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Shoulder Rehabilitation

BACK TO BASICS – PART I

SALVADOR BONDOC, OTD, OTR/L, BCPR, CHT, FAOTA

Objectives

By the end of this course, participants should be able to:

1. Recognize major anatomechanical elements in the normal shoulder functioning
2. Describe concept of kinetic chain in the rehabilitation of the orthopedic shoulder
3. Identify common shoulder conditions and describe key considerations in relation to healing and functional recovery
Content Outline

Shoulder Complex Anatomy
  ◦ Joints and Muscle Groups
  ◦ Kinetic Chain Concept
Basics of Healing (Bone and Soft-Tissue)
Common Shoulder Diagnoses

Disclaimers

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The presentation of these materials are intended to augment the content of this course in order to meet its educational objectives.
The Shoulder Complex in Context

A Functional Perspective

1. Reach to retrieve a cup
2. Carry a tray
3. Throw a ball
4. Rise from the bed
A Functional Perspective

1. Reach-to-grasp in various directions
2. Lend proximal stability to facilitate distal function
3. Accelerate and project the UE kinematic chain
4. Lend dynamic stability to facilitate axial function

What happens to the rest of our body when we...

1. Reach to retrieve a cup from across the table?
2. Pick and Carry a tray over the shoulder?
3. Throw a ball as fast as we could?
4. Rise from the bed from supine?
Kinetic Chain of Function

Kinetic chain is a series of body links and segments activated in a coordinated fashion to generate action and transmit forces to accomplish a specific function.

The Shoulder Complex

ANATOMY AND BIOMECHANICS
Gross Anatomy

- 3 Major Bones
  - Scapular
  - Clavicle
  - Humerus

- 3 Major Joints
  - Sternoclavicular
  - Acromioclavicular
  - Glenohumeral

- 2 Articulations
  - Scapulothoracic
  - Subacromial

- 2 Kinematic Chains

Kinematic Chain Mechanisms

**CLOSED CHAIN MECHANISM**
- Thorax
  - Sternoclavicular
- Clavicle
  - Acromioclavicular
- Scapula
  - Scapulothoracic

**OPEN CHAIN MECHANISM**
- Thorax
  - Scapulothoracic
- Scapula
  - Glenohumeral
- Humerus
Sternoclavicular (SC) joint

- Sternum + prox. clavicle
- Anchors the UE to the body
- Strong and stable
  - Sternoclavicular ligament
  - Costoclavicular ligament
- Saddle joint
  - Mobile with 3 df
  - Contributes ~1/6 of total shoulder motion

Clavicular Osteokinematics

3 Degrees of Freedom

- Frontal plane:
  - elevation 45°, depression 10°

- Horizontal plane:
  - protraction 15°, retraction 30°

- Sagittal plane:
  - 40-50° of posterior rotation
**Acromioclavicular (SC) joint**

- Acromion + distal clavicle
- Sloped plane joint with disc
- Strong and stable
  - Coraco-clavicular ligament
  - Coraco-acromial ligament
  - Acromio-clavicular ligament
- Limited rotation but
  - Contributes ~1/6 of total shoulder motion

**AC and SC Arthrokinematics**

![Graph showing AC and SC kinematics](image)

(Revised from data from Inman VT, Saunders M, Abbott LC: Observations on the function of the shoulder joint, J Bone Joint Surg Am 26:1, 1944.)
AC and SC Kinematics and Kinetics

Primarily driven by actions and motions at the scapulothoracic and/or glenohumeral joints

Scapulothoracic (ST) joint

- Pseudo-joint but an articulation plane between the scapula and the thorax
- Dynamically anchors the UE to the axial skeleton
- Scapular kinematics is influenced by the “shape” of the thorax
Scapular Kinematics

PROTRACTION – RETRACTION
- Pushing - pulling

ELEVATION – DEPRESSION
- Shrugging - Downward Reach

UPWARD - DOWNWARD ROTATION
- Reaching up and forward – Reaching down and back

Scapular Kinematics

Action of the shoulder produces concurrent motions at both the acromioclavicular and sternoclavicular joints
Scapular Elevators

