

UPPER QUADRANT BIOMECHANICS

RIBS

COSTOVERTEBRAL JOINT is a synovial modified ovoid capable of anterior-posterior rotation.

COSTOTRANSVERSE JOINT is synovial modified ovoid capable of superior-inferior glide and is the one we treat. Anterior rib joints will often be tender and possibly inflamed as a result of a posterior fixation.

RIBS 1-6 primarily roll anterior and glide superior with expiration and roll posterior with an inferior glide with inspiration (pump handle action).

RIBS 7-10 primarily roll and glide posterior-medial-superior (PMS) with expiration and anterior-lateral-inferior (ALI) with inspiration (bucket handle action).

RIBS 11-12 have limited movement in anterior and slight inferior glide with inspiration and posterior and slight superior with expiration (caliper type action).

SHOULDER

Includes GHJ, AC, SC & ST articulations

PRIMARY FACTORS RESPONSIBLE FOR STABILITY:

- Depth of fossa

- Labrum

- Rotator Cuff

SECONDARY STABILITY FACTORS:

- Limited joint volume – negative pressure and suction effect (if intact)

- Adhesion-cohesion – 2 solid surfaces in contact with small layer of fluid

Ligaments: Inferior, middle & superior GHL (Z), coracohumeral

Other mm: Deltoid, Clavicular fibers of PMJ, coracobrachialis, LHB, LD, RMM, TMJ, SA, LS

ACROMIOCLAVICULAR & STERNOCLAVICULAR JOINTS

INSPIRATION & EXPIRATION:

Same as ribs

Coronal axis

Posterior rotation with inspiration & anterior with expiration

ELEVATION & DEPRESSION:

Sagittal Axis through root of scapula with an impure swing

RETRACTION & PROTRACTION:

Moving centre of rotation on lateral scapular notch & distal clavicle

Axis vertical through SC joint

Anterior rotation with protraction, posterior with retraction

UPWARD & DOWNWARD ROTATION:

Moving centre on lateral clavicle with sagittal axis

Upward involves posterior and downward anterior rotation

GLENOHUMERAL JOINT

Do not follow typical concave-convex rule

Affected by capsular tension (e.g. Anterior tension creates a posterior glide)

Therefore less translation in mid-ranges with increases in outer ranges

Flexion >55° Ant glide

Extension > 35° Post glide

IR Anterior and ER Posterior

Abduction <30° superior and >30° variable Superior-Inferior

FLEXION-EXTENSION

Coronal axis through centre of humeral head & fossa

55° flexion and 35° extension with ROM 90-110°

ABDUCTION-ADDUCTION

AP axis through centre of humeral head & fossa

ROM 80-90°

INTERNAL ROTATION – EXTERNAL ROTATION

Superoinferior longitudinal axis through humerus

Posterior on ER and anterior on IR

ROM IR 70-90°, ER 60-100°

ER increases with GHJ ABDUCTION

SCAPTION

Movement in plane of scapula with is approx. 30° in a sagittal direction from a pure coronal plane.

SPINAL JOINTS & RIBS

T1-2 – ipsilateral extension, with rib 1-2 inferior

T3 – is an axis level

T4-6 – possible contralateral extension, with rib 4-6 superior

GLENOHUMERAL JOINT OSTEOLOGY – humerus convex, glenoid concave

AC JOINT OSTEOLOGY – Planar, +/- articular disc

SC JOINT OSTEOLOGY – Sellar with articular disc, clavicle convex vertical & concave AP

