitude of the stabilizing pressure is normally 20-30 lbs
- tears in the capsule allow introduction of air or fluid and reduce the force necessary to translate the humeral head by approximately 50%

Theoretical contributions to shoulder stability

dynamic shoulder stability

- Rotator Cuff
  - Active contraction centers GH articulation and compresses joint surfaces
- Force Couples
  - Scapular and humeral
- Neuromuscular Control and Function
  - Increases dynamic ligament tension

Axillary Nerve

- Innervates deltoid and teres minor
- At risk with:
  - Rotator cuff surgery (terminal branches)
  - Anterior instability surgery (adjacent to subscapularis and anterior capsule)
  - Posterior instability surgery (emerging from quadrilateral space)
  - Anterior glenohumeral dislocations
  - Proximal humeral fractures

Muscular innervations

Functional screen for Axillary Nerve Innervation

Ability to put hand in front pocket
Long Thoracic Nerve
- Innervates serratus anterior
- At risk with:
  - Chronic compression or traction
  - Axillary incision approach
  - Neuritis (Parsonage-Turner Syndrome)

Evaluate for “plus sign”
- To differentiate dyskinesis from a palsy
  - Elevate to 90° in sagittal plane and observe winging
  - Protract from this position
    - If scapula protracts – dyskinetic
    - If scapula wings – palsy

Spinal Accessory Nerve
- Innervates the trapezius
  - At risk with
    - Direct blow
    - Surgical complication
    - Lymph node biopsies
    - Neuritis of unknown origin

Evaluate for “flip sign”
- Test for shoulder external rotation strength but monitor medial scapular border
  - If scapula lifts off the thorax (internally rotates) it indicates a spinal accessory nerve lesion where the middle and lower trap can not stabilize the scapula

Suprascapular Nerve
- Innervates supraspinatus and infraspinatus
- At risk with:
  - Spinoglenoid ligament ossification

Suprascapular Nerve
- Innervates supraspinatus and infraspinatus
- At risk with:
  - Spinoglenoid ligament ossification
  - Protracted scapula
  - Superior or posterior arthroscopic portals
**Shoulder Biomechanics**

1. Scapulohumeral Rhythm
2. Scapulothoracic Force Couples
3. Obligate Translation
4. Muscular Function

**SCAPULOHUMERAL RHYTHM**

1. distribute elevation motion between two joints permitting a larger ROM with less compromise of stability

2. maintain the glenoid fossa in optimal congruency with the humeral head and decrease shear forces

3. allow muscles that act on the glenohumeral joint to maintain a good length-tension relationship and minimize active insufficiency

**Scapular Movement with Elevation**

- Without scapular movement, the arm can abduct 90° actively and 120° passively
- The difference in ROM is that the deltoid becomes actively insufficient or to short to develop adequate tension without scapular rotation

**2:1 SCAPULOHUMERAL RHYTHM**

- Scapulothoracic joint contributes about 60° to elevation
- Glenohumeral joint contributes about 120° to elevation
  - 120° with flexion
  - 90-120° with abduction
Scapulothoracic Joint Motion Formula

30° of sternoclavicular motion

+ 30° of acromioclavicular motion

= 60° of scapulothoracic motion

**SCAPULOHUMERAL RHYTHM**

**Scapulothoracic Joint Force Couple**

two forces acting in opposite directions to rotate a part about its axis of motion

**Scapulothoracic Joint Force Couple**

two forces acting in opposite directions to rotate the upwardly rotate the scapula about its AP axis

**Upper Trapezius – Lower Serratus**

**Lower Trapezius – Upper Serratus**
Scapulohumeral Force Couple

- The lower trapezius is more active in abduction above 90° while the lower digitations of the serratus anterior is more active in forward flexion.
- Once the axis of rotation reaches the AC joint, the lower trap and lower serratus anterior can become much more effective in scapular upward rotation.
- 30-90° powered by upper trap-serratus
- 90-150° powered by lower trap-serratus

So Why is Scapular Function Important?

Literature Supported Evidence
Normal and Pathological Kinematics to Arm Elevation

<table>
<thead>
<tr>
<th>GROUP</th>
<th>HEALTHY</th>
<th>RC DISEASE</th>
<th>GHJ INSTABILITY</th>
<th>ADHS CAPSULES</th>
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<tr>
<td>Primary Scapular Motion</td>
<td>Upward Rotation</td>
<td>↑ UR</td>
<td>↑ UR</td>
<td>↑ UR</td>
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<td>Secondary Scapular Motion</td>
<td>Posterior Tilting</td>
<td>↓ Post Tilt</td>
<td>Inconsistent evidence</td>
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<td>Accessory Scapular Motion</td>
<td>Varius Int/Ext Rotation</td>
<td>↑ IR</td>
<td>↑ IR</td>
<td>Inconsistent evidence</td>
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<td>Implications</td>
<td>Maximizes motion; minimizes pain</td>
<td>Contribute to impingement</td>
<td>Contribute to instability</td>
<td>Compensation to allow elevation</td>
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</table>

Implications: Maximizes motion; minimizes pain
Contribute to impingement

Does the humeral head depress?

only when it shouldn’t …
the cuff minimizes superior translation during active elevation
Glenohumeral Elevation Force Couple

- **Elevators - Compressors:**
  - Deltoid
  - Pectoralis
  - Supraspinatus
  - LH of Biceps

- **Depressors: (Elevation Resisters)**
  - Subscapularis
  - Infraspinatus
  - Teres Minor

- Resist superior humeral head translation and compress the humeral head into the glenoid fossa

Rotator Cuff Cross Sectional Volume

- Subscapularis 53%
- Supraspinatus 14%
- Infraspinatus 22%
- Teres Minor 10%

Keating, JBJS, 75B: 1993

Rotator Cuff Elevation Force Couple

- Rotator cuff is active throughout elevation ROM and functions to resist excessive humeral head elevation and decrease subacromial impingement
- RC mm action decreases at higher ranges of elevation as there is less need for depression of the humeral head
- At higher ranges of elevation, gravity and the adductors provide humeral head depression

