JUST BREATHE 101

Biomechanics of the Region

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OBJECTIVES

1. Describe the biomechanics of rotation of a thoracic ring at the levels T1-T7.

2. Describe the biomechanics of the Cervical spine, Thoracic spine, ribs, clavicle and manubrium with elevation of the right or left shoulder.

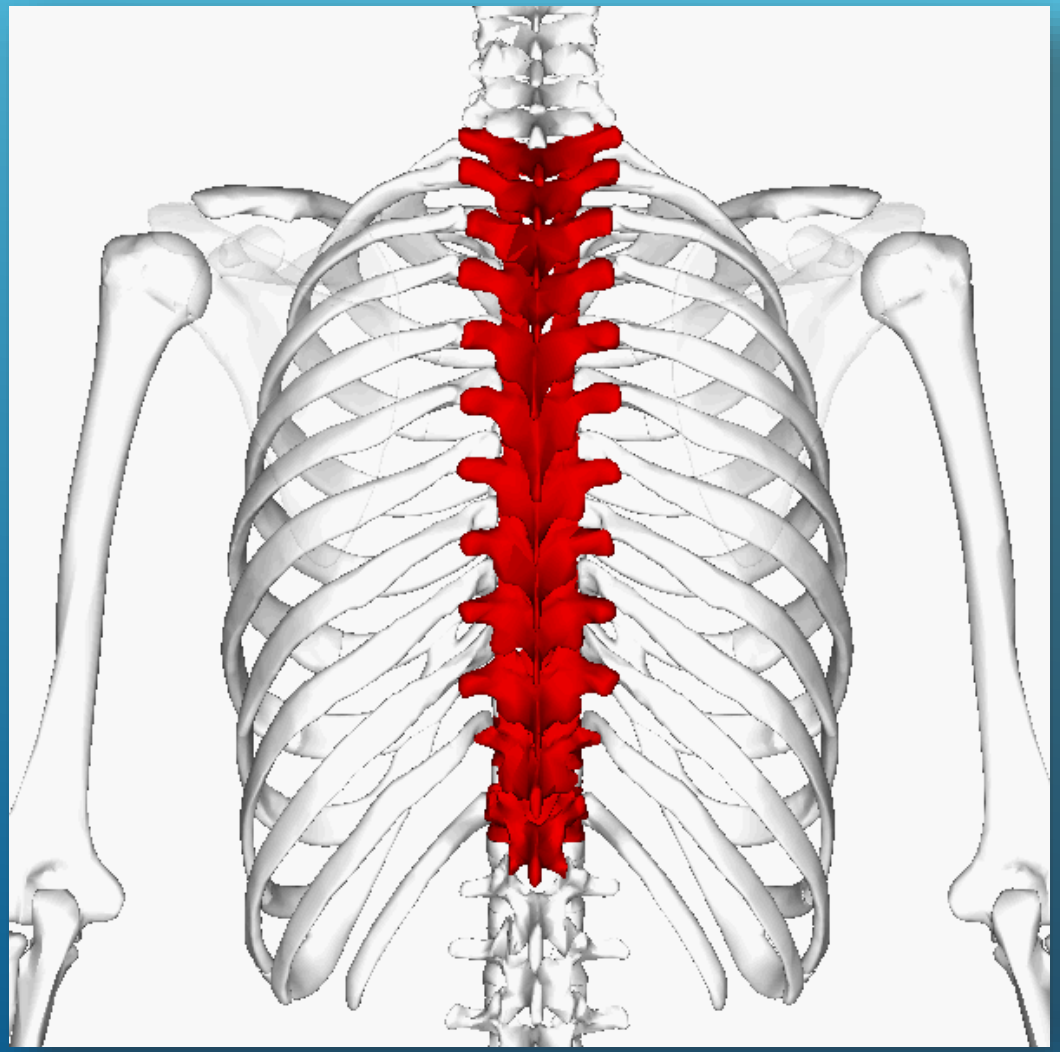
3. Describe the biomechanics of flexion and extension at the Costotransverse joint T9 level.

4. Describe the differences in motion of the mobile segments between T3 -T7 with side flexion occurring first in the Thoracic Spine.

CANADIANISM'S

THORACIC SPINE AND RIBS ANATOMY AND BIOMECHANICS

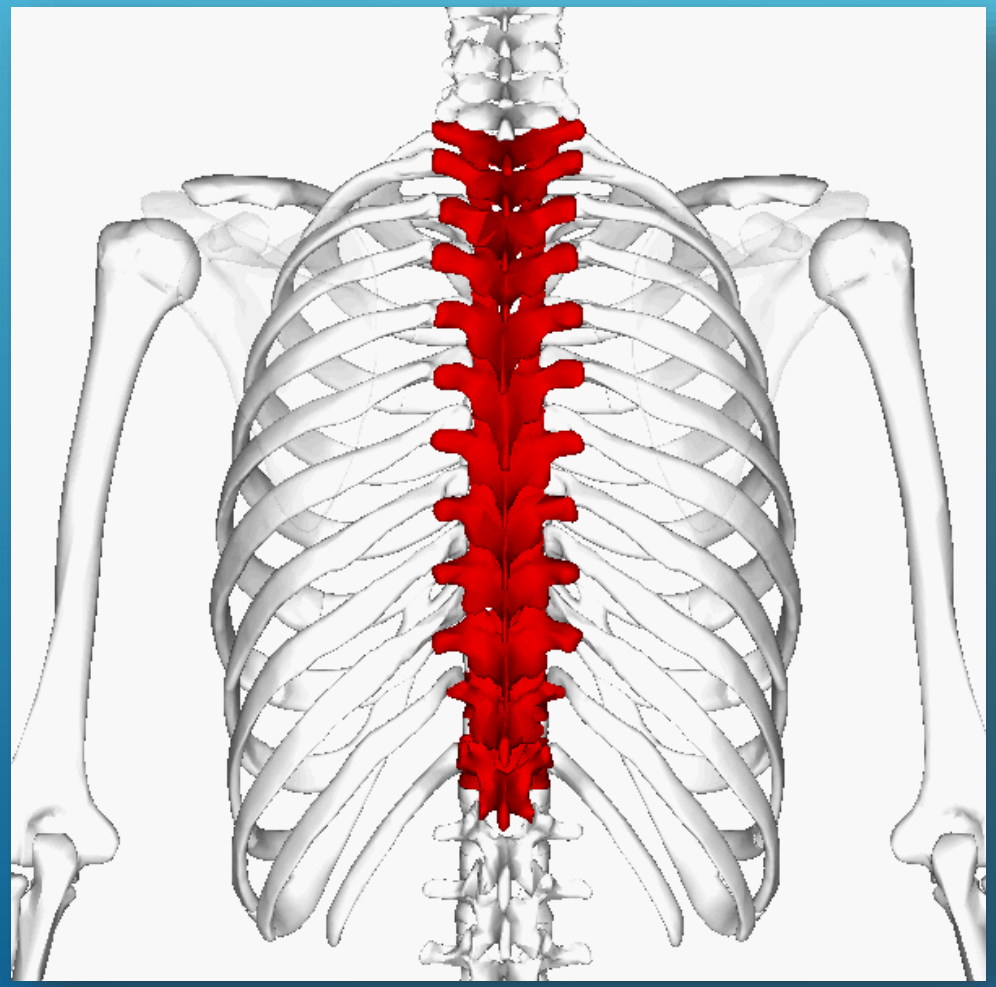
THORACIC SPINE ANATOMY



Rib Cage Adds:

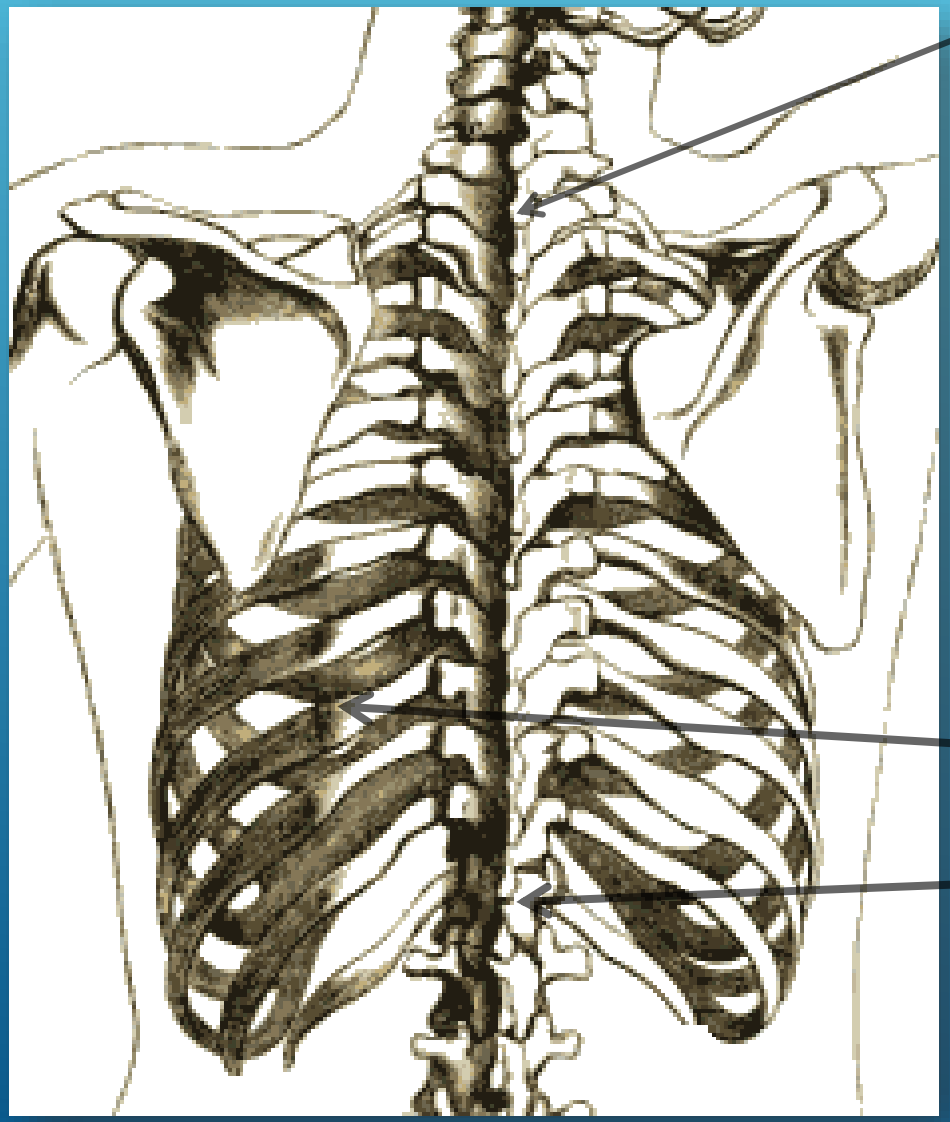
- Stiffness
- Strength
- Has energy absorbing capacity
- Protective cage for vital viscera
- Zygapophyseal/facet joint plane allow rotation