- Upper trapezius
- Levator scapulae
- Rhomboids

Rhomboids rotate scapula with latissimus dorsi and pectoralis minor

Scapular Depressors
Scapular Elevators

- Upper trapezius
- Levator scapulae
- Rhomboids

Rhomboids rotate scapula with latissimus dorsi and pectoralis minor

Scapular Retractors
Scapular Protraction

Kinetics of Upward Rotation

force coupling among upper and lower trapezius and serratus anterior
EMG ACTIVITY OF UPWARD ROTATORS


---

Scapular Tilting/Tipping

**ANTE-TILTING**

Associated with
- Increased scapular protraction
- Tightness of or overactive pectorals
- Prominence of the inferior angle of the scapula

**POSTERIOR TILTING**

Combines
- Scapular retraction and depression
- Provides clearance to the HH during elevation
Glenohumeral (GH) joint

- Complex synovial joint
  - Surrounded by 8 bursae

- "Ball and Disc" configuration
  - convex humeral head
  - concave glenoid fossa

- Loosely fitted, very mobile requires dynamic stabilization
  - Both a link and a segment in the complex kinetic chain

Glenohumeral Articular Surface

- Coracohumeral ligament
- Infraspinatus tendon
- Long head of triceps
- Glenoid labrum
Glenoid Labrum

- Extends the articular surface of the glenoid
- Reduces humeral accessory translation (dycem effect)
- Blends with long head of the biceps

Capsulo-ligamentous Complex (CLC)  
[a.k.a. the Glenohumeral Capsule]

- Fibrous and elastic
  - Allows for joint distraction without disarticulation
- Axillary pouch at the inferior portion
  - Taut during elevation
- Generally, provides static and dynamic stability
  - Static – superior CLC prevents inferior slide of HH at rest
  - Dynamic – taut CLC centers the HH in relation to the fossa
The GH Capsule

Superior GH ligament
- taut in adduction and inferior-posterior humeral translation

Middle GH ligament
- taut in external rotation and anterior humeral translation

Inferior GH ligament
- taut in abduction and inferior humeral translation
- Posterior-inferior GHL is taut in abduction with internal rotation
- Anterior-inferior GHL is taut in abduction with external rotation

Coracohumeral ligament
- taut in extremes of external rotation, flexion, or extension
Capsular Stretch helps to centralize the GH Joint

DURING EXTERNAL ROTATION

DURING ABDUCTION

“Static Locking Mechanism”

1. Superior CLC + Gravity = Resultant compressive force (CF)
2. Maintenance of scapular tilt of ~ 5 degrees
3. Negative intra-articular pressure
Rotator Cuff
Proximal and Distal Attachments of the Rotator Cuff (Anterior View)

Proximal and Distal Attachments of the Rotator Cuff (Posterior View)
Barrier Effect from the Rotator Cuff

Functional Groups (Jobe & Pink, 1993)

1. Scapular pivoters
   - Serratus Anterior (Upper, Lower)
   - Trapezius (Upper, Middle, Lower)
   - Rhomboids
   - Levator Scapula

2. Propellers – axiohumeral
   - Pectoralis major
   - Latissimus dorsi

3. Glenohumeral protectors
   - Supraspinatus
   - Infraspinatus
   - Subscapularis
   - Teres Minor

4. Humeral positioners
   - Anterior deltoid
   - Posterior deltoid
   - Middle deltoid
Osteokinematics of the Humerus

FLEXION - EXTENSION
ABDUCTION – ADDUCTION
INTERNAL – EXTERNAL ROTATION
**HORIZONTAL ABDUCTION – ADDUCTION**

Internal Rotation

- 75-85 degree rotation

- Powered by
  - Subscapularis, Teres Major, and Pectoralis Major
  - and to a certain extent:
    - Anterior deltoid
    - Latissimus dorsi
External Rotation