EMG Action Potential of Rotator Cuff through Elevation Range

- Increasing Action Potential

Rotator Cuff Vectors

- Supraspinatus: dominant vector is compression 63% of total force
- Infraspinatus: dominant vector is superior 89% of total force
- Subscapularis: mean vector of IST is angled 50° inferior to the face of the glenoid 80% of total force
- Deltoid: dominant vector is superior
deltoid muscle

- 40% of the x-sectional mass
  - cross section of 18.2 cm²
- Changing vector action
  - line of pull at rest produces superior shear and 45% of compressive force
  - at 90° - line of pull produces compression

CHALLENGING TRADITIONAL THOUGHT

Convex-Concave Morphology vs. Capsular Obligate Translation

PREMISE

- the relationship of the humeral head to the glenoid fossa should remain relatively constant throughout the ROM
- after an initial superior glide during elevation, the humeral head should essentially spin on the glenoid fossa

CHALLENGING TRADITIONAL THOUGHT

Convex-Concave Morphology vs. Capsular Obligate Translation

EVIDENCE

- Howell, JBJS, 1988 radiographically demonstrated that the humeral head translated 4 mm posteriorly when the arm was position at 90° of abduction, full ER, and maximum horizontal abduction in normal shoulders
- Howell, JBJS, 1988 conversely found that in subjects with anterior instability, the humeral head translated anteriorly when in the same position of 90° abduction, full ER, and maximum horizontal abduction

EVIDENCE

Harryman, JBJS, 1990 analyzed the biomechanics of the GHJ on cadaveric specimens and noted a posterior translation of the humeral head with ER and an anterior translation with IR with the arm at the side

This phenomena increased significantly when the posterior capsule was tightened

Convex-Concave Morphology vs. Capsular Obligate Translation

clinical examples

ADHESIVE CAPSULITIS

obligate translation

tight anterior capsular structures causing obligate posterior translation and possible posterior pain with end range mobilization
Tight posteroinferior capsule causing early and excessive anterosuperior translation and closing the subacromial space

**SUBACROMIAL IMPINGEMENT**

**Convex-Concave Morphology vs. Capsular Obligate Translation**

**INTERPRETATION**
- Translation direction is dictated by the capsuloligamentous complex. During arm movements, the passive restraints act not only to restrict movement but also to reverse humeral head movements at the end range of motion.
  - Humeral head moves in the direction of least resistance.
- When this phenomena is lost - abnormal translation is present.
- Asymmetrical capsular tightness will cause obligate translation away from the side of tightness.

**Typical Arthrokinematics**

| Early ER | Anterior glide with Posterior rotation |
| ER approaching end range | Asymmetrical tension builds – taut anteriorly; lax posteriorly |
| End range ER | Head re-centers by gliding posteriorly |

Questioning the concept of Kaltenborn’s convex-concave rule

Systematic review of the literature indicates that not only passive, but active control subsystems should be considered when determining appropriate direction of humeral head translation.

**Muscular Function of the Shoulder**

- Deltid
- Subscapularis
- Infraspinatus
Muscular Function of the Shoulder

Axioscapular
Anchor
Stabilize & Rotate

Scapulohumeral
Center
Steer and Compress

Axiohumeral
Position
Move

Axioscapular Mms - serratus, traps, rhomboids, levator, pec minor
Serratus, traps, rhomboids, levator, pec minor

Scapulohumeral Mms - SITS rotator cuff muscles, deltoid
SITS rotator cuff muscles, deltoid

Axiohumeral Mms - pecs, lats, teres major
Pecs, lats, teres major

EMG Analysis of Glenohumeral Muscles

Flexion
supraspinatus, anterior deltoid

Scaption
subscapularis, supraspinatus, ant/middle deltoid

Horz Abd - ER
infraspinatus, teres minor, post/middle deltoid

Push Up
latissimus, pec major

EMG Analysis of Scapulohumeral Muscles

Flexion
upper serratus, lower trap

Scaption
lower serratus, lower trap

Rowing
upper/lower trap, levator scapulae, rhomboids

Horz Abd
middle trap, levator scapulae, rhomboids

Push Up +
lower serratus

Shrug
levator scapulae, upper trap

Another Systematic Review of Periscapular EMG Activity

1. Prone Extension
2. Overhead Arm Raise (Superman)
3. Inferior Glide
4. Lawnmower
5. Isometric Low Row
6. Wall Slide

“Therapeutic Ten”

• Standing Flexion
• Standing Scaption
• Standing Shrugs
• Standing Short Arc Military Press
• Prone Row
• Prone Horz Abduction
• Int. Rot. or Mod. D2 Ext Diagonal
• External Rotation
• Dips
• Push-Up +

Elite Elastic Eight

1. Seated Short Arc Military Press
2. Seated Narrow Row (IR)
3. Seated Mid-Wide Grip Row
4. Standing Boxer Punch
5. Standing Dynamic Hug
6. Standing Shrug-Retraction
7. Standing ER Retraction
8. 0-90° Scapular Plane ER
What's so great about scapular plane elevation?