THORACIC SPINE BIOMECHANICS

Movement	Osteokinematics	Arthrokinematics
Flexion	Anterior sagittal rotation with anterior sagittal translation Rib rotates anteriorly	Z-Jt Superior-anterior glide Rib 1-6 CT-Jt superior glide Rib 7-10 CT-Jt PMS All ribs CV-Jt anterior spin
Extension	Posterior sagittal rotation with posterior sagittal translation Rib rotates posteriorly	Z-Jt Inferior-posterior glide Rib 1-6 CT-Jt inferior glide Rib 7-10 CT-Jt ALI All ribs CV-Jt posterior spin
Side Flexion	Ipsilateral translation and contralateral rotation Ipsilateral rib rotates anterior Contralateral rib posterior	Ipsilateral Z-Jt glides inferior and contralateral superior glide Ipsilateral rib superior-anterior and drives the vertebra Contralateral inferior-posterior
Rotation	Ipsilateral side flexion and contralateral translation Ipsilateral rib rotates posterior Contralateral rib anterior	Ipsilateral Z-Jt glides inferior and contralateral superior Ipsilateral rib inferior and contralateral superior glide
Inspiration	Posterior Sagittal Rotation Rib 1-6 Pump Handle Rib 7-10 Bucket Handle Rib 11-12 Caliper	Rib 1-6 Inferior glide Rib 7-10 ALI glide
Expiration	Anterior Sagittal Rotation	Rib 1-6 Superior glide Rib 7-10 PMS glide

ELBOW

ULNOHUMERAL JOINT

DEGREES OF FREEDOM – 1

ARTHROKINEMATICS

Flexion with adduction: anterior and lateral of ulnar on humerus

Extension with Abduction: Posterior and medial ulna on humerus

CPP – extension with supination

RP – 70° flexion and 10° supination

CAPSULAR PATTERN – flexion > extension

END FEEL – flexion soft tissue and extension bony

ULNOHUMERAL JOINT OSTEOLOGY

Trochlea convex AP and concave medial-lateral with ulna reciprocally curved

Oblique orientation with medial more distal hence carrying angle (10-15°)

Conjunct swing of ulna in abduction with extension and add with flexion

Conjunct rotation occurs into supination with flexion and pronation with extension

RADIOHUMERAL JOINT

DEGREES OF FREEDOM – 2 (flexion-extension, medial-lateral rotation)

ARTHROKINEMATICS

Flexion: anterior glide

Extension: posterior glide

Supination: anterior glide of medial radius with lateral spin on humerus

Pronation: posterior glide of medial radius with medial spin on humerus

CPP – 90° flexion and 5° supination

RP – extension with full supination

CAPSULAR PATTERN – flexion > extension

END FEEL – flexion soft tissue approximation and extension bony

RADIOHUMERAL JOINT OSTEOLOGY

Capitulum convex, radial head concave

Restrained by annular and quadrate ligaments and causes head of radius to follow ulna during flexion-extension ROM

SUPERIOR RADIOULNAR JOINT

DEGREES OF FREEDOM – one (supination-pronation)

ARTHROKINEMATICS

Supination: anterior glide with anterior to posterior roll

Pronation: posterior glide with posterior to anterior roll

CPP – Full pronation or supination

RP – superior RUJ 35° supination and 70° flexion, Inf RUJ 10° supination

CAPSULAR PATTERN – equal loss pronation and supination

END FEEL – capsular (however pronation may be bony)

SUPERIOR RADIOULNAR JOINT OSTEOLOGY

Radial head convex and radial notch on ulna concave

Ant translation of radius supination and posterior with pronation

WRIST

INFERIOR RADIOULNAR JOINT

Radius concave and ulna convex

DEGREES OF FREEDOM – 1 (prone-supination)

ARTHROKINEMATICS

Supination: posterior glide and rock of distal radius on ulnar

Pronation: anterior glide and rock of distal radius on ulna

CPP – full pronation & extension or full supination

RP – mid position (slight pronation, flexion & UD)

CAPSULAR PATTERN – equal limitation of pronation & supination

END FEEL – supination capsular

TFCC: Articular disc, meniscus, UCL, dorsal & palmar radioulnar ligament, ECU

RADIOCARPAL & ULNOMENISCOCARPAL JOINTS

DEGREES OF FREEDOM – 2 (flexion-extension, RD-UD)

CPP- full extension

RP – slight flexion with UD

CAPSULAR PATTERN – equal all directions

END FEEL – Capsular, except RD boney

RADIUS & TFCC CONCAVE SURFACE TO CONVEX PROXIMAL ROW OF CARPALS

MIDCARPAL & INTERCARPAL

DEGREES OF FREEDOM – 2 (flexion-extension, RD-UD)