THORACIC SPINE ANATOMY



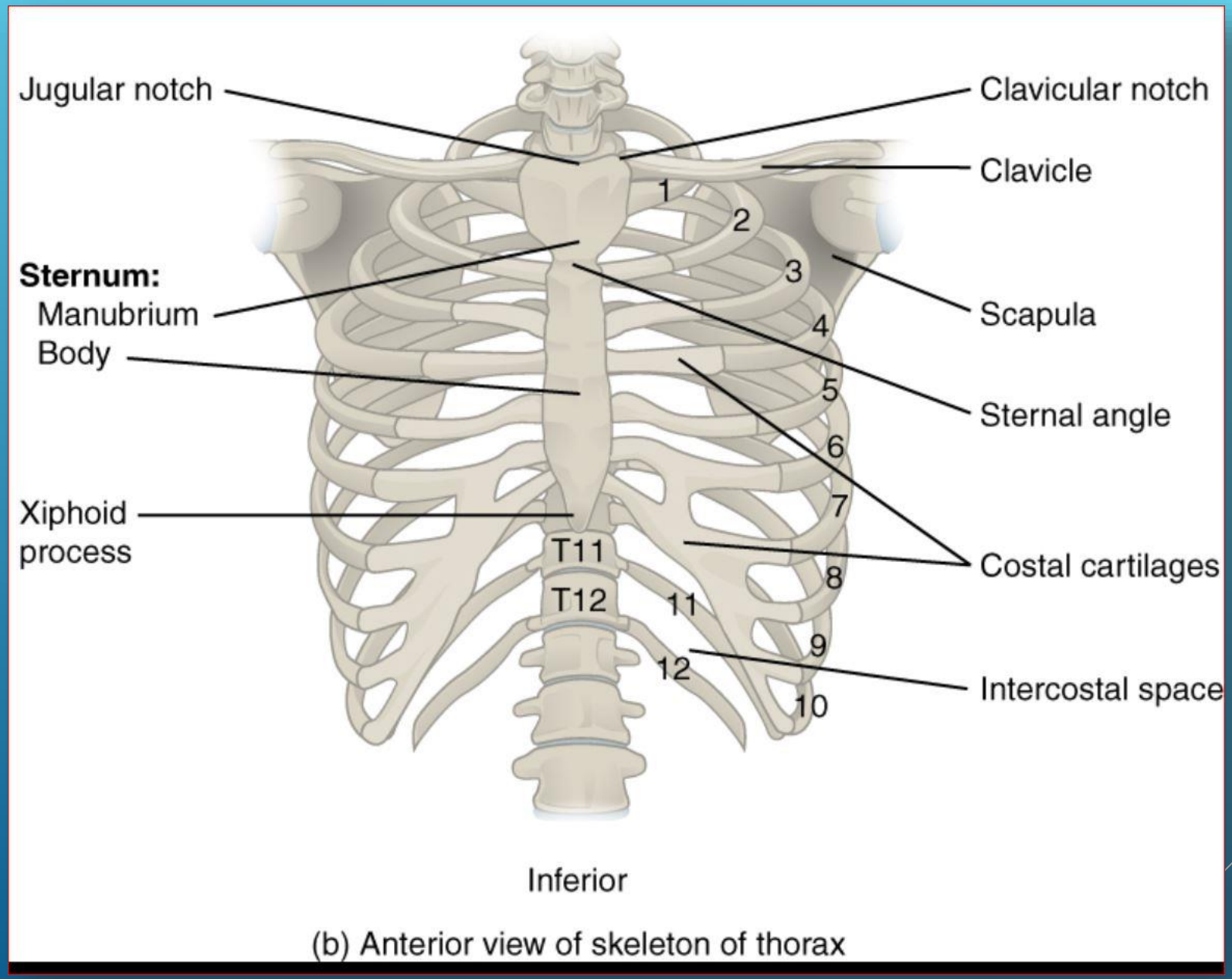
- Sternum
- Spinous processes are varing lengths and relations to same level joint
- Costovertebral joint adds stability against excessive lateral shear

THORAX POSTERIOR VIEW

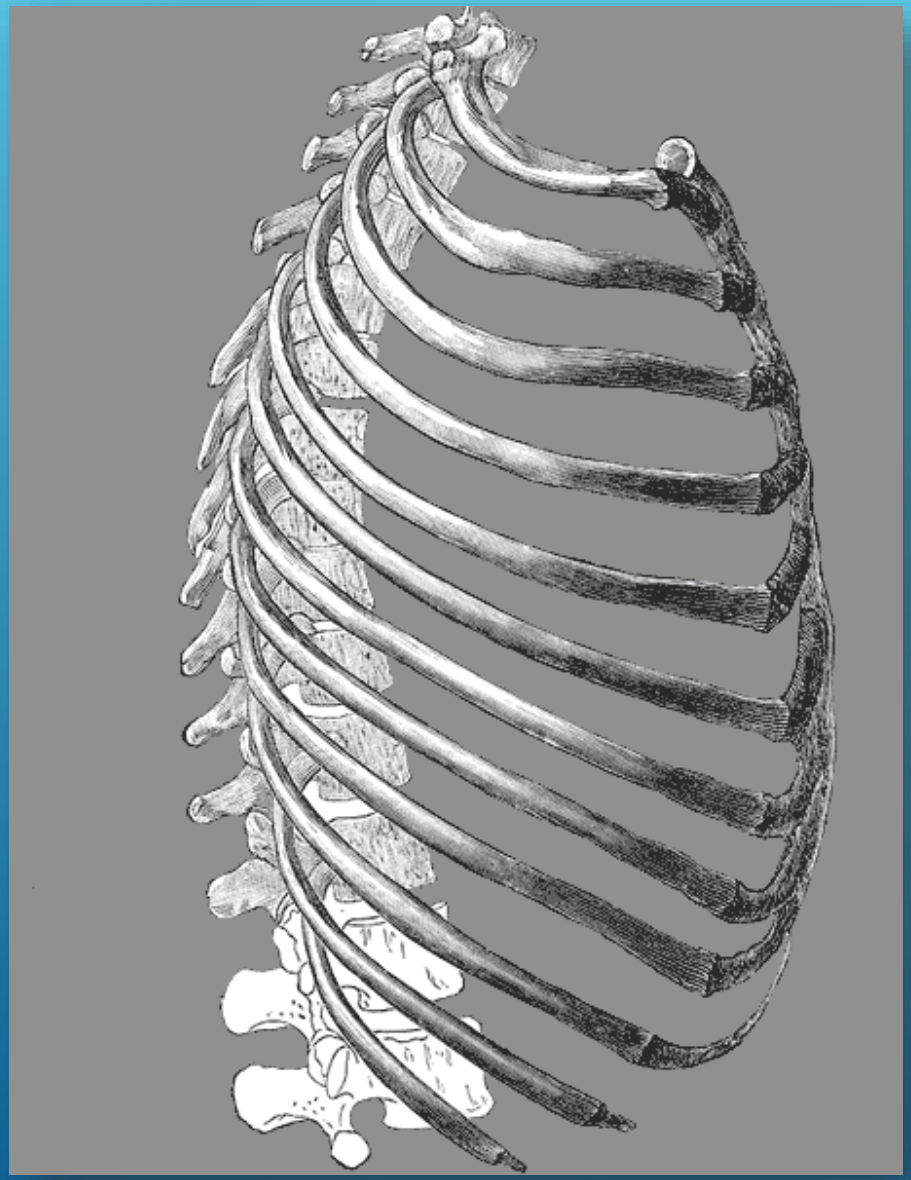


Center of Rotation of the Trunk

- Thoracic rings with 13 joints per ring (LJ LEE)
- 136 joints in the thorax
  - Protective unit
  - Closely related to autonomic nervous system



(b) Anterior view of skeleton of thorax



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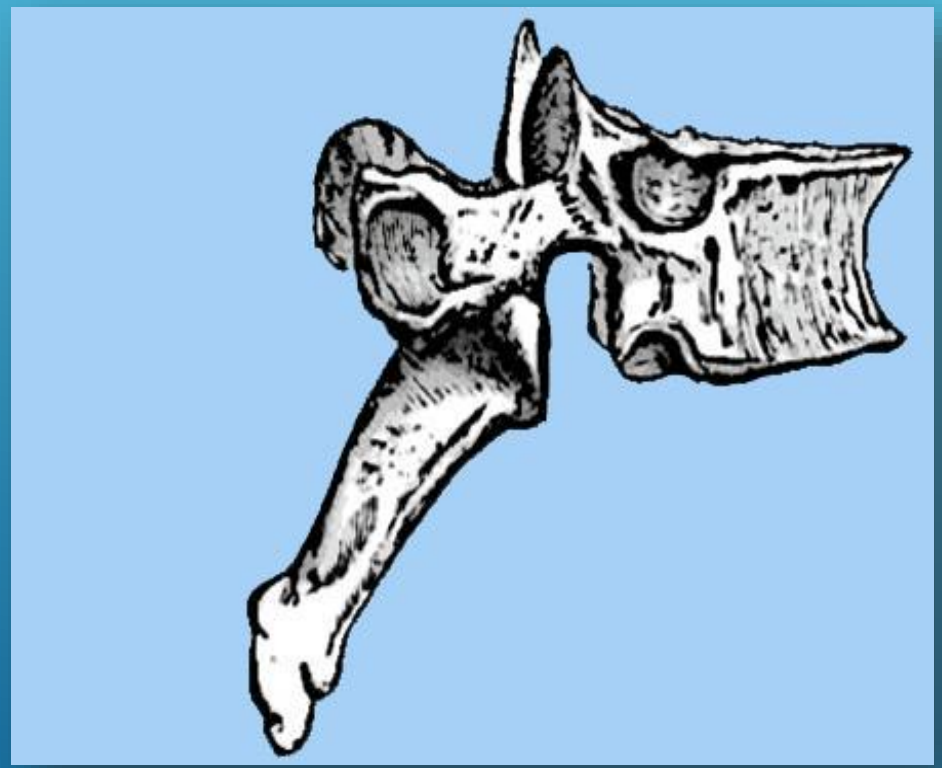
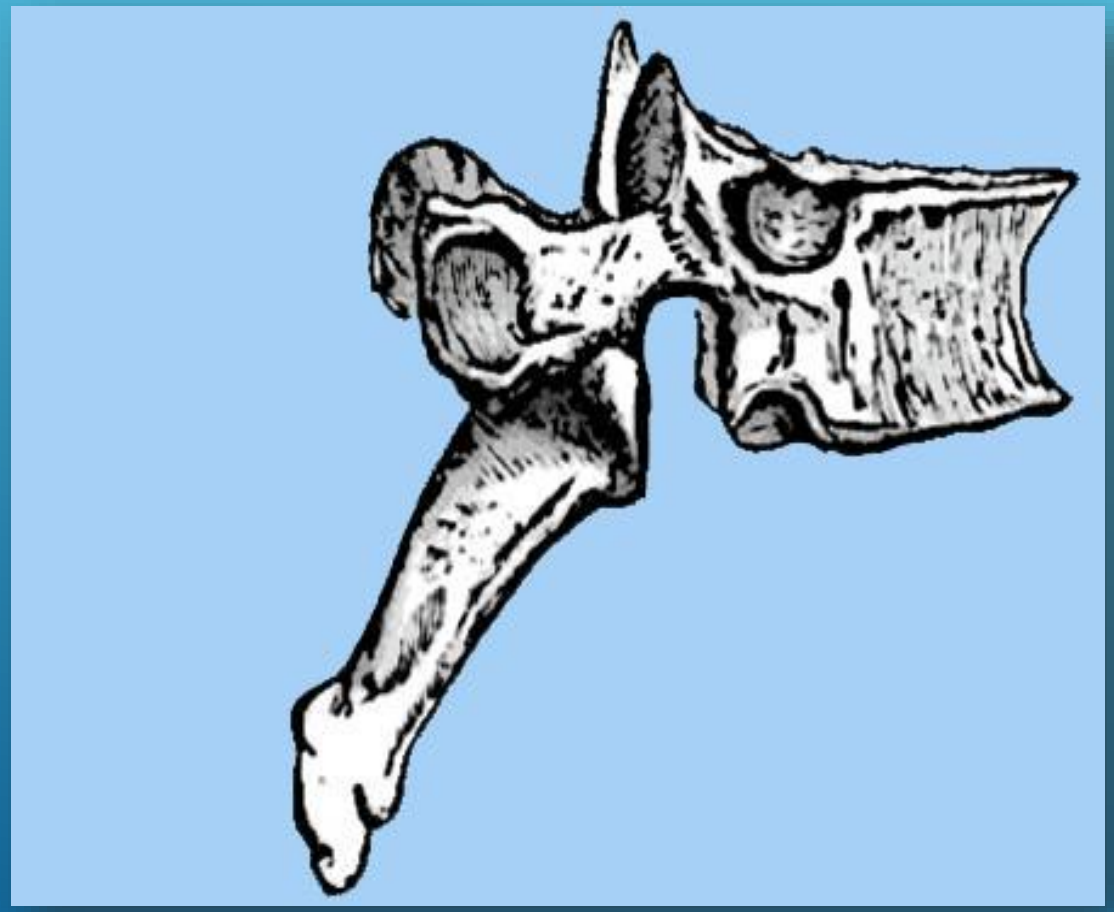
THORAX LATERAL VIEW