- Better clearance
- No humeral rotation required
- Symmetrical anterior/posterior capsular tension
- Length/tension relationships optimized
- Path of least resistance

Shoulder Pathoanatomy

relationship between various shoulder pathologies

Glenohumeral Instability

Methods of Classification

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<th>Frequency</th>
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<th>Etiology</th>
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<td>- Fixed</td>
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<tr>
<td>- Bi/Tridirectional</td>
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TUBS vs. AMBRI

Most Patients

- Traumatic (acute dislocation)
- Unilateral anterior or posterior
- Bankart lesion
- Surgery (or sling)

AMBRI

- Atraumatic or recurrent
- Multidirectional
- Bilateral
- Rehabilitation
- Inferior capsular shift

these two acronyms represent each end of the instability spectrum there are overlapping gradations of instabilities between these extremes

“Torn - worn - born loose”

Bankart Lesion

- Periosteum and capsule of IGHL and anterior labrum complex detach from scapular neck and adhere to the overlying subscapularis tendon
- Anterior capsular avulsion of IGHL between the 3:00 and 5:00 positions
cadaveric transverse section just inferior to the humeral head equator

Normal Anatomy  Bankart Lesion

Essential Lesion
- no detachment, but stretching of inferior glenohumeral ligament leaving
- an attenuated, baggy capsule with a stretched or traumatized subscapularis tendon

Hill Sachs Lesion
- compression fracture of posterior humeral head as it slips over the sharp edge of the anterior lip of the glenoid fossa

Clinical Features of Anterior Dislocation
- Abnormal shoulder contour
  - prominent lateral acromion
  - “flat” deltoid
  - “fullness” anteriorly and inferriorly
- Arm “locked in place” – slightly abducted and ER and unable to internally rotate
- Decreased sensibility
  - axillary nerve damage -15%

Recurrence Contributing Factor
- The changing ratio of Type I to Type III collagen synthesis
- Type III collagen is much more elastic and synthesized in much greater proportion when younger.

Recurrence Contributing Factor
- The changing collagen ratio is so reliable it can be used to determine the chronological age of an individual
- The higher proportion of Type I collagen in older adults explains their propensity for motion loss following trauma and their decreased dislocation recurrence rate
Posterior GHJ Instability

- **Mechanism of Injury**
  - Direct anterior blow
  - Fall on outstretched hand

- **Clinical Features**
  - Abnormal shoulder contour
  - Loss of ER & abduction
  - Excessive posterior glide in load & shift
  - Lesser tuberosity fracture

- **Pathology**
  - Stretched posterior capsule
  - Detached posterior glenoid and capsule
  - Reverse Hill-Sach’s lesion
  - Stretched or avulsed subscapularis tendon

Multi-Directional Laxity

- **Mechanism of Injury**
  - Atraumatic
  - Gradual, insidious
  - “Born loose”

- **Pattern of Instability**
  - A-P-I subluxation
  - Anterior or posterior may predominate, but always has an inferior component

- **Clinical Findings**
  - Overuse history with significant episode of trauma
  - Minimal pain complaint
  - Can usually demonstrate instability
  - + sulcus test & general ligamentous laxity
  - Usually > 30 years old

- **Pathology**
  - Inferior capsular redundancy

Impingement Syndrome

“Very little room for error”

9-10 mm clearance with arm at side

6-7 mm clearance with arm in flex/IR

Subacromial Impingement Syndrome

Pathological changes underneath the coracoacromial arch

Compression of suprhumeral structures against the antero-inferior aspect of the acromion and coracoacromial ligament

Neer, 1972
Combination of intrinsic and extrinsic factors

Intrinsic tension overload and intratendinous degeneration as a result of limited vascularity and external compression

Mehta, 2003

Systematic Review challenges many of Neer’s original conclusions

1. Evidence suggests that coracoacromial arch contact is not in the area that most commonly causes rotator cuff tears
2. Evidence suggests coracoacromial arch contact is normal in cadaveric and asymptomatic subjects
3. Evidence suggests that spurs on the anterior aspect of the acromion are normal traction enthesophytes and normally do not encroach on the underlying rotator cuff
4. Successful treatment of SAS does not require surgical alteration of the acromion and/or coracoacromial arch as evidence by the effective management with physical therapy and injections


Anterior Compressive Impingement

- direct compression of tissue
- “weekend warrior” usually over 30
- usually secondary to hypomobility

Type I

Posterior Compressive “Internal” Impingement

- Supra and infraspinatus rub on the posterolateral glenoid and labrum
- Acquired anterior instability resulting in secondary impingement
- young overhead athlete usually < 30
- usually secondary to hypermobility
- labrum and undersurface of rotator cuff

Type II

Stages of Compressive Impingement

SLAP Lesions

Superior Labrum Anterior-Posterior
- detachment lesion of the superior aspect of the glenoid margin at the insertion of the LH of the biceps
- Increases strain on IGHL by 100-120%
- MOI
  - throwing athletes
  - falls; direct blows; unexpected traction loads on the biceps
SLAP Lesion Classifications

Type I degenerative or shredded labrum; normal bicep tendon anchor
Type II superior separation; best tested for by relocation test
- under 40 associated with Bankart lesion
- over 40 associated with supraspinatus tear or osteoarthritis
Type III labrum separated for biceps; bucket handle type tear
Type IV both labrum and biceps separated from glenoid rim

SLAP Surgical Indications

- Type I
  - debridement if symptomatic
- Type II
  - debridement and fixation repair
  - sutures or suretac anchor
- Type III - rare
  - debridement or excision
- Type IV - rare
  - repair and/or bicep tenodesis

Only 5-20% of total SLAP lesions are Type III or IV and usually occur with a dislocation

RC Pathology

How Common are Rotator Cuff Tears?

- Average Age
  - 49: no cuff tear
  - 59: unilateral cuff tear
  - 68: bilateral cuff tear

Yamaguchi, JBJS, 2006

Prevalence of RC pathology correlates with increasing age in patients with shoulder complaint

RC Tears in Asymptomatic Patients

<table>
<thead>
<tr>
<th>Age</th>
<th>Full Thickness</th>
<th>Partial Thickness</th>
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<tbody>
<tr>
<td>Overall</td>
<td>14%</td>
<td>20%</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>28%</td>
<td>26%</td>
</tr>
<tr>
<td>40-59</td>
<td>4%</td>
<td>24%</td>
</tr>
<tr>
<td>&lt; 40</td>
<td>0%</td>
<td>4%</td>
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- 50% of asymptomatic tears become symptomatic
- Tear size increases in 50% of symptomatic and 22% of asymptomatic
- The risk for RC tears doubles if you have a sibling that has experienced a full-thickness tear (as compared to a spouse) indicating a genetic predisposition

Post-Operative Considerations

How large was the tear?