- 60-70 degree rotator cuff
- 90+ with shoulder elevation
- Powered by:
  - Infraspinatus
  - Teres minor,
  - Posterior deltoid

Arthrokinematics

External Rotation
vs.
Internal Rotation
Kinetics and Kinematics of GH Elevation

- Flexion (combines IR after ~120 degrees)
  - Anterior > Middle Deltoid
  - Coracobrachialis
  - Biceps long head
  - Pectoralis Major (up to 70 degrees)

- Abduction (combines ER after ~120 degrees)
  - Middle > Anterior Deltoid
  - Supraspinatus (esp. 0-120)

- Scaption (0-180)
  - True physiologic motion of the GH elevation
  - Combines efficient synergistic action of the above

Rotator cuff + Deltoid coupling = Centralization of the glenohumeral joint

Coupling action of the Rotator Cuff especially
- Subscapularis
- Infraspinatus
- Teres minor
The Scapulo-Humeral Rhythm

• 2:1 GH-ST ratio?

• Early Phase (0-90 degrees)
  • 50-60 degrees GH
  • 20-25 degrees SC
  • 5-10 degrees AC

• Late Phase (90-180 degrees)
  • 50-60 degrees GH
  • 20-25 degrees AC
  • 5-10 degrees SC

Scapulohumeral Rhythm Kinetics during Shoulder Elevation

• Anterior-Middle Deltoids
  • with coracobrach, LH biceps, pec major as secondary muscles

• Rotator Cuff
  • Especially subscapularis, teres minor, infraspinatus

• Scapular Muscles:
  • Upper and Lower Trapezius
  • Serratus anterior

http://blog.ussathletics.com/home/2015/12/16/movements-you-owe-to-have-the-pose-fly
### Extensors and Adductors

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Extends/Hyperextends</th>
<th>Adducts</th>
<th>Adducts Horizontally</th>
<th>Abducts Horizontally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior Deltoid</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pectoralis Major</td>
<td>Extends only</td>
<td>X</td>
<td>X (with ant. Deltoid)</td>
<td></td>
</tr>
<tr>
<td>Triceps</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teres Minor</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Infraspinatus</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latissimus Dorsi</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Scapulohumeral Rhythm Kinetics during Shoulder Extension

- **Humeral extensors:**
  - Posterior Deltoid
  - Latissimus Dorsi
  - Rotator Cuff muscles and Triceps as secondary power

- **Scapular Muscles:**
  - Rhomboids
  - Middle trapezius
Tissue Healing Process

REHAB CONSIDERATIONS

Tissue Involvement

Bone – fracture
Muscle – tear, post-surgical retraction
Tendon – tear/rupture
Ligaments – tear
Capsule – tear, post-surgical repair
Soft Tissue Healing

STAGE OF RECOVERY

• INFLAMMATION PHASE
  • Safeguards from infection
  • Must protect structures

• FIBROPLASIA PHASE
  • Start of tissue repair
  • Must balance of healing and stress

• REMODELING PHASE
  • Maturation of tissue repair
  • Must promote return of function

KEY MANIFESTATIONS

• INFLAMMATION PHASE
  • Cardinal signs
  • Edema

• FIBROPLASIA PHASE
  • Residual edema
  • Callus, Thick scar

• REMODELING PHASE
  • Edema resolved
  • Healed tissue, Mature scar

Barriers to Healing

COMORBID CONDITIONS

• Diabetes
• Cancer
• Infection
• Cardiovascular Diseases
• Autoimmune conditions