CPP - mid-carpal neutral to full extension

Inter-carpal extension

RP - mid-carpal slight flexion & UD

Inter-carpal neutral to slight flexion

CAPSULAR PATTERN - equal all directions

NORMAL END FEEL - capsular

Convex scaphoid, concave trapezium & trapezoid

Capitate convex all surfaces

Concave lunate & triquetrum articulate with convex capitate and hamate

ARTHROKINEMATICS OF THE WRIST

Flexion

Dorsal glide of proximal carpals on TFCC and radius

Dorsal glide of hamate and capitate on proximal row

Palmar glide trapezoid and trapezium on scaphoid

Extension

Palmar glide of proximal carpals on TFCC and radius

Palmar glide of hamate and capitate on proximal row

Dorsal glide trapezoid and trapezium on scaphoid

Radial Deviation

Ulnar glide of proximal carpal row on radius/TFCC

Radial glide and dorsal rotation of distal on proximal row

Capitate spins

Scaphoid rotates to horizontal and trapezoid rolls posterior and lateral over scaphoid

Ulnar Deviation

Radial glide of proximal row on radius/TFCC

Ulnar glide of distal row on proximal row

Capitate spins

Trapezium rolls anterior and medial over scaphoid

Pronation

Palmar glide & rotation of medial & lateral carpal columns on central

Supination

Dorsal glide & rotation of medial & lateral carpal columns on central

HAND

FIRST CARPOMETACARPAL JOINT

TYPE: Trapezium sellar, concave palmar-dorsal & convex radial-ulnar & reciprocal curve on MC1

DEGREES OF FREEDOM – 2 (flexion-extension, abduction-adduction)

ARTHROKINEMATICS

Flexion – ulnar glide MC1 on trapezium

Extension- radial glide MC1 on trapezium

Abduction – dorsal glide MC1 on trapezium

Adduction – palmar glide MC1 on trapezium

CPP – full opposition or extension & abduction

RP – Mid-position

CAPSULAR PATTERN – equal loss extension and abduction

END FEEL – Capsular, except soft tissue approximation with adduction

SECOND – FIFTH CARPOMETACARPAL JOINTS

MC2 – planar trapezoid, trapezium & capitate

MC3 – convex capitate

MC4&5 – slightly convex with concave capitate and hamate

DEGREES OF FREEDOM – 2 (flexion-extension, Abduction-Adduction)

ARTHROKINEMATICS

Flexion: palmar glide MC 2 on trapezoid, MC 3 on capitate, dorsal glide MC4&5 on hamate

Extension: dorsal glide MC 2 on trapezoid, MC 3 on capitate, palmar glide MC4&5 on hamate

Abduction: Radial glide of MC2 on trapezium, MC3 stationary, radial glide MC4&5 on hamate

Adduction: Ulnar glide of MC2 on trapezium, MC3 stationary, ulnar glide MC4&5 on hamate

CPP – full extension

RP – slight flexion with ulnar deviation

CAPSULAR PATTERN - loss of flexion>extension

END FEEL – Capsular

METACARPOPHALANGEAL JOINT

MCP – MC3 and capitate are axial bones, MC2&3 are stable for thumb opposition, MC4&5 mobile for adaptable grasp.