Linear Size of the Defect
- small: < 1 cm
- Medium: 1-3 cm
- large: 3-5 cm
- massive: > 5 cm

number of tendons involved or diameter cm of involvement

consideration give to the size of the individual

Thickness of the Tear
- full vs. partial thickness
  - bursal surface partial thickness
  - articular surface partial thickness
  - PASTA – partial articular supraspinatus tendon avulsion
  - intratendinous

What was the nature of the tear?

Shape of the Tear
- transverse vs. linear (longitudinal)
- Crescent – do not retract
- U-shape – retract medially
- L-shape

Surgical Approach and Technique
- Arthroscopic SA Decompression without Tendon Repair
- Open Anterior Acromioplasty and Tendon Repair
- Arthroscopic SA Decompression with Mini-Open Tendon Repair
- Arthroscopic SA Decompression and Tendon Repair

Gold Standards

How was the tear fixed?

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Surgery Specifics?

Additional Procedures
- Bursectomy
- Acromioplasty but maintain coracoacromial ligament
- Raise the roof
- Mumford
- distal clavicle resection
- MUA
- Osteoarthritic Change

Method of Fixation
- single vs. double row
- suture anchors
- transosseous tunnels
- stitching technique

Incision Size
- Mini Open 3-4 cm
- Arthroscopic 1 cm

PRP Augmentation
- Numerous studies have failed to show outcome benefit
**Post-Operative Considerations**

**Surgery Specifics?**
- Orthobiological implant providing a scaffold to reinforce soft tissue repair
- May augment repairs at higher risk of failure

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**Definition**
(consensus of literature review)
A progressive condition of uncertain etiology in which there is a spontaneous onset of pain and a gradual loss of active and passive shoulder motion

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**Adhesive Capsulitis**
A common pathology that is difficult to define, difficult to treat, and difficult to explain

Prevalence of 2–5% in a normal population

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**adhesive capsulitis pathology**
- irritation of glenohumeral synovium with chronic capsular inflammation
- capsular fibrosis and perivascular infiltration of adhesions into the lax folds of the anterior and inferior capsule

**Bottom line:** AC is an aggressive inflammatory process

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**adhesive capsulitis pathology**
- obliteration of joint cavity (20-30 ml decreased to 5-10 ml)
- contracted rotator cuff interval and CHL
- thickened contracted capsule holding the HH tightly on the glenoid fossa
- rotator cuff contracture
Capsular “Shrink Wrap”

Adhesive Capsulitis
"Frozen Shoulder"

Thank you
The Elbow: Anatomy, Biomechanics and Pathology

Beth K. Deschenes, PT, MS, OCS

The Elbow Complex

- Mobility of the hand
- Links wrist and shoulder to enhance function
- Allows palm to face up or down without moving the shoulder
- 15 muscles cross the elbow to act on wrist or shoulder

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Modified Hinge Joint

- Articulation between humerus, radius and ulna
- The joints are the humeroradial joint, humeroulnar joint and the proximal radial ulnar joint
- The motion that occurs is flexion and extension with some rotation

Carrying Angle

- Normal valgus angulation between the long axes of humerus and forearm
- The valgus angulation decreases in pronation and flexion
- Normal is about 18 degrees
- Excessive is greater than 30 degrees

Joint Capsule

- Contains all 3 joints
- Thin capsule
- Reinforced anteriorly by fibrous bands of tissue

Medial Collateral Ligament

- MCL ligaments: ulnar side
  - anterior: valgus stability throughout entire ROM are the strongest
  - posterior: valgus stability during extreme flexion
  - transverse: do not offer much stability

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  - transverse: do not offer much stability
Lateral Collateral Ligament

- LCL ligaments; located on radial side and is more variable than the MCL
  - Act to stabilize ulna during sagittal plane motion
  - Radial collateral: blends with annular ligament to resist varus
  - Lateral collateral: resists varus and flexion

Structure of the Joints

- Humeroulna, humeroradial and proximal radioulnar
- Many mechanoreceptors at joint which detect proprioception and passive tension limits
- Position of comfort is 80 degrees of flexion

ROM: Flexion and Extension

- Extension to flexion ROM is 5-0-150 degrees; active 135-145; passive 150-160
- ADLS need ROM between 30-130 degrees
- Co-contraction of muscles surrounding the joint increase stability

ROM: Flexion

- Flexion limited by:
  - Bulk of flexor muscles
  - Position of forearm; increase flexion in supination
  - Position of shoulder
  - Approximation of coronoid and radius with fossa

ROM: Extension

- Extension limited by passive insufficiency of long head of biceps with shoulder hyperextension
- Close packed position: extension
- Extension end feel is bony approximation

Structure of the Humeroradial Joint

- Concave radial head articulates with convex capitulum
- Rim of radial head articulates with capitulo-trochlear groove
- Full extension there is no contact between the capitulum and radial head
- During active flexion radial head pulled against the capitulum
**ROM: Humeroradial Joint**
- during flexion/extension
- roll and slide of radial head across capitulum
- Roll and slide in same direction

**Structure of the Humeroulnar Joint**
- concave trochlear notch and ridge of ulna articulate with convex trochlear groove of humerus
- need extensibility in surrounding structures for full extension
- motion limited to sagittal plane due to bone structure

**ROM: Humeroulnar Joint**
- During extension the olecranon process enters the olecranon fossa
  - stabilized by anterior capsule, brachialis anterior MCL

**ROM: Humeroulnar Joint**
- During flexion the coronoid process enters the coronoid fossa
  - requires elongation of extensor muscles, posterior capsule, ulnar nerve and posterior MCL

**Interosseus Membrane**
- fibers are oblique and medial
- oblique cord that from ulna to radius
- functions to transmit compressive and muscle force from radius to ulna
- distal applied forces distract the radius and brachioradialis contracts to holds radius in place

**Transmissions of Forces via IM**
Distractive Forces

Stability of the Humeroulnar and Humoradial Joints
- Valgus stress in full extension limited by MCL, bone, anterior portion of the joint capsule. Excessive valgus stress such as pitching a baseball can injure these structures.
- Varus stress in full extension limited by 50% by bone and 50% by LCL, joint capsule.

