Chapter 15:
Shoulder Fractures & Instabilities

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I. Bones[1]
1. Clavicle
   A. S shaped
   B. Connects axial skeleton and upper limb
   C. Serves as attachment site for muscles controlling upper extremity
   D. Protects the neurovascular bundle from neck to arm
2. Scapula
   A. Superior angle positioned at T2 and inferior angle positioned at T7
   B. Tilted posteriorly at end range scaption and 30° anterior to the coronal plane
   C. Provides a stable base for shoulder complex
   D. Serves as an attachment site for axio-scapular muscles
   E. Serves as an origin site for scapulo-humeral muscles
   F. Transmits energy proximal to distal
   G. Landmarks
      1. Spine
      2. Acromion process
      3. Root of spine
      4. Glenoid fossa
      5. Coracoid process
      6. Supraspinatus fossa
      7. Infraspinatus fossa
      8. Medial border
      9. Lateral border
      10. Superior angle
      11. Inferior angle
3. Humerus
   A. Proximal lever arm of the upper limb
   B. Attachment and origin site for prime movers of shoulder and elbow
   C. Landmarks
      1. Greater tuberosity: insertion for supraspinatus, infraspinatus, teres minor (posterior cuff)
      2. Lesser tuberosity: insertion for subscapularis (anterior cuff)
      3. Surgical neck
      4. Shaft
      5. Head of humerus

II. Muscles[2]
1. Upward rotation of scapula
   A. Upper & lower trapezius (UT & LT)
   B. Serratus anterior (SA)
2. Downward rotation of scapula
   A. Levator scapulae (LS)
   B. Rhomboid major & minor
   C. Pectoralis minor

3. Elevation of the scapula
    A. Levator scapulae
    B. Upper trapezius
    C. Rhomboid major and minor
4. Depression of the scapula
    A. Pectoralis minor
    B. Pectoralis major
    C. Lower trapezius
    D. Serratus anterior (lower fibers)
    E. Latissmus dorsi
5. Protraction (Abduction) of the scapula
    A. Serratus anterior
    B. Pectoralis minor
    C. Pectoralis major
    D. Latissimus dorsi
6. Retraction (Adduction) of the scapula
    A. Middle trapezius
    B. Rhomboids major & minor
7. Flexion of humerus
    A. Clavicular head of pectoralis major
    B. Anterior deltoid
    C. Coracobrachialis
    D. Short head of the biceps
8. Extension of humerus
    A. Latissimus dorsi
    B. Teres major (t major)
    C. Posterior deltoid
    D. Infraspinatus (infra.)
    E. Teres minor (t minor)
    F. Long head of the triceps
9. Abduction of the humerus
    A. Middle deltoid
    B. Supraspinatus (supra.)
10. Adduction of the humerus
    A. Sternal head of pectoralis major
    B. Latissimus dorsi
    C. Teres major
    D. Coracobrachialis
11. External Rotation (ER) of the humerus
    A. Infraspinatus (infra) - teres minor
    B. Posterior deltoid
12. Internal Rotation (IR) of the humerus
    A. Subscapularis (subscap)
    B. Latissimus dorsi
    C. Teres major
    D. Anterior deltoid
    E. Pectoralis major
13. Horizontal Adduction of the humerus
    A. Anterior deltoid

   B. Clavicular head of pectoralis major
14. Horizontal Abduction of the humerus
   A. Posterior deltoid (Fig. 1)

III. Joints[3]
1. Sternoclavicular (SC) Joint: formed by proximal clavicle and sternum
   A. Only "true" articulation between axial skeleton & upper limb
   B. Sellar joint
   C. Movements: elevation and depression, protraction and retraction and rotation
   D. Stability
      1. Ligaments: costoclavicular, sternoclavicular (anterior and posterior), interclavicular
      2. Articular disk
      3. Joint capsule
2. Acromioclavicular (AC) Joint: formed by acromion of the scapula and distal clavicle
   A. Synovial plane joint
   B. Movement: Allows sliding between lateral clavicle and acromion to conform to changes in the relationship between the scapula & the humerus
   C. Stabilizing structures
      1. Intra-articular disk
      2. Joint capsule: Loose to allow sliding movement of joint
      3. Ligaments: Acromioclavicular, coracoclavicular (trapezoid, conoid)
3. Scapulothoracic (ST) joint: formed between the scapula and the thoracic wall
   A. Not a "true" articulation
   B. Movement: protraction, retraction, elevation, depression, upward & downward rotation, internal & external rotation[4]
   C. Stabilized by muscles
   D. Provides a stable base for glenohumeral mobility and stability; shoulder movement depends on it
4. Glenohumeral (GH) Joint: formed by glenoid fossa and the head of the humerus
   A. Ball & socket joint that sacrifices stability for mobility
   B. Movement: flexion, extension, abduction,scaption (30 degrees anterior to frontal plane), adduction, external & internal rotation, horizontal abduction & adduction
   C. Subacromial space: space between acromion, coracoacromial ligament, coracoid process and the superior humeral head
   D. Contents within sub acromial space
      1. RTC tendons
      2. Long head of biceps
      3. Subacromial-subdeltoid bursa
      4. Subscapularis bursa
      5. Subcoracoid bursa
      6. Articular cartilage

IV. Ligaments and Capsule
1. Area of capsular tension dependent on GH joint position
   A. Superior portion of capsule: tensioned with GH adduction and tension reduces with abduction
   B. Anterior middle and inferior capsule: tension increases with abduction