MC heads convex, proximal phalanges concave

ARTHROKINEMATICS

Flexion - palmar glide of phalanx on MC

Extension - dorsal glide of phalanx on MC

Abduction - radial glide of phalanx 2 on MC, ulnar phalanx on MC4&5

Adduction - ulnar glide of phalanx 2 on MC, radial phalanx on MC4&5

CPP - full flexion

RP – slight flexion

CAPSULAR PATTERN – loss of flexion>extension

END FEEL – capsular

INTERPHALANGEAL JOINTS

Base concave dorsal-palmar and convex radial-ulnar

Head convex dorsal-palmar and concave radial-ulnar

DEGREES OF FREEDOM – one

ARTHROKINEMATICS

Flexion - palmar glide distal phalanx on proximal

Extension - dorsal glide distal phalanx on proximal

CPP – full extension

RP – slight flexion

CAPSULAR PATTERN – loss of flexion > extension

END FEEL - capsular

LOWER QUADRANT BIOMECHANICS

LUMBOPELVIC BIOMECHANICS

Movement	Innominate	Sacrum	L5
Trunk Flexion	Posterior Rotation relative to sacrum	Nutation or flexion relative to innominate	Flexion and anterior translation on sacrum
Trunk Extension	Anterior rotation relative to sacrum	Counternutation or extension relative innominate	Extension and posterior translation
Side Flexion (right)	Left translation Right rotates anterior Left rotates posterior	Sacral base rotates to left	Variable – tends to follow sacrum
Rotation (right)	Right innominate posterior and left anterior	Sacral base rotates left	Rotates right with conjunct side flexion variable
Hip Flexion (right)	Right posterior rotation	Right sacral rotation Bilateral sacrum nutated	Rotates right

HIP

Femoral head convex & directed sup-ant-medial

Acetabulum concave

Coxa Vara/Valga, Anteversion/Retroversion

DEGREES OF FREEDOM – 3

ARTHROKINEMATICS

- Abduction – inferior glide

- Adduction – superior glide

- IR – posterior glide

- ER – anterior glide

- Flexion-Extension – spin

HABITUAL MOVEMENT – gait FABER-EADIR

CPP – FADIR

RP - 30° flexion, abduction and slight ER

CAPSULAR PATTERN

- EARLY - extension-IR & flexion-adduction, extension-ER

- LATE – flexion-adduction-IR > extension-ER

KNEE

Medial Femoral Condyle Convex, Tibial surface Concave

Lateral Femoral Condyle Convex, Possible Sellar Tibial Surface

Trochlear Groove – Articular surface for patella – concave medial-lateral, convex superior-inferior

Patella is a sesamoid bone with vertical ridge dividing medial and lateral facets

Patella moves superior medial in extension and inferior lateral in flexion

TIBIOFEMORAL JOINT

DEGREES OF FREEDOM – 2 (flexion-extension, medial-lateral rotation)

ARTHROKINEMATICS

Flexion: posterior glide with medial rotation (unlocking)

Extension: anterior glide with lateral rotation (locking)

PATELLOFEMORAL JOINT

EXTENSION: superomedial

FLEXION: inferolateral

TIBIOFIBULAR JOINT

DEGREES OF FREEDOM – 2

ARTHROKINEMATICS – variable

END FEELS – capsular for all joints

CAPSULAR PATTERN – tibiofemoral is loss of flexion > extension

Tibiofibular is pain on Biceps Femoris contraction

RP – 30° flexion

CPP- Extension-ER

SUPERIOR TIBIOFIBULAR JOINT

Planar facet

Dissipates torsional stress applied to ankle

Dissipates lateral bending forces

Absorption of tensile loads

FOOT & ANKLE

Ankle is comprised of:

INFERIOR TIBIOFIBULAR JOINT

- Dissipates force / shock

- Allows movement from AP on talus

- Distal fibula is convex and fibular notch of tibia concave

TALOCRURAL JOINT

- Mortise with dome of talus convex AP and concave medial-lateral wedge shaped with posterior narrower

SUBTALAR JOINT

- One posterior and two anterior facets

- Axis aligns and becomes rigid in supination and are parallel and unlocked in pronation

- Posterior facet of the calcaneus convex and talus concave

- Talar facet convex and calcaneus concave

MID-TARSAL JOINTS

- Talonavicular – proximal navicular concave and talus convex

- Calcaneocuboid – Proximal cuboid concave superior-inferior and convex medial-lateral

- Cubonavicular – planar

- Cuneonavicular – convex distal navicular & concave proximal cuneiforms

- Cuneocuboid – planar lateral surface of lateral cuneiform with cuboid

INTERCUNEIFORM JOINTS

- Planar surfaces