- Pain running along the line of rib
  - intercostal nerve pain
- Pain running transverse around trunk
  - Facet or “Z” joint pain referral
- Vague pain in region
  - Possible visceral referral

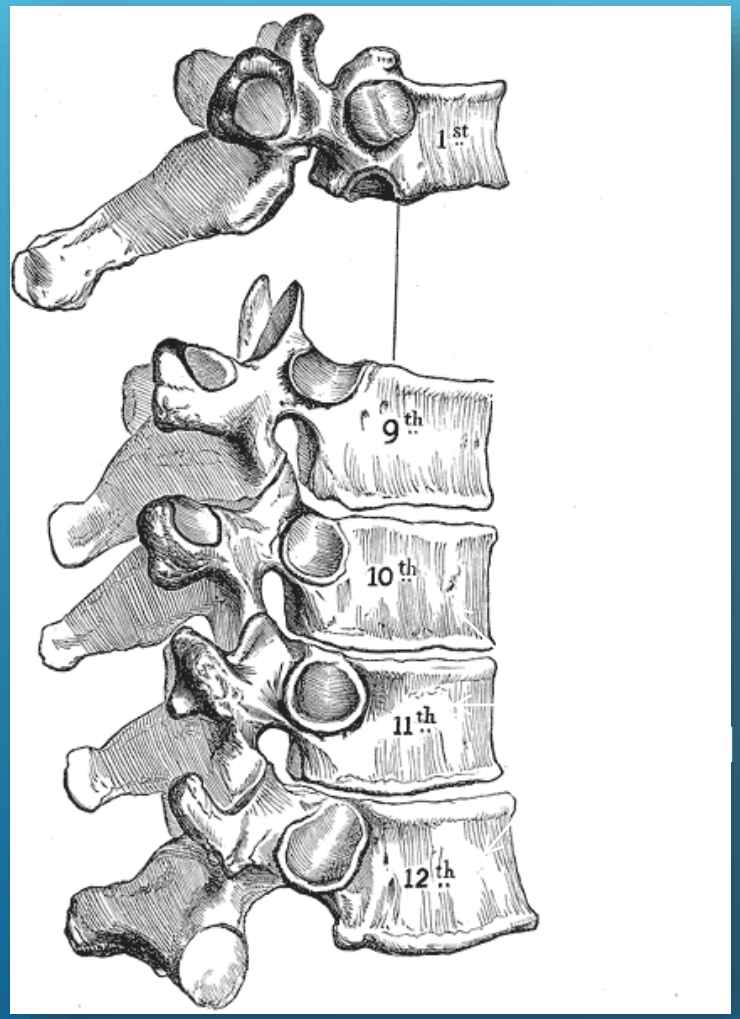


- Demi facets for ribs heads on vertebral body and TVP
- Elongated spinous processes
- Thin intervertebral disc which are supported by ALL and PLL
- Narrow oval shaped spinal canal- narrow especially between T4 and T9



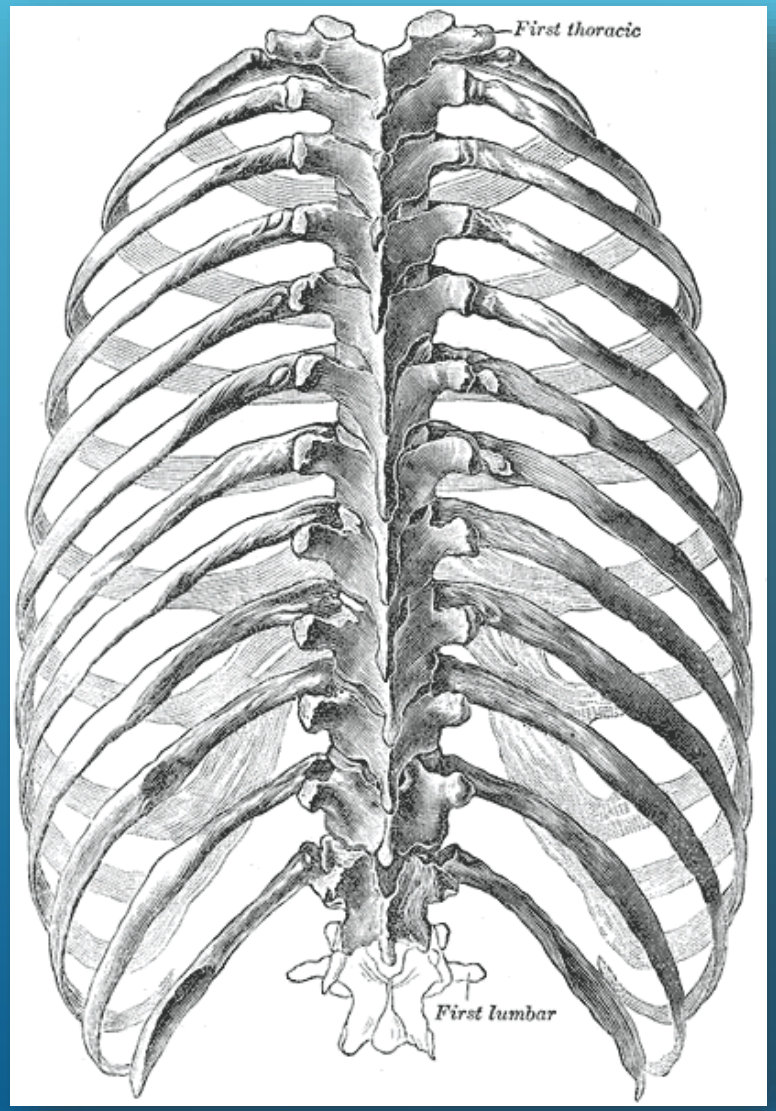
- Coronally oriented facets facilitate rotation in this region
- Typical segment has rib that articulates between two vertebrae and intervening disc
- Ribs will prevent excessive lateral translation

THORACIC SPINE ANATOMY



- T2 through T9 are considered typical
- T1, T10, T11, T12 are considered atypical
- Upper and lower thoracic vertebrae tend to be transitional and show lumbar and cervical similarities

SURFACE ANATOMY



- Rule of threes applies in surface anatomy

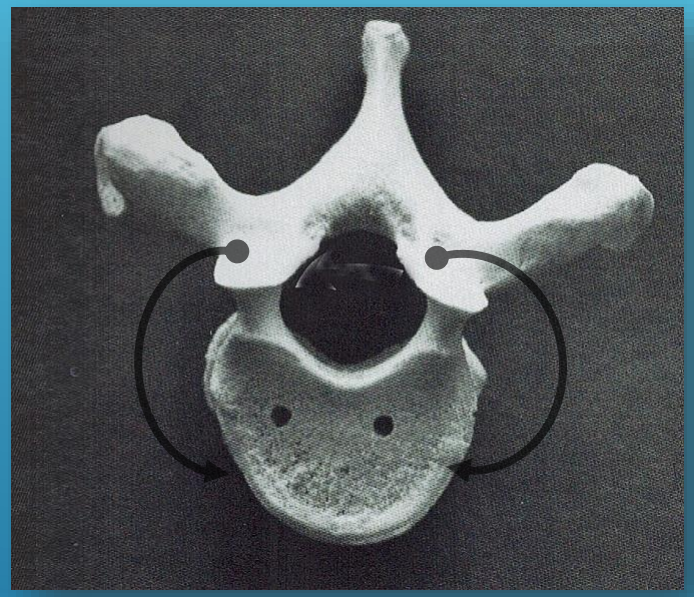
  Tip of spinous process to TVP to same segment

  - T1-3 1 finger breadth
  - T4-6 2 finger breadth
  - T7-T9 3 finger breadth
  - T10 3 finger breadth
  - T11 2 finger breadth
  - T12 1 finger breadth