Radioulnar Joint
- Synovial pivot joint allows supination and pronation.
- Decreased ROM at these joints can lead to increases in IR and ER at the shoulder for compensation.
- Joints are linked by the interosseus membrane.

Proximal Radioulnar Joint
- Concave ulnar radial notch lined with articular cartilage.
- Annular ligament encircles the rim of the radius holding the head of the radius in its articulation with capitulum.
- Annular ligament is lined with continuous articular cartilage.

Distal Radioulnar Joint
- Concave ulnar notch of radius articulates with convex head of ulna.
**Distal Radioulnar Joint**

- Triangular articular disc attaches to inferior edge of notch
- "Triangular fibrocartilage"
  - Proximally articulates with ulnar head
  - Distally attaches to radiocarpal joint
  - Supported by dorsal/posterior/palmar (anterior) radioulnar ligaments

- Ulnocarpal complex: distal end of ulna and the ulnar side of the carpal bones; disruption can cause a dislocation or instability
- Joint is stabilized by ulnocarpal complex, pronator quadratus, joint capsule, ECU

**ROM: Proximal and Distal Joints**

- Pronation: 75 degrees
- Supination: 85 degrees
- Functionally need 50 degrees in each direction for ADLs
- Motion occurs at both joints; if restricted in one joint will affect overall ROM

**Arthrokinematics: Proximal Joint**

- Supination
- Radial head spins in the fibro-osseous ring

**Arthrokinematics: Distal Joint**

- Supination:
  - Roll and slide occurs in the same direction
  - Articular disc remains in contact with ulna head
  - End range palmar capsular ligament is stretched

**ROM: Both Joints**

- Supination ulna and radius are parallel
- Pronation the radius crosses over the ulna
Arthrokinematics: Pronation

- Pronation radius crosses ulna
- Pronation: radius and hand rotate around fixed humerus and ulna

Proximal Joint Pronation

- Radial head spins in the annular ligament
- Opposite kinematics occur for both motions in WB

WB Arthrokinematics

- Pronation is accompanied by ER of the shoulder
- Supination is accompanied by IR of the shoulder

Functional Activities

- Many activities require both elbow and radioulnar motion
  - Radioulnar joint is designed to enhance the use of the hand
  - Hand and wrist muscles increase stability of elbow
  - Head and neck position can effect torque production;

Functional Activities

- Shoulder function can affect elbow symptoms
- Limitation in shoulder IR may cause excessive pronation during throwing activity or loss of shoulder ER may increase supination
- Immobilization of shoulder patient often limits elbow ROM
- Always look above and below the joint for dysfunction
Fall on Outstretched Hand
- Fall on outstretched can affect the MCL or cause a dislocation

Nursemaid's Elbow
- Caused by a distraction force; radius slips out of annular ligament

Lateral Epicondylitis
- Tendinosis involving ECRB, but can include ED, ECRL, ECU
- Insidious onset usually due to overload or overuse
- Point tenderness at lateral epicondyle
- Pain with gripping activities and resisted wrist extension with elbow extension
Radial Tunnel syndrome
- Entrapment of posterior interosseus branch of radial nerve between the radial head and supinator
- Need to rule out lateral epicondylitis

Cubital Tunnel Syndrome
- Ulnar nerve entrapment between the olecranon and medial condyle
- Pain and paraesthesia on ulnar side of forearm
- Need to rule out TOS and cervical

Rheumatoid Arthritis
- There may be a loss of ability of structures to absorb forces results in stabilizing compressive forces may cause joint destruction.
- This could lead to AVN of the radial head

References
- Google Images.
Anatomy, Biomechanics and Pathology of the Wrist and Hand

Beth K. Deschenes, PT, MS, OCS

Function
- Depends on: on shoulder for stability; on elbow to move to/from body; forearm to adjust position
- Loss of function of at wrist cannot adjust with shoulder and elbow
- Wrist functions to maintain optimal length/tension relationship and adjust grip
- Position of wrist alters the function of the hand

THE WRIST

Osteology

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Carpal Tunnel
- Palmar side is concave "tunnel" roofed by the transverse carpal ligament
- Contains tendons of extrinsic flexors (except FCR) and median nerve
- Site of attachment for Palmaris Longus

Wrist Complex
- Composed of radiocarpal, midcarpal and intercarpal joints
- Two joints working together allow increased ROM with less exposed articular surface; less structural pinch at end range
- Flexion = 65-85; extension=55-70; radial deviation = 0-15; ulnar deviation = 0-30 (due to ulnar tilt of radius)
- ADLs require 45 degrees of sagittal motion

Radiocarpal Joint
- Proximal: radius, triangular fibrocartilage complex TFCC (accepts 20% of compressive force)
- Distal: scaphoid, lunate, triquetrum (during full ulnar deviation)
- Contact greatest at radiocarpal joint during wrist extension and ulnar deviation
- Articulation: lateral radial facet with scaphoid; medial radial facet with lunate