   C. Posterior capsule: tension increases with GH IR combined with extension and posterior inferior capsule: tension increases with IR in scapular plane[5]
2. Coracohumeral ligament (CHL)
   A. Thick band of capsular tissue
   B. Originates from coracoid process and inserts to the greater and lesser tuberosities
   C. CHL with superior glenohumeral ligament restrains inferior glenohumeral translation with the humerus adducted
   D. CHL with superior glenohumeral ligament restrains GH posterior translation in forward flexion, adduction, and internal rotation
3. Superior glenohumeral ligament (SGHL)
   A. Originates at the anterosuperior edge of the glenoid and inserts into the lesser tuberosity.
   B. Parallels with the CHL
   C. SGHL and CHL are similar in function
   D. Restrains inferior translation and ER in adducted arm
   E. SGHL and CHL restrains GH posterior translation in flexion, adduction and IR
4. Middle Glenohumeral Ligament (MGHL)
   A. Most variable of GH ligaments
   B. Absent in 8% to 30% patients
   C. Originates at supra-glenoid tubercle, superior labrum, or scapular neck
   D. Inserts into lesser tuberosity
   E. Restrains anterior GH translation at 60 to 90 degrees ABD/ER[6]
   F. Contributes restraining inferior translation with GH in adducted position
5. Inferior Glenohumeral Ligament (IGHL)
   A. Thickest GH ligament
   B. Complex made of anterior band, axillary pouch, and posterior band.
      1. Anterior band extends from anteroinferior labrum and glenoid lip to lesser tuberosity
      2. Anterior band restrains anterior translation in the throwing position (90 degree abduction, 90 degree ER)
      3. Axillary pouch resembles a hammock
      4. Posterior portion is primary restraint to posterior translation in abd
      5. Traumatic or repetitive microtrauma injuries to IGHL play integral role in recurrent instability
6. Coracoacromial Ligament
   A. Provides a suspension function
   B. Contributes to glenohumeral stability (restraining anterior and inferior translation with the coracohumeral ligament)[7]
7. Coracoclavicular Ligaments[8]
   A. Trapezoid (lateral)
      1. Resists posterior translation
   B. Conoid (medial)
      1. Resists anterior and superior loading
8. Acromioclavicular (AC)
   A. Fibers are anterior, posterior, and superior
      1. Resists posterior and superior translation
9. Sternoclavicular (SC)
   A. Has soft tissue constraints that contribute to stability
10. Specific patterns of capsular restriction

A. Adhesive capsulitis: ER limited most followed by abduction and internal rotation
B. Tight posterior capsule: limited IR and horizontal adduction
C. Tight subscapularis: ER limited more at 0°abd vs. 45°-90°
D. Tight MGHL and IGHL: ER limited more at 45°-90°abd vs. 0° (Fig. 2)

V. Stabilizing Structures of GH Joint: Both Static and Dynamic Structures
1. Static structures
   A. Articular surface
   B. Glenoid fossa is shallow
   C. Humeral head is 2.5 times larger than the glenoid fossa[9]
      1. Glenoid fossa and humeral head are highly congruent with curvatures within 2-3 mm over the entire surface[10]
   D. Glenoid Labrum
      1. Superior labrum loosely attached at the 10 o'clock to 2 o'clock position and firmly attached at the 2 o'clock to the 10 o'clock position[11]
   E. Fibrocartilaginous complex that deepens the glenoid fossa
      1. Generally loose superiorly and tighter inferiorly
   F. Capsuloligamentous complex[12]
      1. Capsule and ligaments (capsuloligamentous complex) reciprocally tighten and loosen to limit glenohumeral translation
      2. Capsuloligamentous complex provides functional stability at end ranges of motion
      3. Capsule seals GH joint creating a negative intra-articular pressure
      4. Provides a suction effect to resist humeral head translation[13]
      5. Capsule surface is twice the size of humeral head
      6. Allows for extensive ROM
      7. Truncated in shape
         a. Inferior GH ligament complex has an interweaving and crimping characteristic
            1. Allows for a wide range of energy absorption at terminal joint positions[14]
      8. Counterforce to the humeral head in the direction opposite of humeral head motion is created when a ligament is stretched[15]
      9. GH ligament fails at approximately 10% elongation beyond the resting length
      10. Circle concept
         a. A ligamentous lesion on one side of the joint capsule can result in shifting loads to the opposite side of the capsule permitting humeral subluxation or dislocation (Fig. 3)
2. Dynamic stabilization and dynamic constraints
   A. Rotator cuff muscles (supraspinatus, infraspinatus, teres minor and subscapularis)
   B. Supraspinatus, teres minor and infraspinatus fuse to make one continuous band
   C. Loads from one tendon affect neighboring tendons
   D. Muscles function to provide compressive forces to centralize humeral head
   E. Provide stability in superior-inferior and anterior-posterior directions
   F. Infraspinatus and teres minor contributes to posterior stabilization[16]
   G. Subscapularis contributes anterior stabilization with the humerus adducted and 45° abduction

Chapter 15 Figures

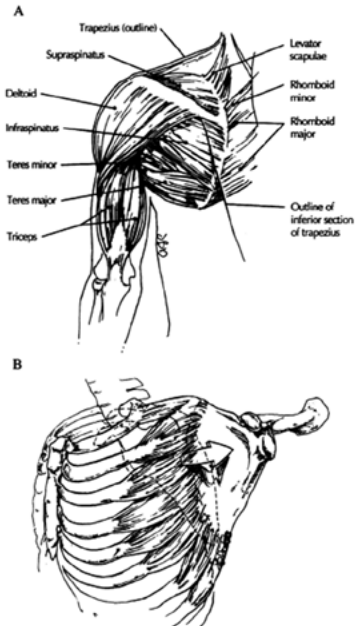

Fig. 1. Axioscapular and Scapulohumeral Muscles.

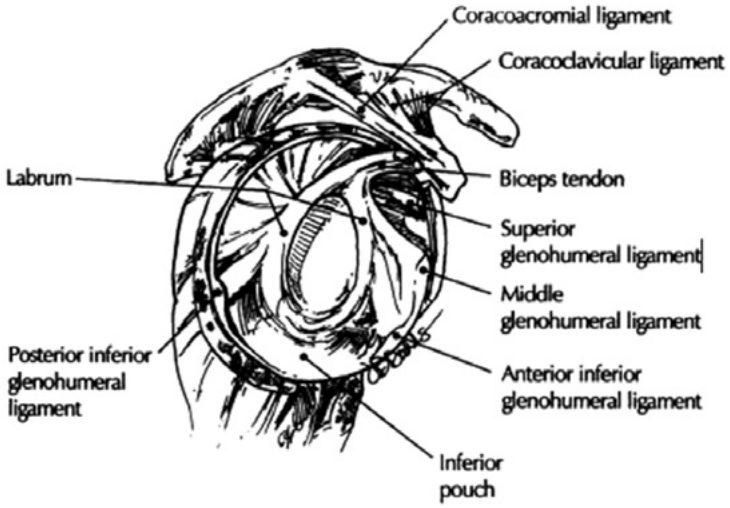

Fig. 2. Ligaments of the Shoulder Girdle.