  - Palpate laterally- less tissue and less tone

"Z" joint- Facet joint

THORACIC SPINE JOINT ORIENTATION



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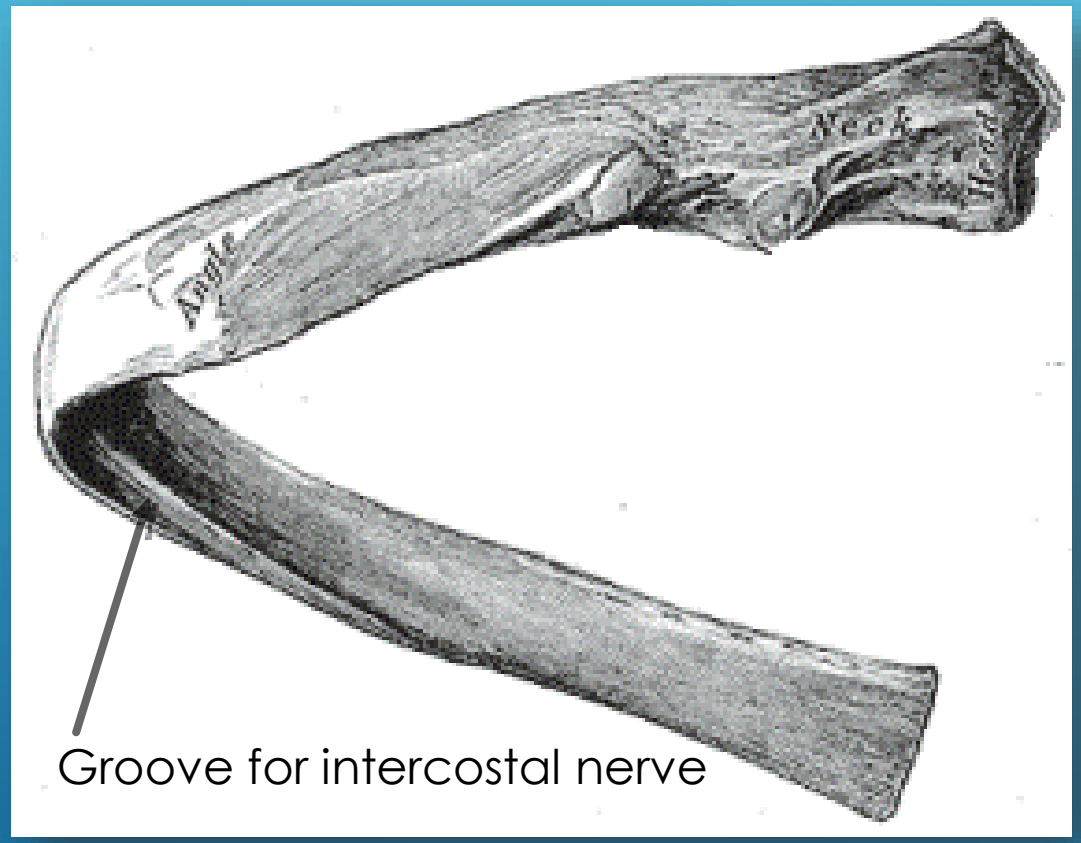
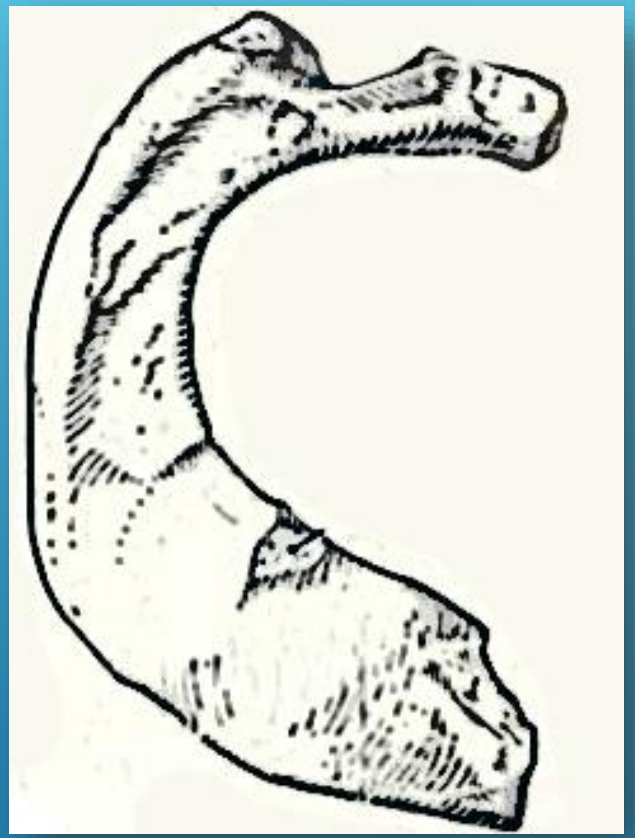
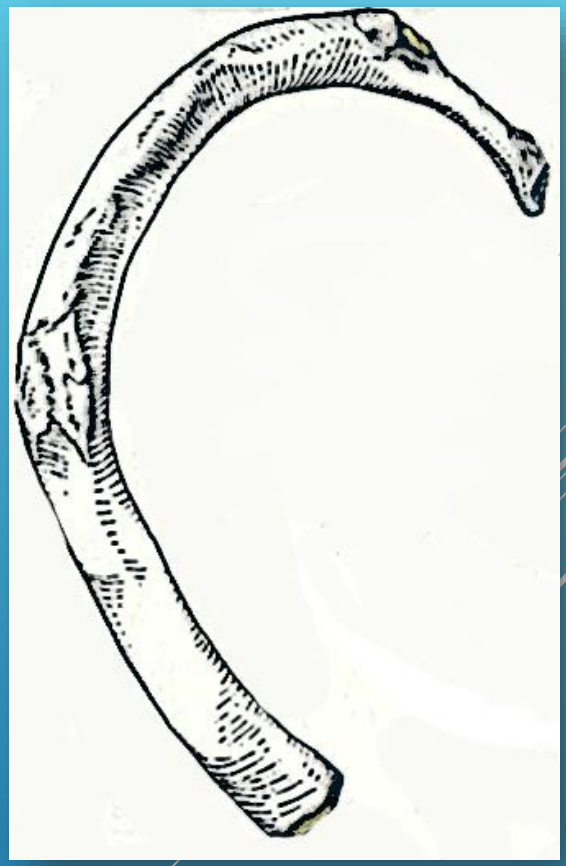
- "Z" joint planes are coronally oriented
- Axis of rotation nearer to centrum of the vertebral body
- Allows for pure rotation except for effect of ribs which restrict and modify coupling

THORACIC SPINE ANATOMY



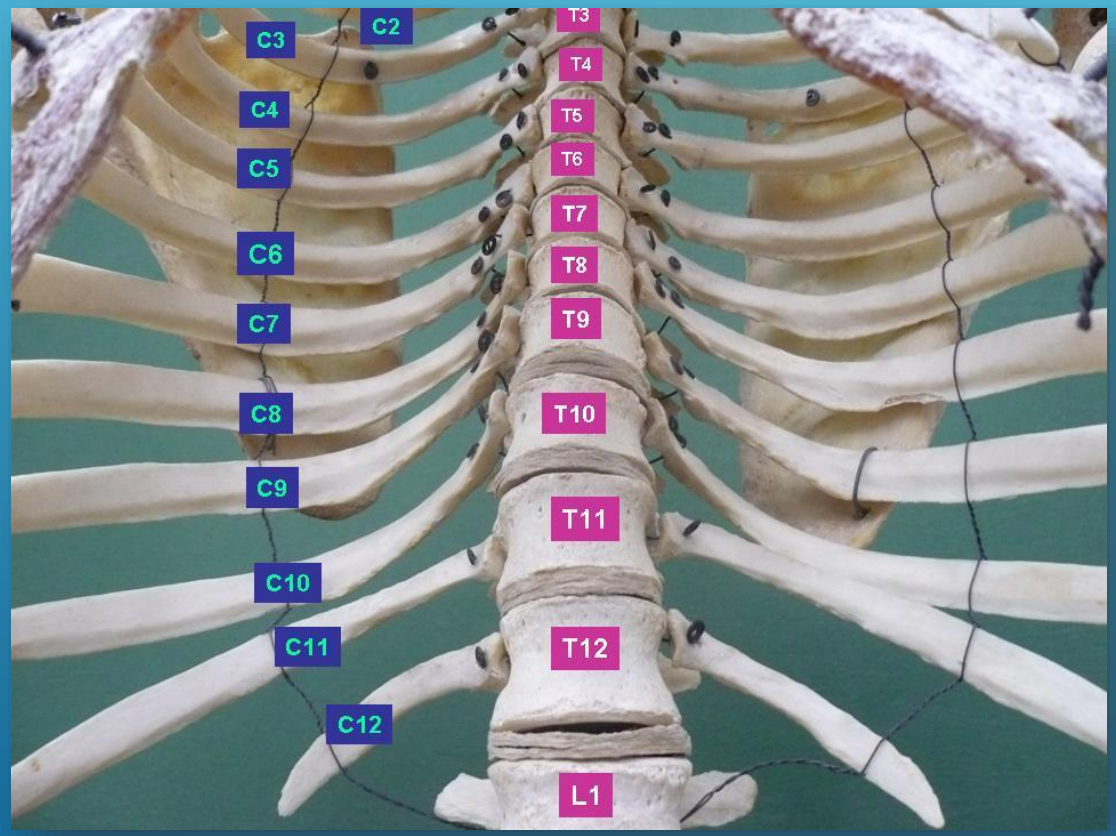




Typical rib 6th rib

First and second ribs

THORACIC SPINE ANATOMY



- Rib 11 and 12 have no tubercles or necks
  - detached anteriorly from thorax
  - provide attachments for lumbar and thoracic muscles
- Line of the rib angles is not vertical with 8th rib being furthest from the midline and the rib angles form a diamond shape above and below
- Rib angles are palpated just below or at the same level of the TVP