LIFESTYLE

NUTRITIONAL STATUS

ADVANCING AGE
Skin Model

Tendon Model
Mobilized vs. Immobilized
Healing of Soft Tissues

<table>
<thead>
<tr>
<th>LIGAMENT HEALING</th>
<th>TENDON HEALING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflammatory</td>
<td>Inflammatory – first 2 weeks</td>
</tr>
<tr>
<td>◦ first 2 weeks</td>
<td>◦ Weakest point at ~day 10</td>
</tr>
<tr>
<td>Fibroplasia/Repair</td>
<td>Fibroplasia/Repair</td>
</tr>
<tr>
<td>◦ week 2 through weeks 6-8</td>
<td>◦ week 2 through weeks 6</td>
</tr>
<tr>
<td>◦ Tensile strength is near normal at week 6-8</td>
<td>◦ Tensile strength is near normal at week 4</td>
</tr>
<tr>
<td>Remodelling/Maturation</td>
<td>Remodelling/Maturation</td>
</tr>
<tr>
<td>◦ Starts at week 4 through 18 months.</td>
<td>◦ Starts at week 3 through 6 months.</td>
</tr>
</tbody>
</table>

Fracture Healing Basics

Primary healing: direct bone reconstruction
◦ Contact healing
◦ Gap healing

Secondary healing: tissue repair through
◦ Callus healing: Callus formation ➔ Remodelling
◦ Enchondral ossification: Cartilage ➔ Bone

Primary Fracture Healing

Factors that influence primary healing:

Intrinsic factors:
- Fracture configuration
- Accuracy of fixation
- Rigidity of fixation device

External factors:
- Lifestyle
- Nutritional status
- Co-morbid or premorbid conditions

Complications

Compartment swelling
- Nerve or circulatory compromise

Loose hardware

Infection
- Local vs. systemic

Poor healing:
- Mal-union
- Delayed union
- Non-union
Inflammatory Phase to Early Repair Phase

Inflammation (1 Week)
- Absolutely necessary
- Continues for weeks in distal UE

Rehab Implications:
- Absolute support
- Edema management
- Manage acute pain
- Tissue gliding to prevent scar adhesions
- For stable fixations, early movements that does not trigger swelling or inflammation

Repair Phase

Repair phase (Weeks 1 to 4)
- Angiogenesis
- Soft callus formation (usu. radiologically prominent at 2+ weeks)
- Fracture fragments have settled
- Angulation may still exist, potential for re-fracture

Rehab Implications:
- Continue with external support
- Controlled mobilization: Active First → Passive

Active Approximation is Key
Remodelling Phase

**Remodelling** (week 4 up to 4 months)
- Soft callus $\rightarrow$ hard callus $\rightarrow$ bone

Rehab Implications:
- Controlled Mobilization $\rightarrow$
- Neuromuscular Re-education + Progressive Resistance (PREs)
Orthopedic Shoulder Conditions
PATHOLOGY AND REHAB CONSIDERATIONS

Basic Categories

Rotator Cuff Disease
- Partial or full tear
- Tendinopathy
- Impingement Syndrome

Joint Degeneration/Arthritic
- Osteoarthritis
- Rheumatoid Arthritis

Instability and Dysfunctions
- Instability/Laxity
- Scapular Dyskinesia

Other Soft-tissue Conditions
- Adhesive capsulitis
- Bicipital tendinitis
- Labral lesions

Fractures/Osteopathic
- Non-displaced vs. displaced
- Fracture-dislocation

Nerve Conditions/Neuropathic
- Nerve entrapments
- Brachial plexopathies
Rotator Cuff Disease and Impingement Syndrome

- Common SxS
  - Pain with overhead reach, greater by end of day, or with weight bearing
  - Loss of motion in humeral elevation-rotation is due to pain vs. joint stiffness

- Clinical Exam & Diagnostics
  - X-rays are usually negative, may show osteophyte
  - MRI may show tearing

Impingement Syndrome

Impingement Syndrome

Leads to:

1. Bursitis
   - Subacromial, subdeltoid
2. Tendinopathy
   - Tendonitis
   - Tendinosis
3. Osteophytes (bone spurs)
   - cause gradual tendon tears

Related Conditions: 