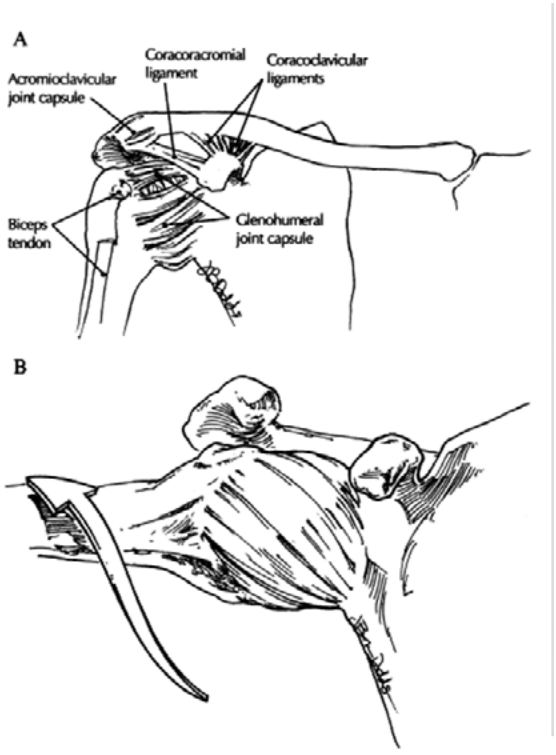

Fig. 3. Glenohumeral Joint Capsule.

H. All 4 cuff muscles contribute to anterior stabilization with the humerus adducted or externally rotated.
I. Biceps tendon: contributes to humeral head depression and is an anterior stabilizer of GH joint[17]

VI. Common Shoulder Injuries and Pathology (instability, fractures, arthroplasty)[18,19,20,21]

1. Shoulder Instability
   A. Definition: Inability to maintain the humeral head centered in the glenoid cavity
   B. A component of the stabilizing matrix has become dysfunctional
   C. Direction of Instability
      1. Anterior
      2. Posterior
      3. Inferior
      4. Multidirectional (instability in more than one direction)
      5. Anterior-inferior is most common
2. Clinical presentation of instability
   A. TUBS: traumatic, unilateral, bankart, surgery
      1. Specific traumatic event causing dislocation
      2. Dislocation in one direction[22]
         a. Ninety-eight percent of cases dislocate anteriorly
         b. Two percent dislocate in posterior direction
      3. Usually labroligamentous complex lesion
   B. AMBRI: atraumatic, multidirectional, bilateral, rehabilitation, inferior shift
      1. No clear cut history of dislocation
      2. Multiple planes of instability in both shoulders
         a. Rehab: 85% successful
         b. If rehab is not successful require inferior capsular shift (tightening of the inferior capsule)
         c. Can typically dislocate voluntarily
   C. General shoulder evaluationwith suspected instability
      1. History
      2. Chief complaint
      3. Pain: aggravating factors
      4. Functional deficits
      5. Mechanism of injury
   D. Observation
      1. Humerus positioned in protective position (adducted and internally rotated)
      2. ROM: active/passive (AROM/PROM)
      3. Observe quality of movement
      4. Scapulo-humeral rhythm
      5. Note excessive movement at one joint if restriction at another—may give the appearance of "normal" motion
3. PROM
   A. Note irritability and end feel
   B. Pay attention to substitution at surrounding joints
   C. Weak/painless: muscle or tendon rupture
      1. Accessory motions and special tests: assess at all 4 joints to determine hyper/hypomobilities
      2. Joint mobility: anterior glide, posterior glide, inferior glide

a. Compare to contralateral side
b. Increased joint play in direction of dislocation
c. Laxity vs instability
1. laxity is often bilateral and asymptomatic
2. lax in all directions
3. instability is symptomatic and associated with active or passive movement
d. Instability grades[23]
e. Grade 0: no humeral head translation
f. Grade I: humeral head rides up glenoid slope not over rim
g. Grade II: humeral head rides over glenoid rim, but reduces as stress is removed
h. Grade III: humeral head rides over glenoid, remains dislocated as stress is removed

3. Multi-directional laxity
a. laxity without symptoms is not pathologic
b. if lax with symptoms, may not be the cause
4. Multi-directional instability
a. Instability in more than one direction (anterior, posterior, and inferior translation)

D. Special tests with diagnostic values
4. Apprehension test—anterior instability
a. No formal research reported on diagnosing instability
5. Subluxation/Relocation—anterior instability
a. Apprehension criteria-sensitivity 65%, specificity 100%[24]
6. Load and shift test—anterior and posterior instability[25]
a. Anterior direction-sensitivity 50%, specificity 100%
b. Posterior direction-sensitivity 14%, specificity 100%
7. Sulcus test—inferior instability
a. Sulcus sign of 2 cm or more as criteria-sensitivity 28%, specificity 97%

VII. Rehabilitation for Instabilities

1. Anterior glenohumeral dislocation conservative management[26]
A. Evidence supports immobilization with sling in slight ER decreases redislocation rates[27]
1. Phase I (protective stage)
Goal: Protect healing tissue and decrease pain
a. Sling with 10 degrees external rotation worn all times
b. Modalities to decrease inflammation and pain
2. Phase II (Intermediate phase)
Goal: restore normal AROM
a. Sling only as needed
b. Gradual return to full AROM as tolerated
c. AROM progression as tolerated starting at 30/30 (ER/ABD) and progressing to AROM to 90/90 (ER/ABD)
d. Modalities as needed
e. Isotonic training of rotator cuff in scaption
1. 30/30 ER/ABD, rhythmic stabilization, scapular stabilization avoiding provocative positions (90/90 ER/ABD)