Radiocarpal Joint
- TFCC: radioulnar disc, triangular shaped fibrocartilage and fibrous attachments; that is compressible adding to wrist ROM
- Acts as part of the distal radius

Midcarpal Joint
- Proximal row: scaphoid, lunate, triquetrum
- Distal row: trapezium, trapezoid, capitate, hamate; moves as fixed unit with MC also function as foundation of transverse and longitudinal arches of hand

Midcarpal Joint
- No single joint capsule; intercarpal articulations and capsules
- Motion occurs predominately in the medial compartment (capitate, hamate, scaphoid, lunate and triquetrum)
Ligaments of the Wrist

- **Extrinsic**: connect carpals to radius or ulna
  - Anterior: Palmar radiocarpal ligament: separate from the joint capsule (radiocapitate, radiolunate, radioschapholunate) stronger and thicker than dorsal with tension all positions; maximally taut at full wrist extension
  - Lateral: Radial collateral: radius to scaphoid, trapezium and transverse carpal ligament; taut with extension and UD; more developed palmar laterally
    - Additional lateral support of joint is supplied by AB pollicis longus and extensor pollicis brevis
  - Medial: Ulnar collateral ligament: ulna to triquetrum; limits RD
  - Posterior: Dorsal radiocarpal ligament: radius to dorsal scaphoid and lunate, taut in full flexion
  - Ulnocarpal complex: triangular fibrocartilage ulnar collateral ligament and palmar ulnocarpal ligament
  - Palmar Ulnocarpal ligament: disc to lunate and triquetrum; taut in wrist extension and UD

- **Intrinsic**: short, intermediate or long
  - Short ligaments: stabilize and unite bones and allow them to work as a functional unit
  - Intermediate and long ligaments: add stability and connect carpals
    - Intermediate: lunotriquetral, scapholunate, scaphotrapezial
    - Long: Palmar and dorsal intercarpal

Motions of the Wrist Complex
Motion of the Wrist Complex

- Two degrees of freedom: flexion/extension and ulnar/radial deviation
- Axis of motion is capitate; motion occurs at radiocarpal and midcarpal simultaneously

Central Column

- Central column of wrist: radius, lunate, capitate and 3rd MC
- Reciprocally convex/concave orientation with synchronous motion

Central Column

- Central column: radius, lunate, capitate and 3rd MC
- Reciprocally convex/concave orientation with synchronous motion

ROM: Extension and Flexion

- Radiocarpal joint: Lunate rolls dorsally on radius and slides palmarly
- Midcarpal joint: Capitate rolls dorsally on lunate and palmarly
- Both joints are convex moving concave
- Allows about 60 degrees of wrist extension
- Elongation of palmar radiocarpal, palmar capsule and wrist and finger flexor muscles
- Closed packed position and most stabilize to allow WB activities

ROM: Wrist Extension

- Flexion reverse of extension
- Position not as stable and not designed for WB activities

ROM: Wrist Flexion
Scaphoid Stability

- Scaphoid during flexion and extension moves with action limited by scapholunate ligament
- Any damage to this ligament affects stability of the wrist

ROM: Ulnar and Radial Deviation

- Radiocarpal: scaphoid, lunate and triquetrum roll ulnarily and slide radially
- Midcarpal: capitate rolls ulnarily and slides radially
- Full ROM triquetrum contacts the disc
- Wrist is stabilized by the compression of the hamate against the triquetrum
- Increased tension in lateral palmar intercarpal ligament and palmar ulnocarpal ligament controls the motion
- Equal motion at both joints

ROM: Ulnar Deviation

- Same arthrokinematics as ulnar deviation
- Hamate and triquetrum separate
- Increased tension in medial palmar intercarpal ligament and palmar radiocarpal ligament
- Most motion occurs at midcarpal joint as radius is a bony limit

Funtional ROM at Wrist

- Functional: 10-15 degrees of extension and 10 degrees of UD
- Wrist ext and UD most important allows max grip
Muscles of the Wrist

Six tunnels that house extensor tendons

Gripping activities

During gripping activities, hold wrist in 35 degrees of extension and 5 degrees of ulnar deviation to optimize the length tension relationship of finger flexors (allows up 3x amount of grip strength)

Pathologies of the Wrist

- Fractures
- Instability
- Tenosynovitis
- Nerve involvement

Colles Fracture

- Most common fracture age > 40
- Transverse fracture of distal radius
- Proximal fragment is volarly and laterally displaced

Scaphoid Fracture

- Fall on outstretched hand
- Pain in anatomical snuffbox
- May need surgery due to poor blood supply
Carpal Instability

- Mechanical stability that will fail like a train derailment if there is compression from both ends; rotational collapse
- Lunate is the most frequently dislocated carpal bone (maybe due to fall on outstretched hand and disruption of ligaments)

Carpal Instability

- Collapse can occur volarly or palmarly
- Will affect the muscles that cross the wrist due to alteration on the length tension relationship

Carpal Instability: Lunate Dislocation

Ulnar drift due to RA

- Due to the ulnar tilt a pathological process such as RA that weakens ligaments will allow the carpal bones to drift ulnarly

DeQuervain’s Tenosynovitis

- Affects the 1st dorsal compartment as EPB and APL cross the radial styloid
- Pain radiates to thumb when thumb is flexed and RD

Carpal Tunnel

- Formed by carpal arch and flexor retinaculum as a pathway provides protection for long finger flexors and median nerve
Carpal Tunnel Syndrome

- Prolonged or extreme wrist positions can irritate these tendons cause swelling and put pressure on the median nerve.
- Parathesias over the sensory distribution of the median nerve can be the hallmark.
- In progressive cases muscle weakness and atrophy can occur over thenar eminence.
- Can also occur in pregnancy, RA, DM and obesity