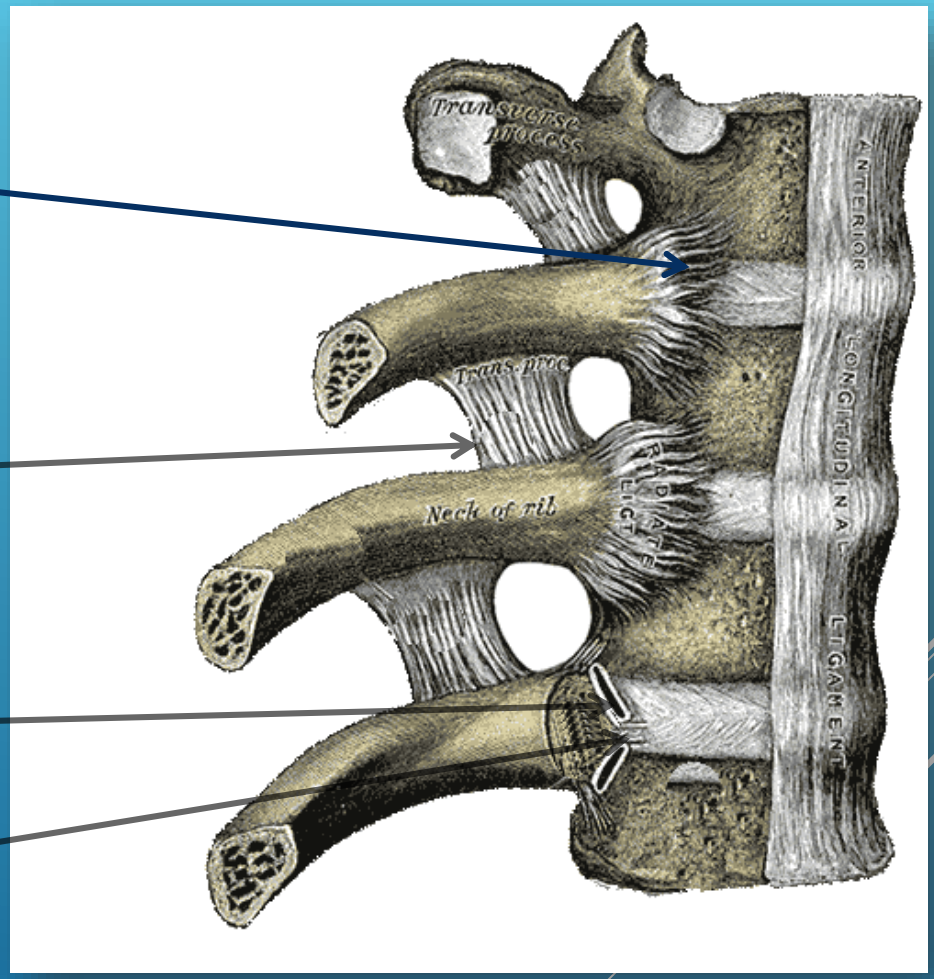
THORACIC SPINE: COSTOVERTEBRAL AND COSTOTRANSVERSE JOINTS

Radiate ligament

Superior costo Transverse ligament

Joint space

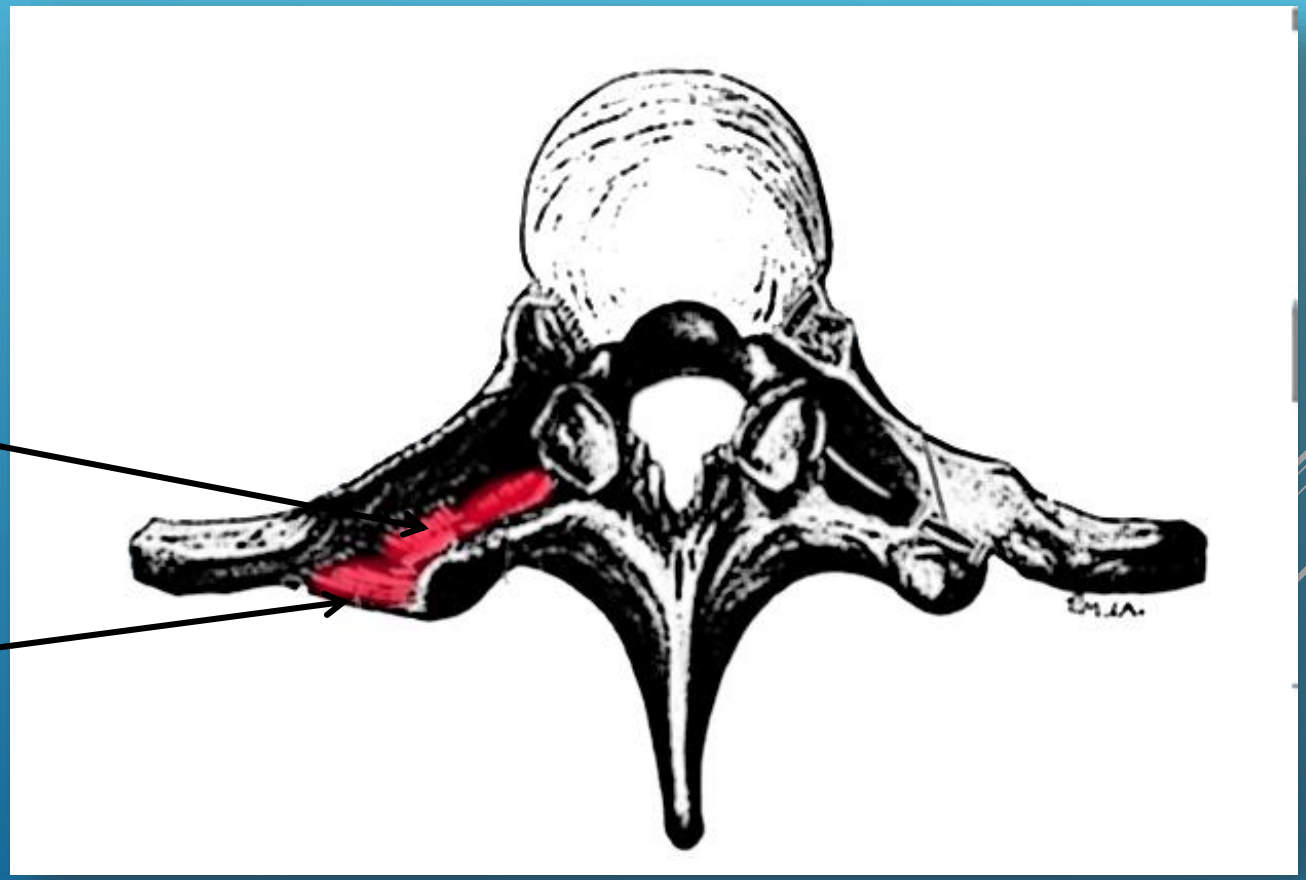
Intra articular ligament



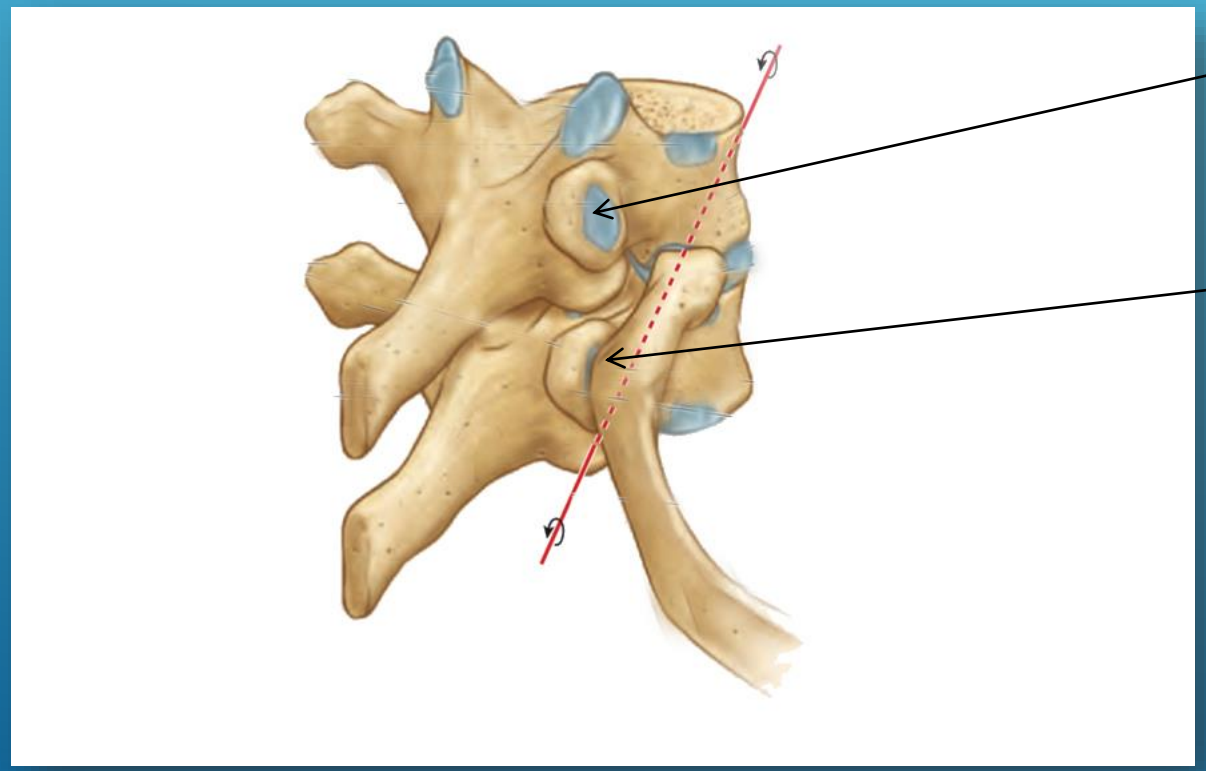
THORACIC SPINE ANATOMY: COSTOTRANSVERSE JOINTS

Costotransverse ligament

Lateral costotransverse ligament

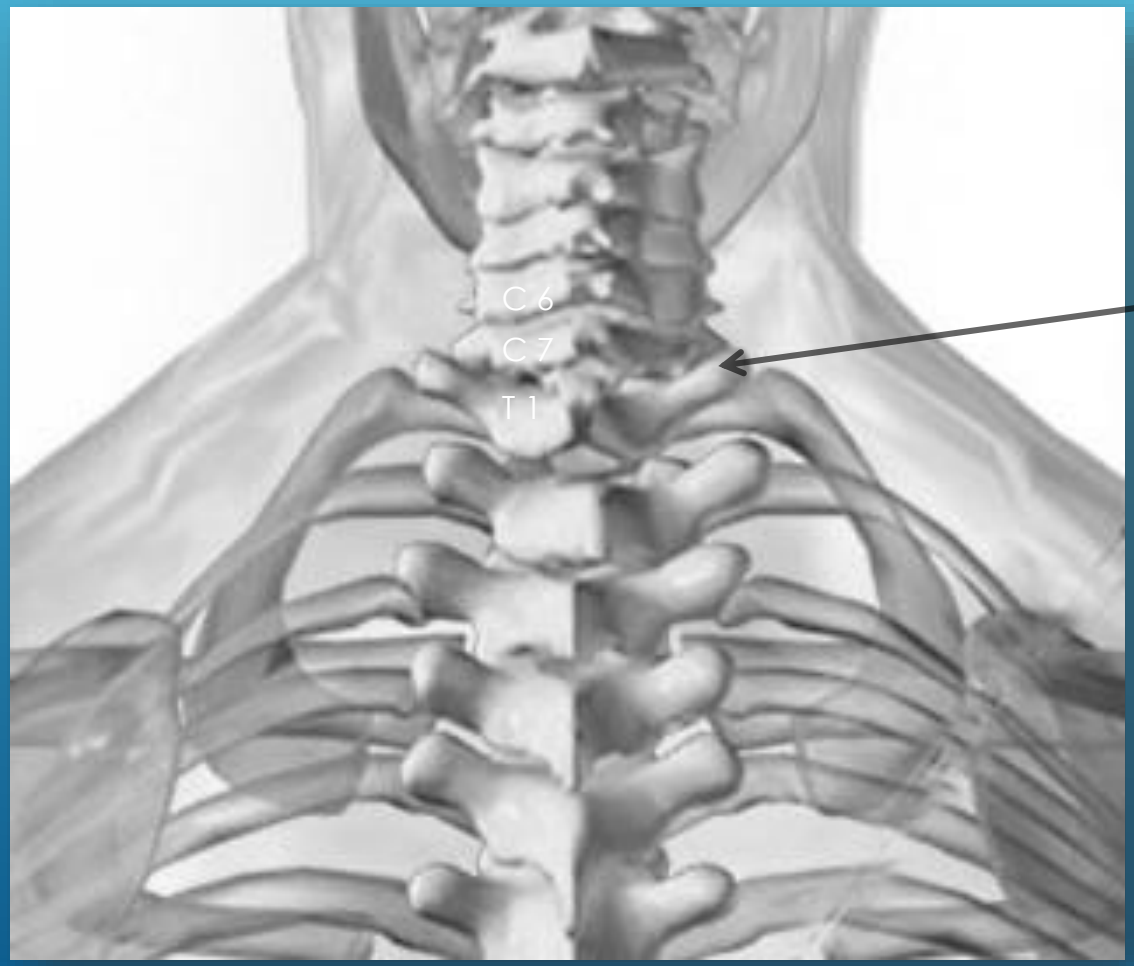


THORACIC SPINE ANATOMY: COSTOTRANSVERSE JOINTS



- Upper six ribs - concave surface of TVP - rotation of rib on long axis
- Convex tubercle of the rib fits into concave facet
- Lower three ribs (7-10) tubercles are flatter and face obliquely down, medial and backwards