2. Rhythmic stabilizations
3. Increase strength of RTC, deltoid and scapular muscles
4. Start in non-provocative positions and slowly progress to overhead positions
5. Slowly progress to RTC and scapular muscle control at ER/ABDto 45/45 degrees

3. Phase III (Strengthening and dynamic stability)
   Goal: restore strength and retrain dynamic stability (Ligaments restrain at end ROM only; otherwise it is the dynamic stabilizers that maintain stability. Need to retrain dynamic stabilizers)
   a. Isotonic training of rotator cuff to ER/ABD 90/90
   b. Scapular strengthening
   c. Plyometrics
4. Redislocation rate highly dependent on age when first dislocated[28]
   a. Adolescents have higher rate of redislocation

2. Bankart Lesion
   A. Bankart Lesion: Tear of anterior-inferior labrum and/or attenuation and stretching of the anterior-inferior capsule and inferior GH ligament, and periosteal stripping of subscapularis from glenoid fossa
   B. BankartSurgery requires repair of the defect
      1. May be open or arthroscopic
         a. Capsule is revealed through the subscapularis muscle
            1. Split longitudinally (usually arthroscopic)
            2. Tenotomy (open)
         b. Capsule is split to expose labral lesion
         c. Lesion is repairable with anchors
         d. Capsule is repaired
   C. Bankart repair open repair[29]
      1. Multiple protocols exist; progressions will vary based on integrity of healing tissues
      2. Therapy guidelines status post stabilization procedure open repair
      3. Phase I
         Goal: Protect repair and decrease pain and inflammation
         a. Protect healing capsule with immobilization sling
         b. Prevent hypomobility with controlled PROM
         c. Limited PROM ER 0-20 in scaption first 4 weeks, progress to 0-40 ER in scaption at 4 to 6 weeks
         d. PROM flexion and scaption 0-90 degrees
         e. Diminish pain and inflammation
         f. Sub-maximal isometrics at 4 to 6 weeks
         g. Contraindications: Avoid passive ER beyond 20 during early healing;progressing to 40 at 4 weeks. No PROM flex or scaption above 90 degrees. Avoid abd andext beyond neutral
      4. Phase II (Intermediate phase)
         Goal: Restore ROM
         a. Discharge sling with soft tissue healing (usually at 6 weeks post injury)
         b. Return full shoulder mobility

c. PROM flexion, abduction, and scaption progressing end range gradually
d. Begin A/AROM
e. Initiate gentle AROM ER/ABD gradually starting at 30/30 progressing to 90/90 in scapular plane
f. Improve neuromuscular control
g. Improve muscle strength and endurance with scapular stabilization and rotator cuff isometrics progressing to isotonics
h. Isokinetics at 8 to 10 weeks post-op

5. Phase III (Advanced phase)
Goal: Restore strength, endurance and function
a. Strengthening
b. Dynamic stabilization exercises

D. Bankart repair rehabilitation guidelines for arthroscopic repair
1. Multiple protocols exist; progressions will be based on integrity of soft tissue
2. General therapy guidelines status post stabilization arthroscopic repair progressions are slower than open repairs due to less soft tissue scarring

Phase I
Goal: Protect repair and decrease pain and inflammation
a. Protect healing capsule with immobilization sling
b. Prevent hypomobility with controlled PROM
c. Limited PROM ER 0-20 in scaption first 5 to 6 weeks
d. Limit PROM flexion and scaption 0-90 degrees
e. Diminish pain and inflammation with modalities
f. AROM in scaption at 4 to 6 weeks avoiding ER and ext beyond neutral
g. Contraindications: Excessive ER and extension motion. No forceful internal rotation. No flexion or scaption beyond 90 degrees

Phase II
Goal: Restore ROM
a. Discharge sling as soft tissue heals
b. Progress gradual PROM flex, scaption, abduction to end range at 10 to 12 weeks
c. Start PROM ABD/ER 30/30 progressing to 90/90 by 12 weeks
d. Progress AROM flex, scaption, and abd to end range as tolerated
e. Improve neuromuscular control
f. Contraindications: No aggressive ABD/ER, progress slowly to 90/90.

Phase III
Goal: Restore strength, endurance and return to function
a. No ROM restrictions
b. Scapular stabilization and rotator cuff strengthening

3. Outcome difference between Bankart open repair and Bankart arthroscopic stabilization
a. Bankart open associated with 12 degrees loss of external rotation[30]
b. Arthroscopic anterior shoulder stabilization procedures associated with higher re-dislocation rate compared to Bankart open repair (2-18% versus 11%)[31]

E. Superior labrum anterior posterior (SLAP) lesion
1. Superior labrum and biceps tendon injury

2. Increased anteroposterior and superoinferior translations in the lower and middle ranges of elevation[32]
3. Humeral head pulls on the superior labrum and biceps anchor resulting in tearing away from the glenoid
4. Involves anchor of the biceps tendon to the labrum
5. 4 types
    a. Type I: degenerative fraying of the superior labrum with the edge firmly attached to the glenoid rim
    b. Type II: detachment of the superior labrum and biceps tendon from the glenoid with destabilization of the biceps anchor (most common, 55% of labrum tears)
    c. Type III: bucket-handle tear of the superior labrum
    d. Type IV: bucket-handle tear of the superior labrum with extension into the biceps tendon
6. Clinical presentation
    a. Compressive force applied to shoulder ie: fall on an outstretched arm that is abducted and slightly flexed (most common)
    b. Traction injuries
    c. Repetitive injury related to eccentric deceleration
    d. Repetitive traction when throwing referred to as "peel back" mechanism[33]
    e. Repetitive overhead lifting
7. Obligate translation in throwers
    a. Posterior capsule contracture with decreased IR results in the humeral head forced posteriorsuperiorly instead of posteriorinferiorly during cocking phase[34]

C. History
1. Subjectively c/o deep pain, popping and clicking
2. Mechanism of injury

D. Special tests
1. O'Brien's test (Sensitivity 47%, specificity 55%)[35]
2. Compression rotation test (Sensitivity 24%, specificity 76%)[18]
3. Rehabilitation
    a. Conservative Management
        1. Rest, physical therapy, NSAIDs
        2. No data is available regarding efficacy of conservative management
4. Operative management has proven to be successful[36]
    a. Type I and III: arthroscopic debridement of the frayed portion
    b. Type II: frayed tissue is debrided and detached biceps-labral complex is reattached to the superior glenoid with suture anchors or biodegradable tacks
    c. Type III: debrided and surgically repaired
    d. Type IV: depends on the extent of biceps involvement whether the frayed portion is debrided or repaired. Detached portion is reattached with suture anchors or biodegradable tacks.
5. Rehabilitation: Type II repair
    Phase I
    Goal: Protect repair, decrease pain, protected ROM.