*Rotator Cuff Tears*

**Severity**
- Tendinitis vs. Tendinosis
- Tears: Partial vs. Full

**Pathomechanics and Onset**
- Acute injury
  - Often FOOSH, sports-related or MVA
  - Tends to fill thickness
- Chronic Injury
  - Repetitive micro-trauma from overhead internally rotated motions
  - Tends to be partial

Associated Conditions
- Arthritis
- Shoulder instability
Rotator Cuff Repair

Arthroscopic Rotator Cuff Repair

Anatomical Considerations
- Infraspinatus/Teres minor
- Pectoralis major
- Deltoid
Related Condition: 
**Shoulder Instability**

Directional Patterns:
- Unidirectional vs. Multidirectional
- Anterior dislocation or instability is most common
  - May be associated with Bankart lesion (labral tear) → requires surgery

Severity:
- Functional instability and laxity
- Subluxation → Dislocation

---

Related Condition: 
**Capsular Shift and Repair**

[Image of diagrams showing the process of capsular shift and repair]


Conservative Management

MEDICAL MANAGEMENT

1. Nonsteroidal anti-inflammatory drugs (NSAIDs)
2. Brief rest and immobilization x 3 days
3. Corticosteroid injections
   ◦ Caution: max of 3 injections
   ◦ Risk: further tearing in partial tears

REHABILITATIVE MANAGEMENT

1. Therapeutic exercise
2. Manual therapy
   ◦ soft tissue
   ◦ joint mobilization
3. Pain control modalities
4. Work and ADL modifications (including Ergonomics)

Rehab Pearls

- Impingement Syndrome may be considered as Chronic Rotator Cuff Pathology  
  - Primary vs. Secondary
- Pathomechanics is largely a biomechanical issue!
  - Muscle imbalance that results in poor humeral head stabilization
  - Postural dysfunction → cervical to thoracolumbar
- In post-surgical conditions
  - Consider neuromuscular re-education to “reset” muscle memory
Scapular Dyskinesia

Not an ICD-10 diagnosis but a well-documented phenomenon

Altered function of the scapula due to
- proximal or distal biomechanical dysfunctions
- Adaptations to primary conditions (e.g., rotator cuff tear, frozen shoulder)

Quick and dirty observations:
- Asymmetrical manifestations
- Scapular winging
- Disrupted scapulo-humeral rhythm (usu. initiation or termination)
Arthritic Conditions

OSTEOARTHRITIS
- Degradation of articular cartilage and bone due to "wear and tear"
- Rarely have RC tear
  - But CRCP may lead to OA
- Presence of Osteophytes

RHEUMATOID ARTHRITIS
- Destruction of articular cartilage as part of the systemic process
- 20-40% have RC tear
- Osteopenia or poor bone stock
**Osteoarthritis vs. Rheumatoid Arthritis**

- [Image of X-rays comparing normal and abnormal joint conditions]


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**Management**

**CONSERVATIVE**
- Pain Control Medications
- Rest and immobilization

Rehabilitation
- Therapeutic Exercises to improve Strength and ROM
- Joint Protection strategies

**SURGICAL**
- Shoulder Arthroplasties
  - Conventional TSR – primary goal is pain control
  - Reverse arthroplasty – goal is to reduce pain and restore function

Pre-operative and post-operative rehabilitation
GOALS OF
SHOULDER
ARTHROPLASTY
1. Relieve pain
2. Restore function

X-RAYS BEFORE AND AFTER
CONVENTIONAL TSA SURGERY FOR RA
Reverse Hemiarthroplasty
(Matsen & Wilmar, 2009)

http://www.orthop.washington.edu/cas/reverseshoulder/tabid_3351/ItemID_168/PageId_5/Article/Default.aspx

http://orthoinfo.aaos.org/topic.cfm?topicid=400094

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TSA vs. rTSA

TOTAL SHOULDER (TSA)
- Mostly indicated for arthritic conditions
- Also for complex fractures including the humeral head
- Avascular necrosis of the humeral head