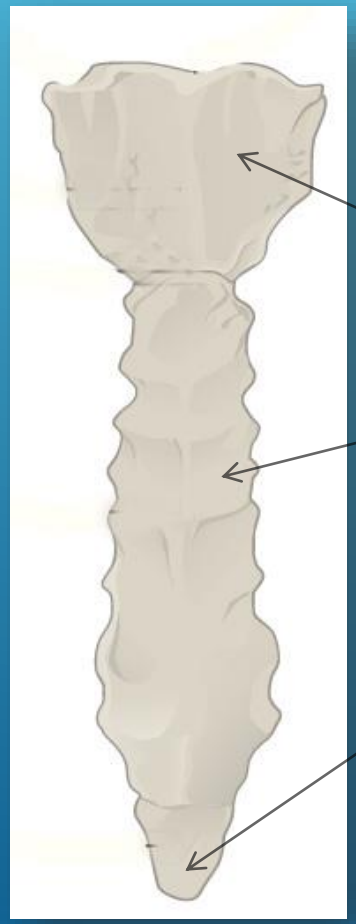
CERVICOTHORACIC JUNCTION: POSTERIOR ASPECT



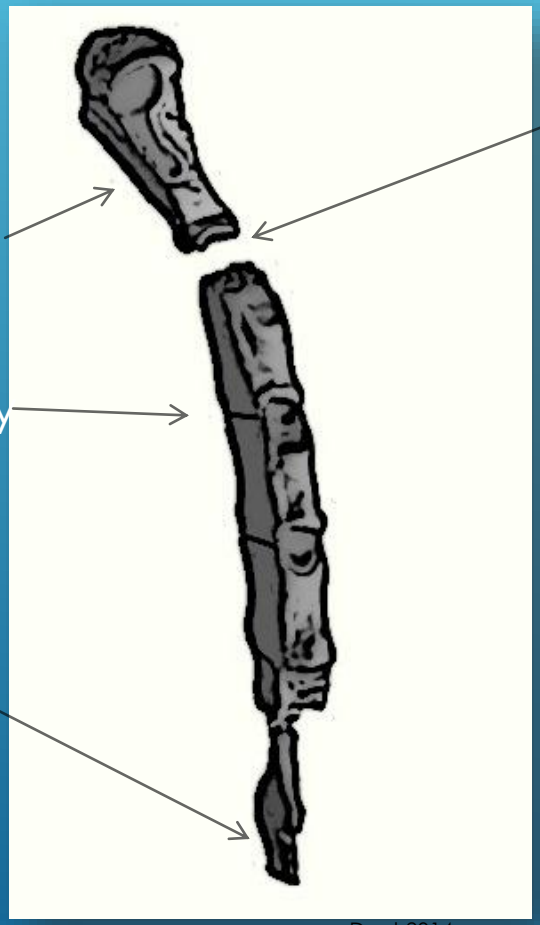
- Spinous process is long and non-bifid
- TVP lateral to SP
- 1st rib articulates with T1 only
- Small demi facet on inferior aspect of T1 for head of 2nd rib
- 1st rib "hangs" anteroinferiorly from TVP of T1

Sternum and Manubrium

Anterior View



Lateral View



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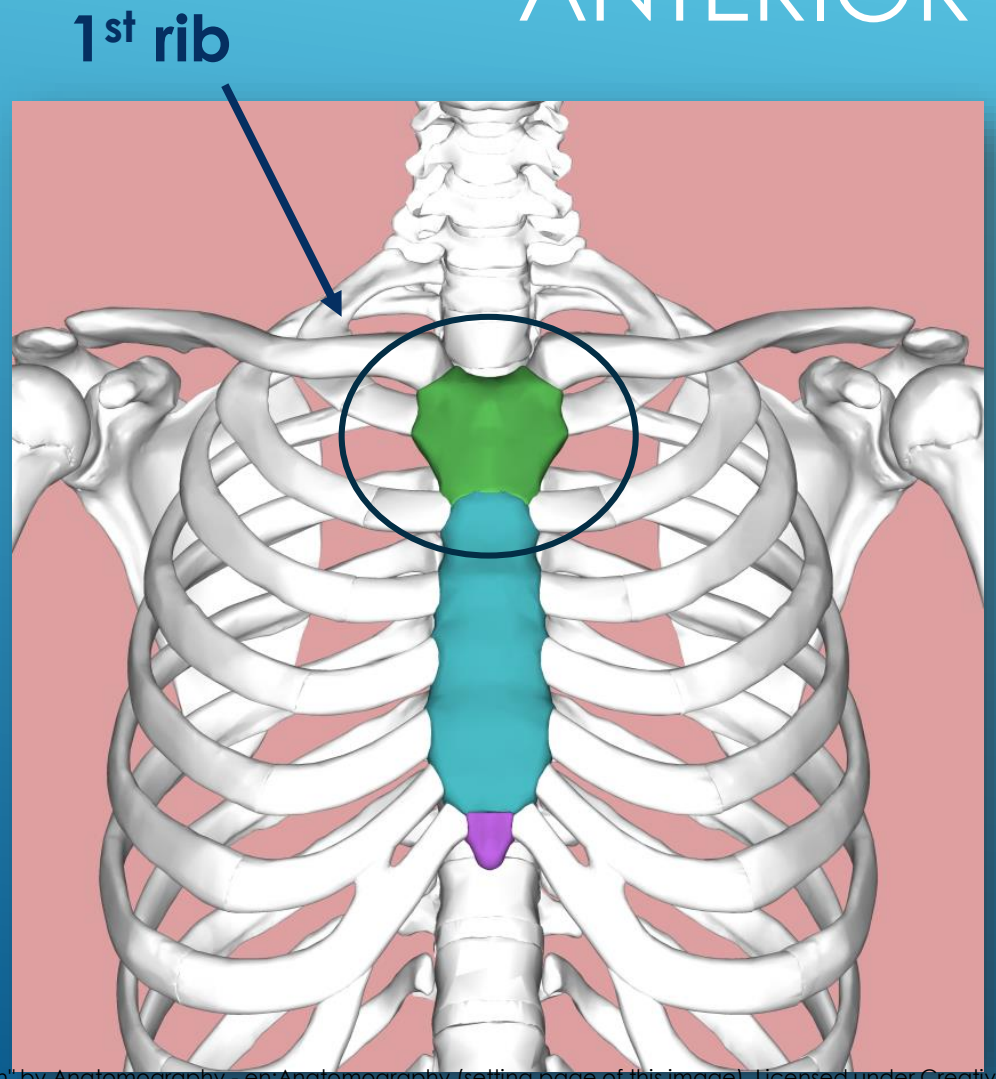
Can flex, extend and side flex at manubrial sternal junction

Ossified in 10% of the population

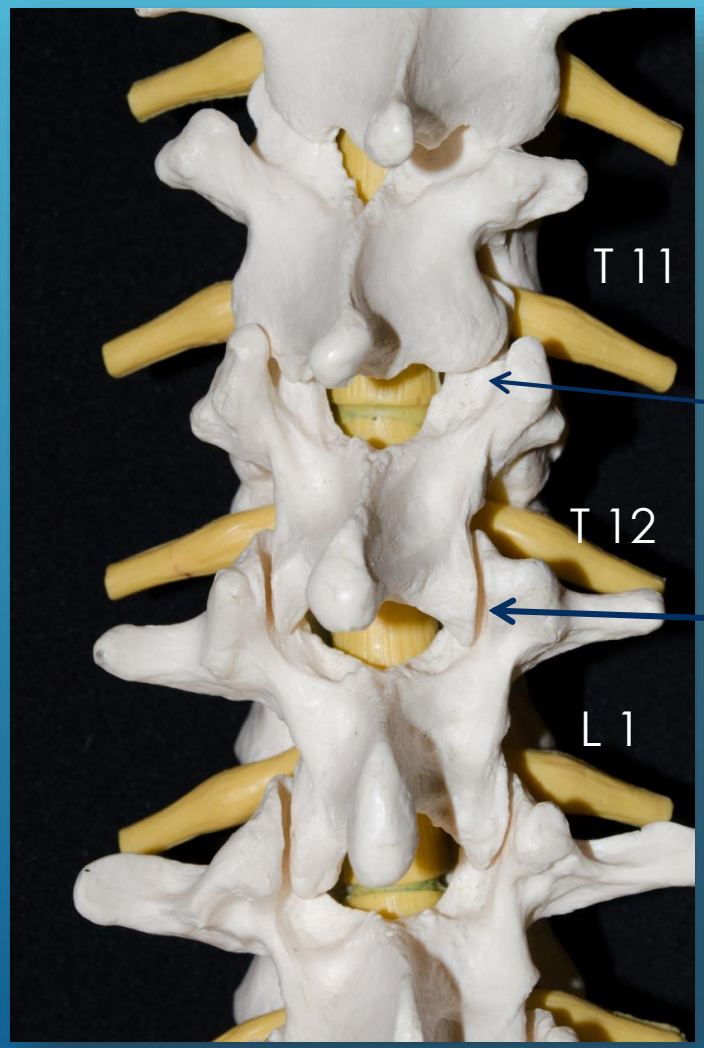
CERVICAL THORACIC JUNCTION: ANTERIOR VIEW



- Sternochondral joint is fibrous- more stable
- Clavicles are 25-30 degrees from horizontal with normal breathing patterns

THOROCOLUMBAR JUNCTION

THOROCOLUMBAR JUNCTION



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- Transition zone
- Unique biomechanical features