1. Usually immobilized in a sling for ~ 3-4 weeks to allow healing of repaired structures
2. PROM with humerus adducted: IR 0-45, ER 0-30
3. PROM/AAROM flexion 0-90 and controlled IR/ER as above (~4 wks post-op)
4. Contraindications: PROM/AAROM IR>45, ER>30, ext, 90/90 position, active biceps contraction

Phase II
Goal: Restore ROM

5. Discharge sling when soft tissue is healed (usually 6 weeks post-op but protocols vary)
6. Gradually progress PROM to full ROM by 8-10 wks
7. Gradually progress AROM to full ROM by 10-12 wks
8. Progress to 90/90 position ~ 8 wks
9. Restore posterior capsule extensibility
10. Scapular stabilization exercises in safe positions

Phase III
Goal: Restore strength for return to function
Regain length to posterior capsule

11. Rotator cuff strengthening starting at 30/30 in scaption and progressing to 90/90
12. Scapular stabilization exercises
13. Proprioceptive/kinesthetic exercises
14. Total body conditioning

a. Rehab process typically takes 3-4 months
b. Rehab of type I and III is limited only by symptomatic healing time. Progression into ROM, strength, proprioceptive exercise can occur as soon as pain dictates.
c. Outcomes: Early treatment with staple fixation demonstrates good to excellent outcomes[37]

3. Acromio-clavicular (AC) Instabilities
   A. Six types[38]
      1. Type I: Sprain without loss of joint congruity
      2. Type II: Disruption of AC joint ligaments with joint subluxation and coracoacromial ligament sprain
      3. Type III: Dislocation of AC joint with both coracoacromial(CC) ligaments
      4. Type IV: Same ligament disruption as type III, but clavicle dislocates posterior
      5. Type V: AC and CC disruption with clavicle widely spread from acromion and button-hole through trapezius
      6. Type VI: AC and CC disruption with distal clavicle displacing inferior into subacromial or subcoracoid space (Fig. 4)
   B. Rehabilitation
      1. Type I: Conservative management with sling, cryotherapy, rest and NSAIDs.
      2. Type II: Same treatment as Type II, but will likely require longer immobilization period.
      3. Conservative management types I, II
         Goal: Pain reduction, protect healing structures, prevent capsular stiffness, progress to function use

Chapter 15 Figures

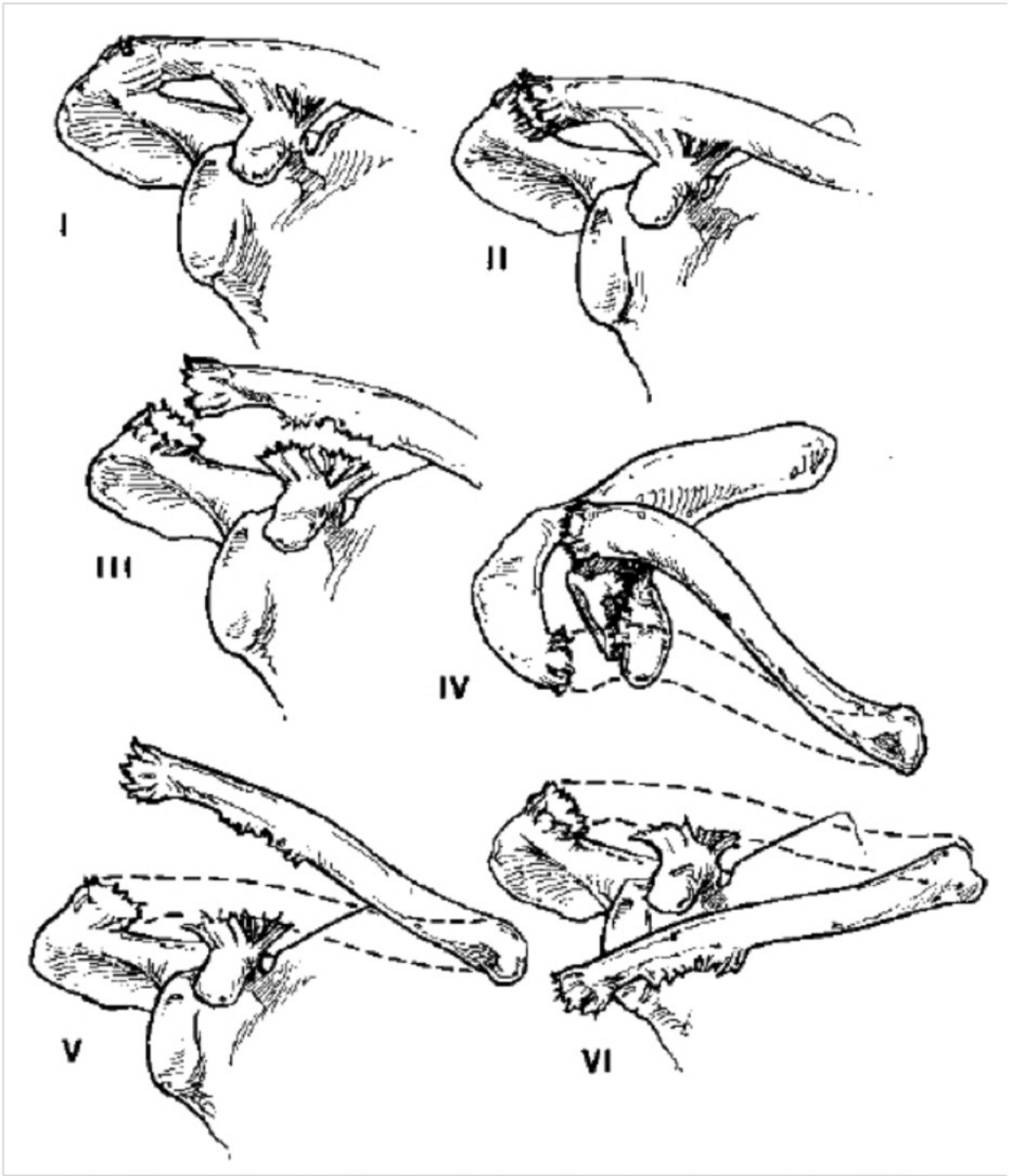

Fig. 4. Acromioclavicular Joint Injuries.