REVERSE TSA (RTSA)
- Mostly indicated for complex RC trauma
- Also complex fractures where RC is nearly un-salvageable
- Revision of TSA

continued
Post-Surgical Management

Phase I: Begins within 1 week post-op
- Sling Immobilization
- Passive ROM in “safe” range (50% FF, 25% ER)

Phase II: Begins 4-6 weeks
- Wean Off Sling
- Maximize PROM and Restore AAROM and SHR kinematics (75% FF, 50% ER)

Phase III: Begins 6-8 weeks
- Progressive AROM to Strengthening
- Gradual Return to Usual Activities

Rehab Pearls

1. Prevent joint stiffness
   - Instruct on early PROM [Note: PROM is NOT stretching]

2. Respect the healing structures
   - Avoid stress to anterior capsular structure
   - TSAs may involve RCR → clinical signs matter more than timelines
   - Dislocation happens → esp. with extension + adduction with int. rot.

3. Understand the post-operative biomechanics
   - Deltoids (> RC) become the primary kinetic factor not RC
   - Post-operative scapulohumeral rhythm (SHR) is 1:1 (Friedman, 1996)

4. Appreciate the outcomes
   - Primary outcome in TSA and rTSA is decrease in pain
   - ROM may be regained up to 66% with unusual SHR

continued
Proximal Humerus Fractures

4 Typical Sites:
- Surgical neck
- Greater tuberosity
- Lesser tuberosity
- Shaft

Neer’s classification:
- 2-Part
- 3-Part
- 4-Part

Pathomechanics

Two part fracture
- Surgical neck
  - Pectoralis Major pulls humerus anteromedially
- Greater tuberosity
  - Supraspinatus, Infraspinatus, Teres Minor pull Greater Tuberosity (GT) supero-posteriorly

Two - Three part fracture
- Lesser tuberosity
  - Subscapularis is unopposed; humerus torques
  - Pathognomonic with full Rotator Cuff (RC) tears
Management
Factors that may determine approach:
Surgical vs. Non-surgical/Conservative
- Type of surgery
- Type of involvement
MDs Preferences
Patient’s Contexts

Non-surgical Management

INDICATIONS:
Minimally displaced fx
- <1 cm displacement, 45° angulation (Neer, 1970)
Displaced unstable fx
- Poor outcome in > 5 cm displacement
- Adjust expectations

COMPONENTS:
Immobilization
- 1-2 weeks in minimally displaced fx
- Greater in displaced unstable fx
Mobilization
- Indicated once callous is stable (usu. 3-4 weeks in stable fractures)
- Time frame varies
Surgical Management

Closed reduction
Percutaneous pinning
Intramedullary nailing

Open Reduction – Internal Fixation (ORIF)
  ◦ locking plate
  ◦ blade plate

Arthroplasties:
  ◦ Hemiarthroplasty
  ◦ Total arthroplasty
  ◦ Reverse arthroplasty

Percutaneous Pinning

Indicated if closed reduction is not sufficient
Rehab progression depends on gradual pin removal
Intramedullary (IM) Nailing or Open Reduction Internal Fixation (ORIF)

- Used more in multiple shaft fractures
- Indicated when fracture geometry alters GH alignment

- Most common fixation procedure
- Indicated in surgical neck, 3-part or 4-part fractures

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**Post-Surgical Management**

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**Phase III:** Begins 6-8 weeks
- Progressive AROM to Strengthening
- Gradual Return to Usual Activities
Rehab Pearls

1. Prevent joint stiffness
   - Scarring + immobilization leads to secondary frozen shoulder or stiffness

2. Understand the surgical process
   - ORIF affords early mobilization
   - Anterior approaches indicate subscapularis was retracted

3. Understand the fracture healing process
   - Fracture healing is main guide for progression of rehab
   - Fracture union is hastened by muscle activity
   - Fracture non-union is affected by co-morbidities and lifestyle choices

QUESTIONS
A Primer for Occupational Therapy Practitioners

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