The Hand

Function of the Hand

- Hand Complex Functions to maintain grasp and manipulate objects
- Primary source of sensation
- Joints: CMC, MCP, PIP, DIP of digits and thumb (ray complex)

Creases of the hand

- Increase palmar friction to increase grasp
- Proximal palmar: joint line of MCPs
- Middle digital: at PIP
- Distal digital: at DIP

Three Arches of the Hand
Arches of the hand

- **Proximal transverse arch**: formed by trapezoid, trapezium, capitate, and hamate; aids in maintaining concavity and rigidity.
  - Capitate is keystone
- **Distal transverse arch**: increases concavity of palm through the MCP joints.
  - Allows increased surface contact
  - Increases manipulation of objects
  - Flattens with extension
  - Hollows with flexion

Arches

- **Longitudinal arch**: from 2nd and 3rd ray very rigid
- Arches are mechanically linked together; if disease alters the arches the hand will flatten and not be able to grasp and manipulate objects

Osteology of the Hand

- **Carpometacarpal Joint**:
  - Increases concavity of the palm
  - Second MC articulates with trapezoid and trapezium and capitate secondarily; 3rd with capitate and hamate; 5th with hamate
  - Joint capsule and ligaments:
    - Dorsal
    - Palmar
    - Interosseous

Osteology: CMC
Palmar Ligaments of the CMC Joint

Dorsal Ligaments of the CMC Joint

Central Pillar
- Digits 2-3 along with the trapezoid and capitate form central pillar to increase stability and are considered complex saddle joints
- The thumb and 4th and 5th digits of CMC fold around the central pillar

CMC Joint Movement
- 4th and 5th CMC joints are designed to allow the ulnar border move to the center of the palm
  - cupping motion when making a fist
  - accomplished by forward flexion and rotation of the ulnar MC toward the middle digit

CMC motion
- 4th and 5th digits move toward the palm to make a tight fist

1st CMC Joint
- Saddle Joint
- Both surfaces are reciprocally convex and concave
1st CMC Joint
- Allows the thumb to touch all fingers to increase the grasp
- Design allows flexion in plane intersecting the digits to increase grasp
- Loose joint capsule with ligaments and muscles increasing stability

ROM at 1st CMC Joint
- Two degrees of freedom
- Flexion/Extension
- Abduction/Adduction

ROM: Flexion and Extension
- During flexion the metacarpal internally rotates
- During extension it externally rotates
- The thumb flexes across the palm about 45 degrees

ROM: Abduction
- Full abduction stretches the web space

ROM: Opposition
- MC abducts then flexes and IR toward the 5th digit
- Full opposition is closed packed position with the ligaments taut
- Reposition requires the opposite

Metacarpal Phalange Joint
- Convex MC head and concave phalanx; synovial condyloid joint allowing flex/ext and AB/AD
- Keystone for the mobile arches of the hand; stability here is crucial
MCP Joint

Palmar (volar) plate: fibrocartilage structure attached to proximal phalanx which increases joint congruency and stability
- Purpose is to restrict hyperextension, prevent pinching of flexor tendons and strengthen MCP joint
- Blends with capsule and attaches to MC head and blends with deep transverse metacarpal ligaments that stabilize the 4 MC

Collateral ligaments:
- Slack in extension
  - Increase stability through the ROM; limit AB/AD in flexion
  - Stabilize the volar plate
- Fibrous digital sheaths act as pulleys for flexor tendon

ROM at MCP Joint
- Close packed position is 70 degrees of flexion
  - AB/AD max in extension; limited in flexion
  - Joint play helps fingers conform to different shapes
ROM: Extension at MCP Joint
- Active extension coordinated activity of ED and intrinsics
- Hyperextension varies with individuals; passively about 30-45 degrees

ROM: Flexion at MCP
- Flexion increases from digit 2 to 5 (90 to 110)
- Flexion stretches and increases the passive tension in dorsal capsule and collateral ligaments.
- This helps guide arthokinematics

ROM: Abduction at MCP Joint
- Greater range in extension of MCP than in flexion

ROM: 1st MCP
- MCP of the thumb allows flexion/extension
- About 60 degrees of flexion
- AB/AD occur as accessory motions due to limitations by collateral ligaments; this motion occurs across the CMC joint

Structure of the IP joints
- Synovial joint allowing flex/ext
  - 2 collateral ligaments
  - Some portion remains taut to provide support throughout DIP and PIP motion; limit AB/AD
  - Palmar plate
  - Joint capsule
  - Check rein ligaments

IP Joints
- Increasing motion as move ulnarly
- Closed packed position in full extension
- Immobilize in extension to decrease risk of flexion contracture
ROM IP Joints

- PIP: flexion 100-120 to 135 at 5th; minimal hyperextension
- DIP: flexion 70 to 90 at the 5th; passive hyperextension

Important!!!

- Increase in flexion and extension ulnarly facilitates opposition and increase gripping

Extrinsic Flexors

- FDS: flexes the PIP; each tendon is controlled independently
- FDP: most active DIP assist with PIP; the tendon to the index finger can act independently
- Camper’s chiasm: FDP emerges thru split in FDS tendon so FDS can attach to base of mid phalanx

Extrinsic Flexors

- Thumb PIP allows 70 degrees of flexion; increase passive hyperextension with aging due to stretching of palmar structures
Extrinsic Flexors

- Optimal function depends on wrist position and improves with gliding mechanism
  - Retinaculum and ligaments prevent bowstringing tendons
  - Synovial sheaths (radial, ulnar) decrease friction and protect the tendons
    - ulnar encases FDS & FDP
    - radial encloses FPL

Flexor Sheaths

- Flexor pulleys (fibrous osseous tunnels) at MCP proximal and mid phalanx aid in lubrication and nutrition
- Any thickening of flexor tendons due to overuse or scarring from trauma decreases gliding mechanism and decreases flex/ext
- Rehab is focused on maintaining the gliding mechanism