Coronal

Note change in Orientation of Facet Joints

Sagittal

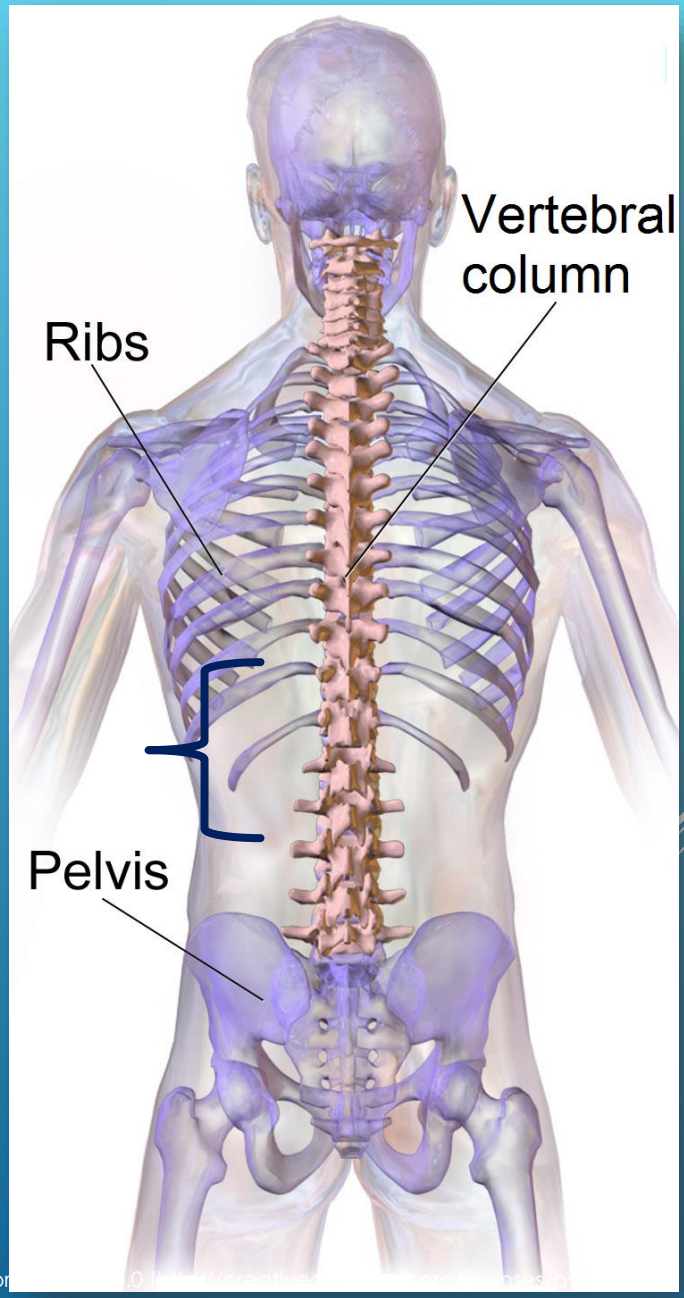
- Junction between the thoracic spine which rotates and the lumbar spine which doesn't

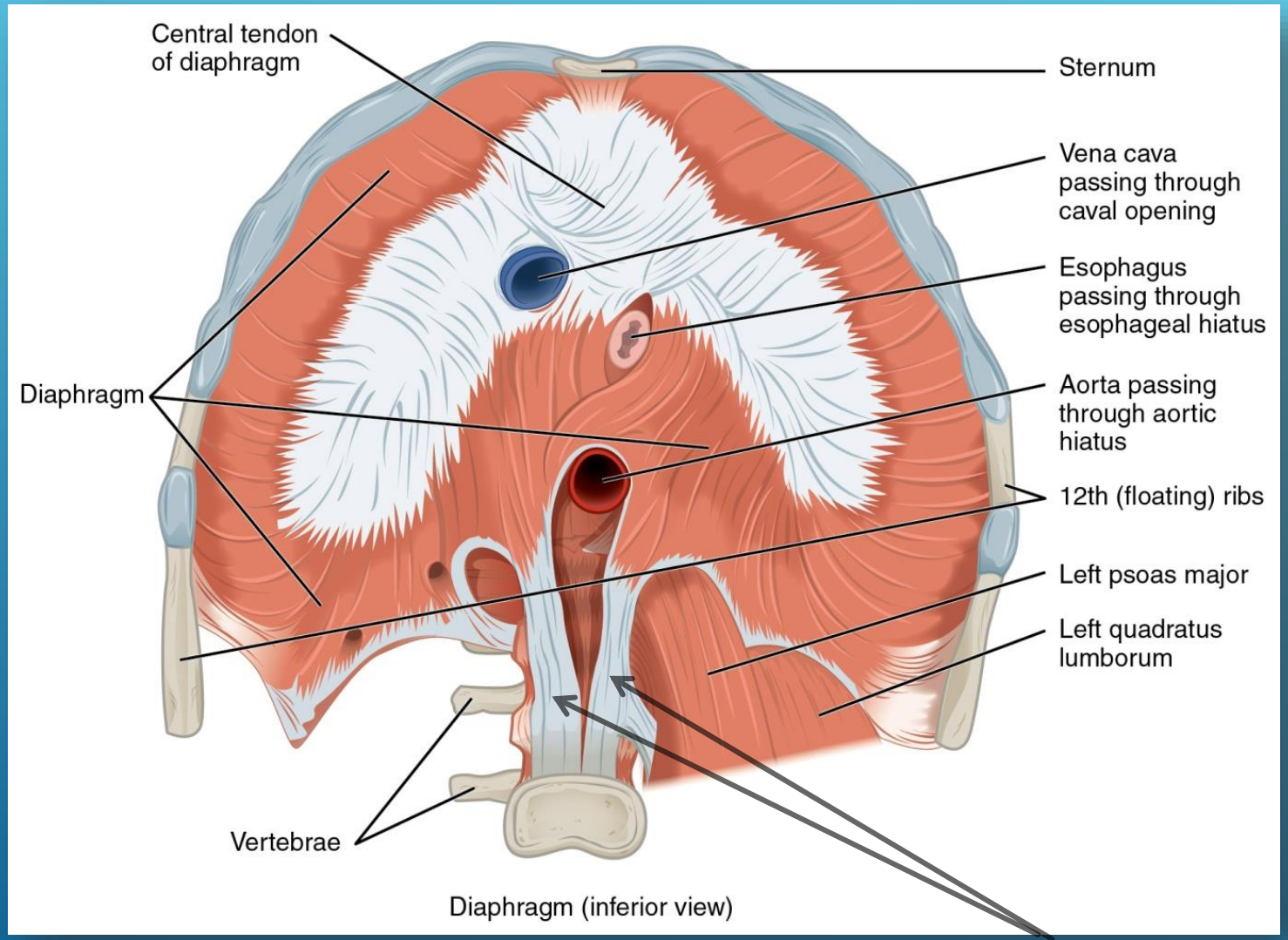
THOROCOLUMBAR JUNCTION

- Lumbar spine has two degrees of rotation per segment
- Thoracic spine has 6-9 degree per segment.
- Lumbar spine cannot rotate in extension
- This transitional vertebrae may occur at T11/12 or T12/L1

There is stress due to the change in orientation and function of both sections of the spine.

THOROCOLUMBAR JUNCTION





- Diaphragm crura originate from L1-L3 on the right and L1-2 on the left
- Tendons of the crura connect facially to the anterior longitudinal ligament
- Diaphragm shares connections with the quadratus lumborum and psoas major

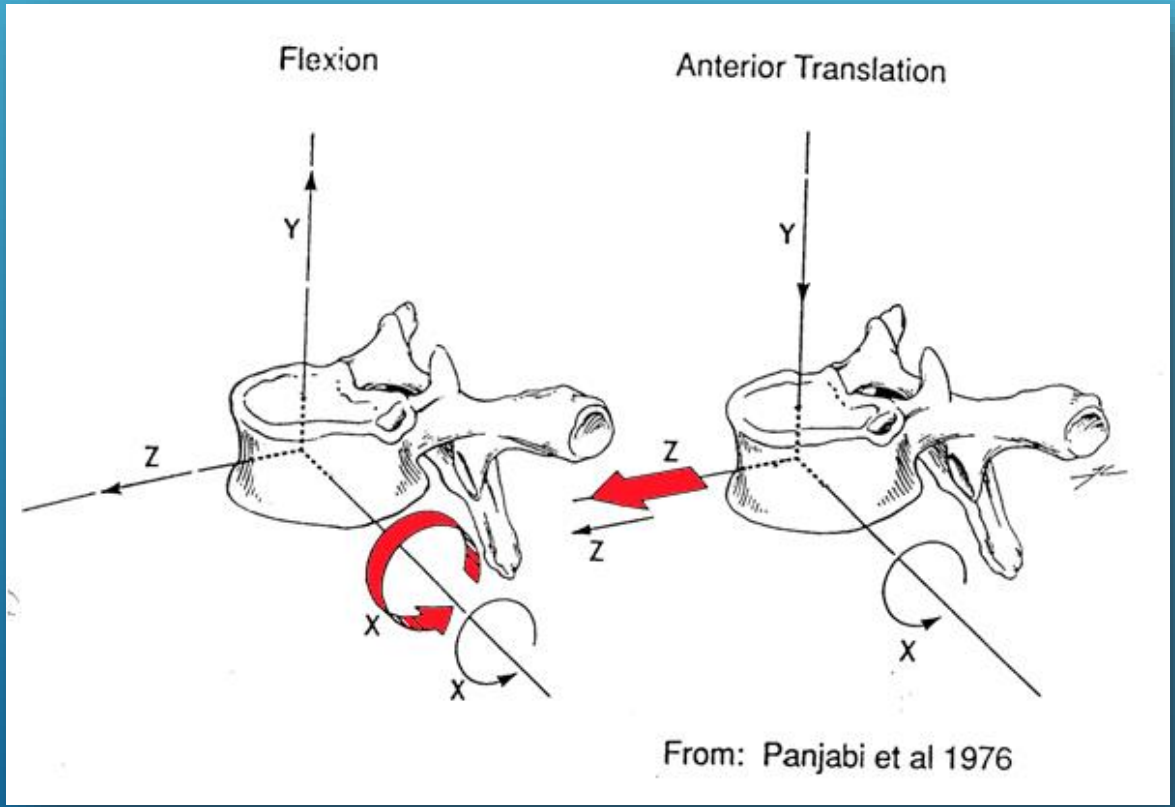
Diaphragm crura

- There must be a balance between the upward tension exerted by the diaphragm and downward force exerted by the psoas major
- Compensatory patterns occur at the thoraco-lumbar junction
- Positional change of the diaphragm can occur relative to the lumbar vertebrae
- Poor diaphragmatic contraction will cause an increase in tension of crura tendons
- Can restrict motion of the L1-L3 segments
- May cause the the lower lumbar spine segments L4-L5 to become hypermobile.