a. Phase I: Pain control and protected ROM side-lying or standing to allow scapular motion to couple with clavicle.
b. Phase II: Advance to strengthening exercises
c. Phase III: Dynamic strengthening progressing to power, endurance and neuromuscular control.
d. Contraindications: Traction forces to arm

4. Type III: Conservative or surgical management. Advantage of surgical management is potential reduction of step-off deformity. [39]
5. Type IV-VI: Varying techniques of surgical management are described in the literature.
    a. Surgical management types III, IV, V, VI
        1. 4 to 6 weeks with AC sling.
        2. Phase I: Protective phase 4 to 6 weeks with AC sling
        3. Phase II: Advance to ROM and light strengthening.
        4. Phase III: Progress strengthening for return to work/activity goals
        5. Contraindication: Stress to repair during first 4 to 6 weeks

4. Fractures of the humerus

A. Basic Science of Fracture Healing[40]

1. Fracture union can occur through primary or secondary healing
2. *Primary healing* occurs with compression and stability to direct bone growth across fracture line provided through fixation devices.
3. *Secondary healing* occurs when motion is minimized through a fracture gap resulting in fibrous callus repair that converts to bone. Secondary healing occurs with closed reduction or reduction with semi-rigid fixation. Fracture ends are approximated for alignment, but not compressed.
4. Primary Healing Phases: inflammatory, fibroplasia, remodeling
    a. Inflammatory phase (3 to 5 days)
        1. Hematoma is eliminated by the apposition of fracture ends during reduction.
        2. Bone ends are compressed and held together by implants
        3. Osteoclasts form cutting cones and move across fracture gap to form haversian canals.
        4. Blood vessels re-vascularize bone fragments as they cross the fracture site.
    b. Fibroplasia phase (4 to 5 weeks)
        1. Osteoblasts fill the haversian canals with new osteons
        2. New bone unites the fracture site
        3. New woven bone is weak
    c. Remodeling phase (6 to 8 weeks)
        1. Bone remodeling occurs through static and cyclic loading along the fracture line
        2. Bone gains tensile strength
        3. Lamellar bone is formed (Fig. 5)
5. Secondary Healing Phases: Overlapping phases of inflammatory, fibroplasia, remodeling
    a. Inflammatory Phase (0 to 5 days)
        1. A hematoma expands spanning the fracture gap and surrounding area

2. Macrophages phagocytose necrotic areas of bone
3. Release of signaling factors that initiate tissue regeneration
4. Growth factors signal the recruitment, proliferation, and differentiation of mesenchymal stem cells.
5. Stem cells commit to becoming cell types required for tissue restoration (angioblasts, chondroblasts, fibroblasts, osteoblasts)

b. Repair Stage (4 to 40 days)
1. Soft callus is formed in the first 2 to 3 weeks
2. Granulation tissue replaces the hematoma
3. Progenitor cells become osteoblasts, chondroblasts, and fibroblasts
4. Woven bone tissue is synthesized distal to the fracture site, chondrous tissue adjacent to the fracture site, and fibrochondrous tissue between the fragment ends.
5. Intramembranous ossification progresses towards the fracture gap and chondrocytes cease to proliferate.
6. Chondrocytes hypertrophy to form a large tissue mass.
7. The tissue mass forms a bridge that crosses the two fracture ends.
8. A bony or hard callus begins to form across the fracture gap.
9. Blood vessels invade spaces where chondrocytes have died.
10. Osteoclasts resorb calcified cartilage and osteoblasts subsequently secrete osteoid.
11. Osteoid is mineralized to form primitive bone.

c. Remodeling Stage (25 to 100 days)
1. Resorption of bone in low stress areas and deposition of bone in areas of high stress.
2. Osteoblasts secrete osteoids in areas of applied stress.
3. The osteoids form concentric and interstitial lamellae.
4. Mechanical loading or unloading facilitates fracture alignment.
5. Callus formation and lamellar remodeling occurs. (Fig. 6)

B. Humeral fractures
1. Lesser tuberosity: Rare; often seen with posterior dislocation
   a. Closed reduction
2. Greater tuberosity
   a. Usually the result of a fall on the shoulder
   b. Common in elderly individuals
   c. Non-displaced: begin active exercise ASAP to avoid stiffness
   d. Displaced and/or avulsed: usually requires surgical fixation with post-op immobilization 2-3 weeks
3. Neck of the humerus
   a. Fall on outstretched arm or elbow
   b. Usually older patient with low impact injury
   c. Categories: unimpacted, angulated impacted and comminuted
   d. Hemiarthroplasty often needed for older individuals with angulation greater than 45 degrees
   e. May require open reduction internal fixation (ORIF)
      1. Rehabilitation Neck of humerus fracture
         a. Phase I Goal: Protect fracture and maintain ROM

Chapter 15 Figures

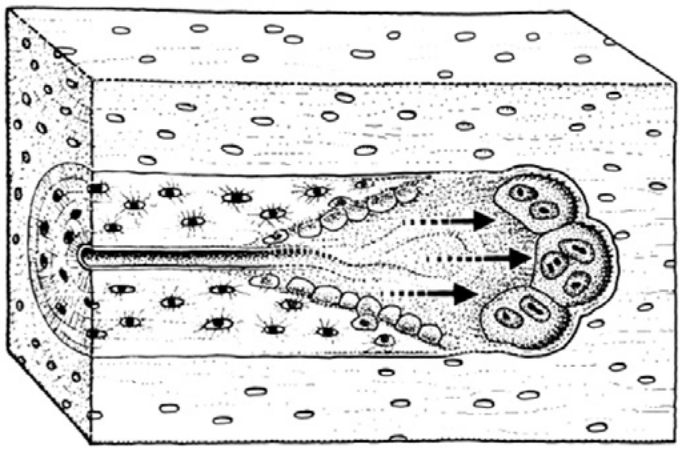

Fig. 5. Primary Bone Healing.