Flexor Pulleys

Extrinsic Extensors

- Pass under extensor retinaculum in individual tendon sheaths to improve excursion efficiency
- Different than flexor tendons: no common synovial sheath, lack a defined digital sheath and no annular pulley
Extensor Mechanism

- Distal attachment for ED and intrinsic finger muscles
- ED at the proximal phalanx flattens into a central band and then attaches to the middle phalanx
- Lateral bands rejoin as terminal tendon to distal phalanx. This allows extensor force to be transferred throughout the whole finger

Extensor Mechanism

- The extensor mechanism attaches to the palmar surface of the finger via the dorsal hood and the transverse fibers
  - Transverse fibers: attach to the palmar plate and form a sling
  - Pull proximal phalanx into extension

Extensor Mechanism

- Oblique fibers fuse with lateral and central bands and the lumbricales and interossei attach to them
  - Due to this connection the intrinsic muscles help ED extend the PIP and DIP

Extensor Mechanism

- Oblique retinacular ligaments help coordinate movement between PIP and DIP
- If ED contracts alone hyperextension at MCP results. Need intrinsics via the extensor mechanism to fully extend PIP and DIP

Result of Extensor Mechanism

External Extensors of Thumb

- Anatomical snuffbox:
- EPL: adduction, extension and lateral rotation
- EPB: extend CMC and MCP
- ABPL: extend CMC
- Need offsetting FCU contraction to prevent radial deviation when extending the thumb
Intrinsic Muscles

- **Thenar Eminence**
  - ABPB, FPB, OP
  - Function to position thumb during opposition
  - Injury to median nerve decreases the ability to oppose (which decreases grip) Left with 30% of the AB torque due to radial nerve innervation of ABPL

- **Hypothenar Eminence**: FDM, ABDM, ODM, PB
  - Function to cup ulnar border and deepen transverse arch
  - Injury to ulnar nerve prevents cupping of the hand

Adductor Pollicis

- Distal attachment allows the muscle to exert a pull on the extensor mechanism
- Extensors of IP joints and flex MCP due to anatomical position

Lumbricales

- 1st and 2nd innervated by median nerve 3 & 4 by ulnar nerve
- From the proximal attachment go palmarly to deep intermetacarpal ligament, pass the radial side of the MCP joints and distally blend with the oblique fibers of the dorsal hood.

Interossei

- Act at MCP joints to AD or AB digits
- Add stability to the MCP joints
- Flexes MCP and extends IP joints
- Larger flexion torque than the lumbricales
Extrinsic vs Intrinsic

Intrinsic and Extrinsic Muscle Activity
- Intrinsic Plus: “table top” MCP flexion and IP extension
- Extrinsic Plus: MCP hyperextension and IP flexion
- Extensor Mechanism is the mechanical link
- Intrinsic minus: MCP hyperextension and slight IP flexion

Opening the Hand
- Resistance to opening the hand is from passive resistance of the finger flexors
- ED pulls MCP into extension via the extensor mechanism
- Intrinsic muscles pull on the bands of the extensor mechanism and the flexors resist MCP hyperextension.
- This has to occur for full PIP and Dip extension

Opening the Hand
- Wrist flexion occurs to maintain the length tension relationship of the ED during finger extension
- Oblique retinacular ligament is the link as it appears to synchronize extension at both joints
  - if contracted can limit the amount of the extension available at the PIP
Opening of the Hand

- Lesion of the ulnar nerve results in intrinsic minus: MCP hyperextension and slight IP flexion

Closing the Hand

- Normal low resistance gripping is primarily FDP
  - During resistance need FDS, FDP, Interossei
  - Lumbricales exert a stretch which creates a passive flexion torque at the MCP joint

Closing the Hand

- ED active to stabilize and allow more distal joints to flex
- Wrist extension occurs to maintain proper length tension relationship of wrist flexors
- Ulnar nerve injury will decrease grip and if paralyzed may result in a asynchronous grasp

Prehension

- Power Grip
  - All flex all joints to hold object in palm; palm contours to object and thumb stabilizes
- Precision Grip
  - Thumb partially AB fingers partially flexed
- Power Pinch
  - Between the thumb and lateral border of 2nd digit
  - ADP and 1st dorsal interossei
Prehension

- **Precision Handling**
  - Fine motor control
  - Two jaw chuck: thumb is AB and rotated from palm contacts either distal tip of 1st finger or side of finger
  - Three jaw: 1st and 2nd finger
    - Pad to pad
    - Tip to tip

- Primarily the fingers and not the thumb
- Carrying a briefcase
- Mm FDP and FDS activity determined by position of the load; if distal on DIP then FDP; if proximal on PIP then FDS
- Thumb in moderate extension held by extrinsics

**Functional Position of the Wrist:**

- Wrist extension 20 degrees
- UD 10 degrees
- MCP flexion 45 degrees
- PIP flexion 30 degrees
- DIP slight flexion
- Optimizes the power of finger flexors with least effort

**Pathologies of the Hand**

- Finger deformities
- Dupuytren’s Contracture
- Gamekeeper’s Thumb
- 1st CMC DJD
Finger Deformities

- Swan Neck: MCP and DIP flexed with PIP extended common with RA
- Boutonniere: PIP flexed and DIP extended due to central tendon rupture

Dupuytren’s Contracture

- Unknown etiology
- Progressive contracture of palmar aponeurosis
- Flexion contracture of fingers

Gamekeepers Thumb

- Or skier’s thumb
- Torn ulnar collateral ligament of 1st MCP
- May have a fracture on proximal phalanx as well
- Usually by fall on outstretched hand

1st CMC DJD

- More prevalent in women after 50
- Prevalent in PTs
- May arise after trauma but typically due to overuse leading to instability
- Most common surgical intervention in upper quarter

References

- Google Images.