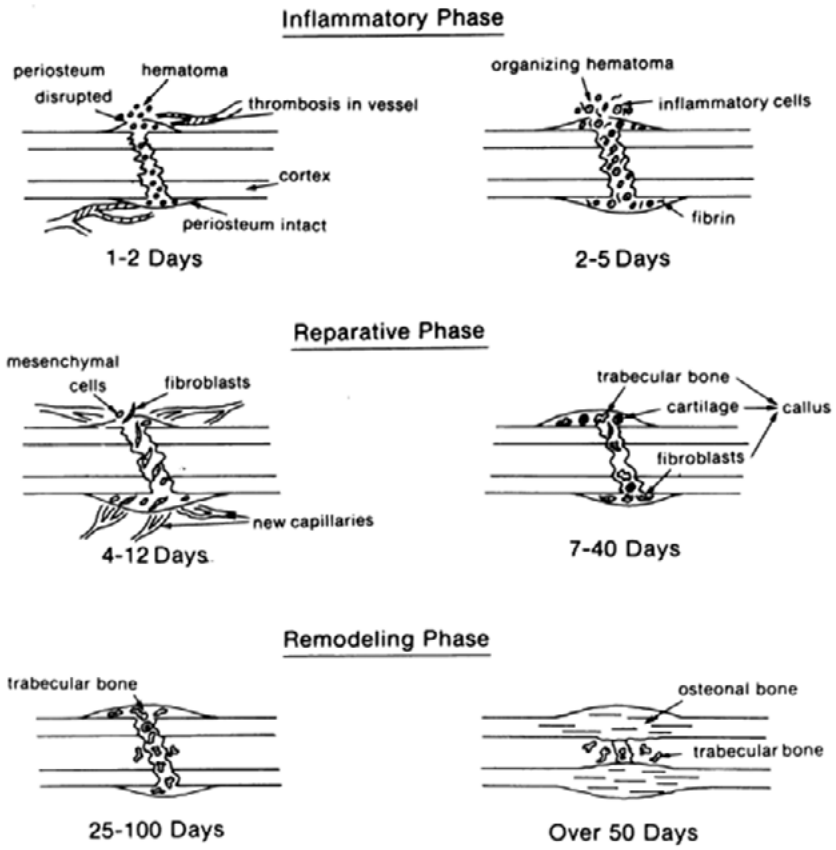

Fig. 6. Phases of Secondary Bone Healing.

   b. Immobilization depends on severity of displacement
   c. Impacted, nondisplaced can come out of sling for exercise frequently
   d. Significant displacement requires longer immobilization for 2-3 weeks
   e. Immobilization varies with ORIF
   f. Early movement is desired
   g. Progress to strengthening when bone is clinically healed
2. Shaft of the humerus: blow or twisting force causing spiral fracture in middle one-third of humerus
   a. Usually younger patient with high energy injury
   b. Early motion is desirable
   c. Immobilization varies depending on stability
   d. May require surgical fixation; watch for radial nerve palsies
3. Rehabilitation for non-operative humeral fractures (neck and shaft fractures) and goals:
   a. Phase I goal: Prevent capsular restrictions, manage pain and edema
   b. Phase II goal: Restore AROM progressing ROM goals as fracture heals (4 to 6 weeks post injury)
   c. Early mobilization is essential once safe, to avoid stiffness: A/AAROM, progress based on symptoms and bone healing
   d. Once fracture is stable initiate PROM
   e. Immobilization in a sling lends itself to capsular pattern
   f. Shoulder ROM as tolerated. Proximal humerus fractures start AROM approximately 6 weeks or per MD orders
   g. Grade I and II oscillatory mobilizations for pain and relaxation
   h. Phase III goal: Gain strength for return to previous level of function (12 weeks)
   i. Initial mobilization techniques
   j. Grade III and IV for ROM once pain levels are low
   k. Strengthening: once fracture is stable, pain is low and patient has 50% of ROM starting at approximately 12 weeks
   l. Shaft fractures treated with cast bracing generally have high union rate.
   m. Complications include non-union and/or nerve palsy
   n. Contraindication: aggressive ROM before bone healing
4. Rehabilitation for operative humeral fractures (neck and shaft) and goals
   a. Goals same as goals for non-operative fractures
   b. Surgical techniques vary. Shaft fractures may be treated operatively with intramedullary nail or plate fixation. Proximal neck fractures may be treated operatively with reduction and fixation or arthroplasty
   c. Phase I: Reduction and fixation generally begin with PROM to tolerance
   d. Phase II: Advance to AAROM when radiographic union evident

e. Phase III: Begin strengthening at 12 to 16 weeks as healing occurs
f. Surgical complications include avascular necrosis, fixation failure, infection, nerve injury, and stiffness.
g. ROM progressed slowly when sutures tie down tuberosity
h. ROM progressions predicted on the type and adequacy of fixation device.
i. AAROM advancement dictated by radiographic union and patient tolerance
j. Contraindication: aggressive ROM before bone healing

5. Total Shoulder Arthroplasty
   A. Indications: osteoarthritis, rheumatoid arthritis, avascular necrosis, cuff tear arthropathy, acute fractures, posttraumatic arthritis
   B. May be done with a rotator cuff repair depending on soft tissue quality
   C. Two classifications for rehabilitation
      1. Set normal ROM progression goals when patient has good pre-op ROM and good rotator cuff tissue
      2. Set limited ROM goals (physician will assign this category) when patient has poor pre-op PROM and poor rotator cuff tissue
      3. Check with referring physician regarding status of rotator cuff
         a. General principles
            i. ROM: PROM initiated post-op day 1
            ii. Do not exceed the amount of ER achieved in OR for first 6 weeks. If don't know, do not exceed 0° to 10°
            iii. Scapular strengthening exercise at 2-3 weeks. Progress to RTC strengthening at 8 weeks
            iv. Time guidelines will be delayed if RTC repair was performed and for the patient with limited goals
            v. Outcomes regarding pain relief are good
            vi. Outcomes regarding function are based on quality of soft tissues as determined by physician
            vii. Poor soft tissue quality: "eyes to thighs" function
      4. Goal: Stable shoulder during functional activity with minimal pain.
      5. Contraindications: No active IR during phase I of rehabilitation
      6. Precautions: Aggressive ROM and strengthening
         a. Protect subscapularis with limited ER ROM and no active IR during first 8 weeks
6. Reverse Shoulder Arthroplasty (rTSA)[41]
   A. Indications: pain not controlled by nonoperative methods including: cuff tear arthropathy, failed conventional prosthetic arthroplasty with superior, anterior, or posterior instability, or failed reconstruction following traumatic injury with significant instability.
   B. Rehabilitation
      1. General Principles
      2. Phase I:
         a. Goal: Protect soft tissue structures
         b. Wear shoulder immobilizer for ~ 4 to 6 weeks post-op
         c. Light ADLs below shoulder level

   d. PROM with forward flexion to 90 working towards 120 degrees, 0 working towards 30 degrees external rotation with arm adducted, scaption to 90 degrees
   e. Contraindications: ER past limits determined by surgeon to protect subscapularis,if indicated.No reaching behind back (IR).
   Initial PROM guided by intraoperative measures. If unknown limit passive flexion to 120°, external rotation to 10° to 30°, and abduction to 45°
3. Phase II:
   a. Goal: Functional ROM
   b. Wean from shoulder immobilizer
   c. AAROM in flexion, scaption, ER and IR within limits determined by surgeon
   d. Submaximal deltoid isometrics and scapular stabilization.
   e. Progress PROM to operating room goals
4. Phase III:
   a. Goal: Functional strength
   b. Begin strengthening supine with shoulder flexion
   c. Progress to isotonic strengthening with 1 to 2 lbs against gravity
5. Phase IV:
   a. Goal: Functional shoulder with stability and no pain
   b. Progress to closed chain activities and work/sports specific exercises
6. Contraindications: Aggressive internal rotation. Avoid activities positioning shoulder in external rotation and abduction beyond 80 degrees to avoid stress at the anterior capsule.

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Multiple Choice Questions

1. Which passive motion should be avoided following a Bankart open repair?
   A. Passive flexion/scaption to 70 degrees
   B. Passive external rotation greater than 20 degree and passive scaption/flexion pass 90 degrees
   C. Passive external rotation to 10 degrees
   D. Passive extension to 0 degrees

2. What is the translation of the head of the humerus when a superior labrum anterior posterior (SLAP) lesion?
   A. Posteriorsuperior translation with adduction
   B. Posterioroinferior with internal rotation
   C. Anterioroposterior and superoinferior translations in the lower and middle ranges of elevation
   D. Posterioroinferior with adduction

3. What is a contraindication following a SLAP lesion repair during the protective stage of healing?
   A. Glenohumeral PROM at 90/90 (abduction/external rotation)
   B. PROM external rotation to 20 degrees with glenohumeral joint adducted
   C. PROM glenohumeral joint to 70 degrees of flexion
   D. PROM IR to 0 degreees

4. Which best describes aacromio-clavicular (AC) type III dislocation?
   A. Disruption of the AC joint ligaments and joint subluxation and coracoacromial ligament sprain
   B. Clavicle widely spread from acromion and button-hole through trapezius
   C. Dislocation of the AC joint with both coracoacromial ligaments
   D. Sprain without loss of joint congruity

5. Which iinterventions are most desirable during the early phase of humeral shaft fractures?
   A. Grade III and IV joint mobilizations
   B. Strengthening exercises
   C. Isometric exercises to biceps and triceps
   D. Early ROM when fracture is stabile

6. What is a contraindication following total shoulder arthroplasty?
   A. Edema reduction techniques
   B. PROM within safe arcs of motion and tolerance
   C. Aggressive ROM and strengthening
   D. Scapular motion

7. Which best describes primary fracture healing?
   A. Fibrous callus repair converts to bone
   B. Compression and stability through a fixation device directly allows bone growth across the fracture line.
   C. Fracture repaired with closed reduction
   D. Fracture ends are approximated but, not compressed

Multiple Choice Questions

8. Which best describes therapy interventions during the early phase of a type I AC joint injury?
   A. Sling, cryotherapy, rest, and NSAIDS
   B. ROM to end ranges
   C. Scapular strengthening
   D. Upper trapezius stretching

9. Which clinical test is NOT indicated for a glenohumeral anterior-inferior instability?
   A. Apprehension test
   B. Load and shift test
   C. Subluxation/relocation test
   D. O'Briens test

10. Which muscle is protected during the early phase of healing following a TSA?
   A. Long head of the biceps requiring limitations of passive elbow extension
   B. Subscapularis requiring limitations of ER
   C. Supraspinatus requiring limitations of passive adduction
   D. Posterior deltoids requiring limitations of passive cross body adduction

11. What is a precaution during phase II of rehabilitation following a reverse shoulder arthroplasty?
   A. Light ADLs below shoulder level
   B. Wean from shoulder immobilizer at 4 to 6 weeks post-op
   C. PROM to 90 degrees of shoulder flexion
   D. Aggressive internal rotation

12. Which best describes the mechanism of injury when the humeral neck is fractured?
   A. Direct blow to the humerus
   B. Twisting of the humerus
   C. Fall on outstretched arm or elbow
   D. Fall on the greater tuberosity of the humerus

13. What is complication following humeral shaft fractures?
   A. Necrosis of the supracondylar region
   B. Osteoporosis
   C. Osteopenia
   D. Nerve palsy and/or non-union

Multiple Choice Question Answer Key
Chapter 15

1-B, 2-C, 3-A, 4-C, 5-D, 6-C, 7-B,
8-A, 9-D, 10-B, 11-D, 12-C, 13-D