THOROCOLUMBAR JUNCTION

THORACIC SPINE BIOMECHANICS

THORACIC SPINE BIOMECHANICS: FLEXION



Osteokinematics

- Anterior sagittal rotation
- Anterior translation

Arthrokinematics

- Superior vertebrae's inferior facets glide superoanterior at "Z" joints or open
- Superior facets of inferior vertebrae are convex which promotes the superoanterior glide

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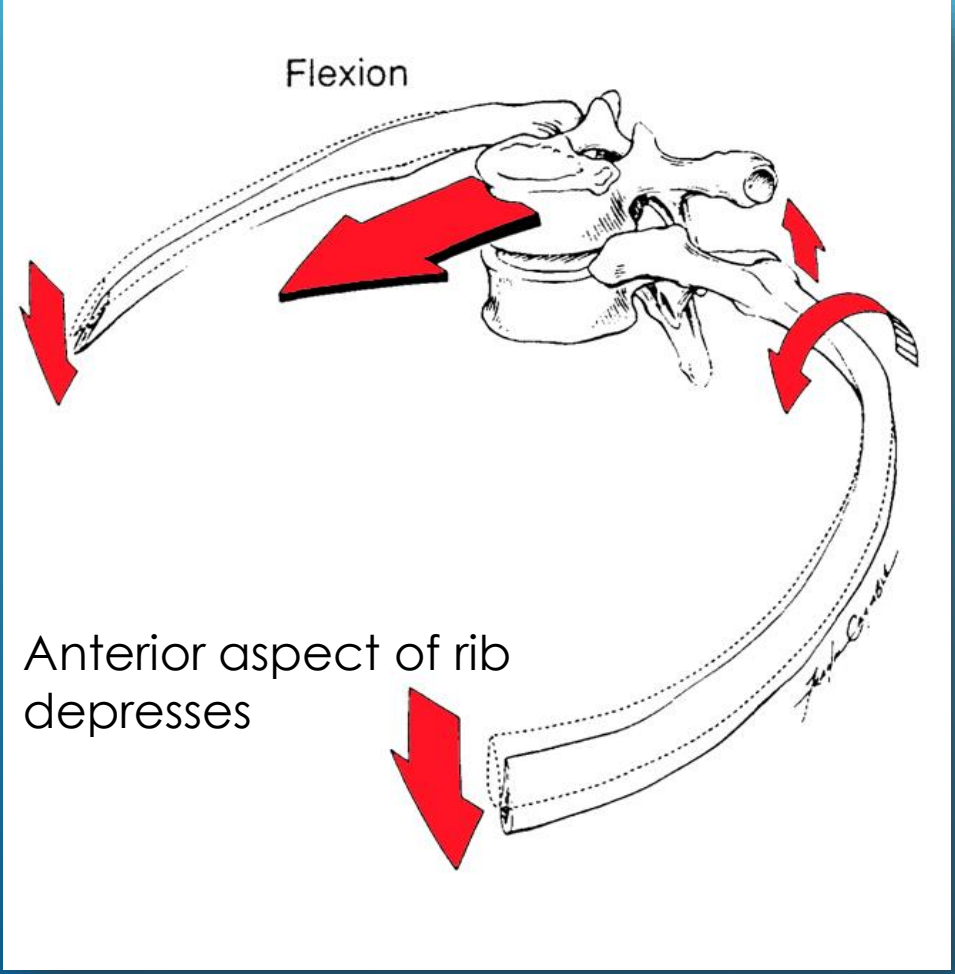
FLEXION T1-T7



- Occurring at vertebral sternal region T1-T7
- Anterior translation pulls the rib into anterior rotation at the costovertebral joint
- This is due to a concave CT joint and a convex tubercle

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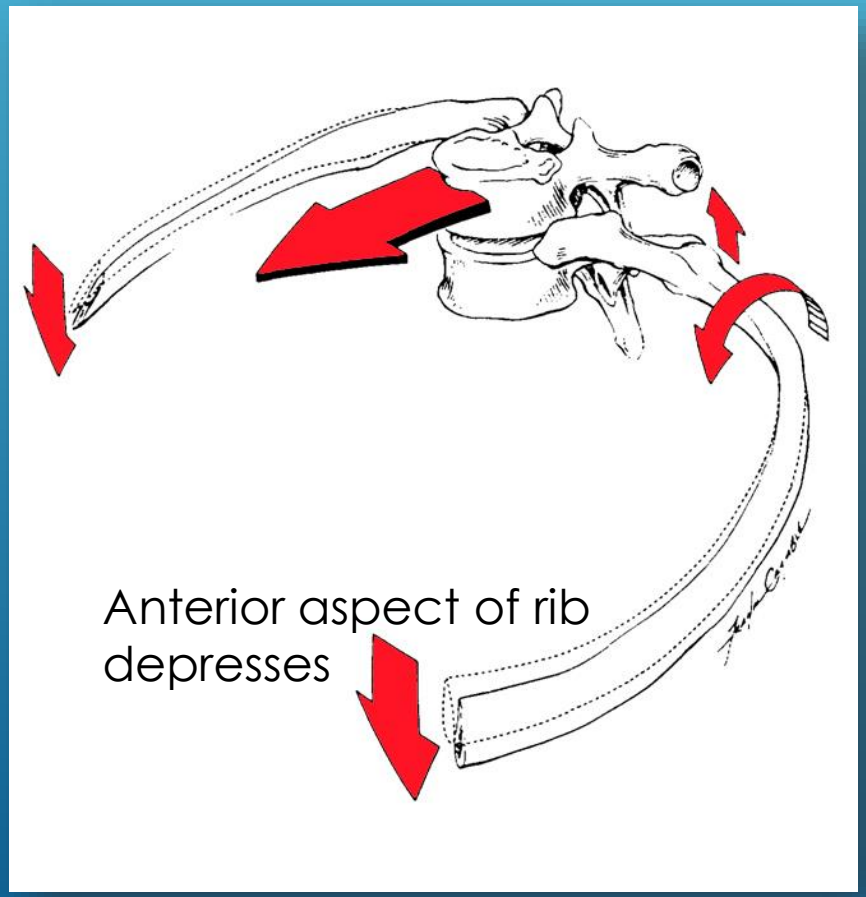
EXPIRATION:T1-T7

Occurring at vertebral sternal region T1-T7



- Depression of anterior aspect of rib
- Elevation of posterior aspect of rib
- The convex tubercles of ribs 1-7 glide superiorly at concave CT joints and produce an anterior rotation of rib during expiration
- During quiet respiration, "Z" joints have minimal movement

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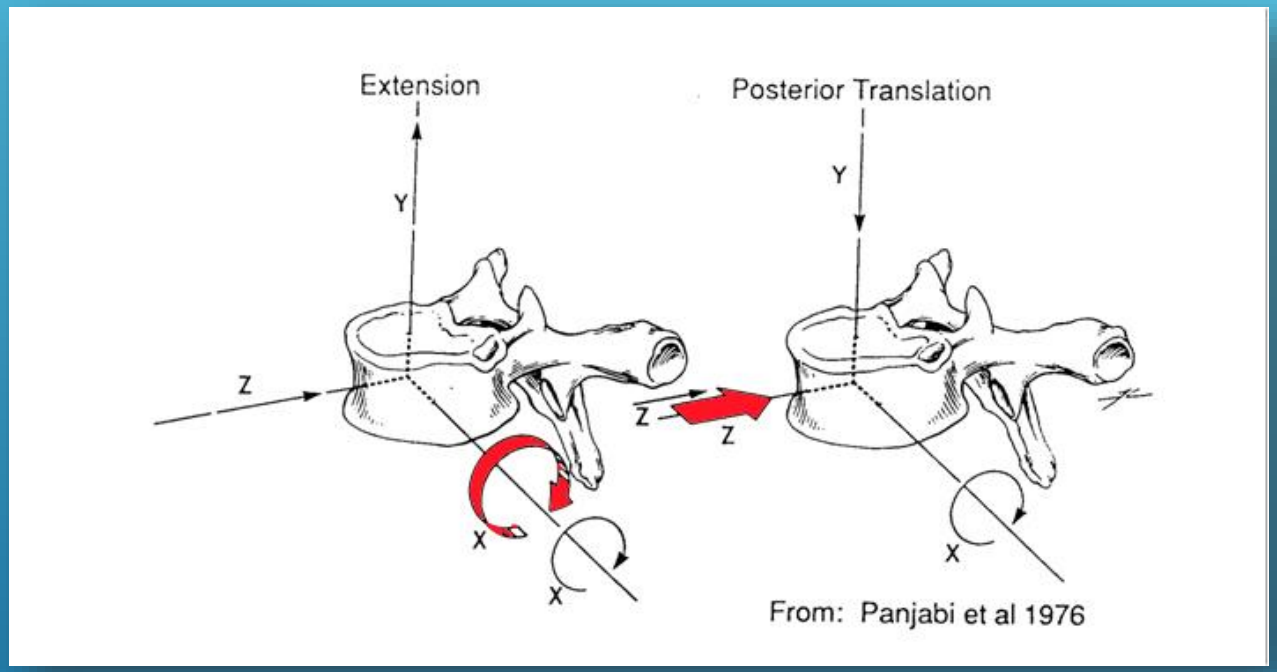

EXTENSION

Osteokinematics

- Posterior sagittal rotation
- Posterior translation or shear

Arthrokinematics

- Inferior facets of superior vertebrae glide inferoposterior or close
- Superior facets are convex which promotes the posteroinferior glide

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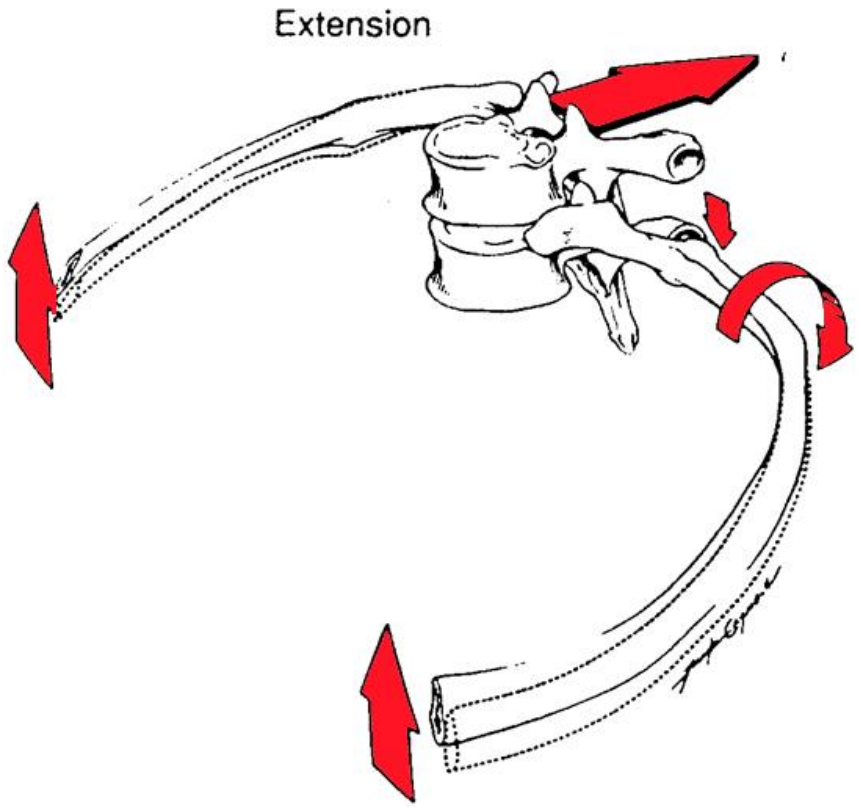
EXTENSION:T1-T7



Occurring at vertebral sternal region T1-T7

- Posterior translation pulls the rib into posterior rotation at the costovertebral joint
- Costotransverse joint is concave and the tubercle of rib is convex
- Posterior rotation of rib

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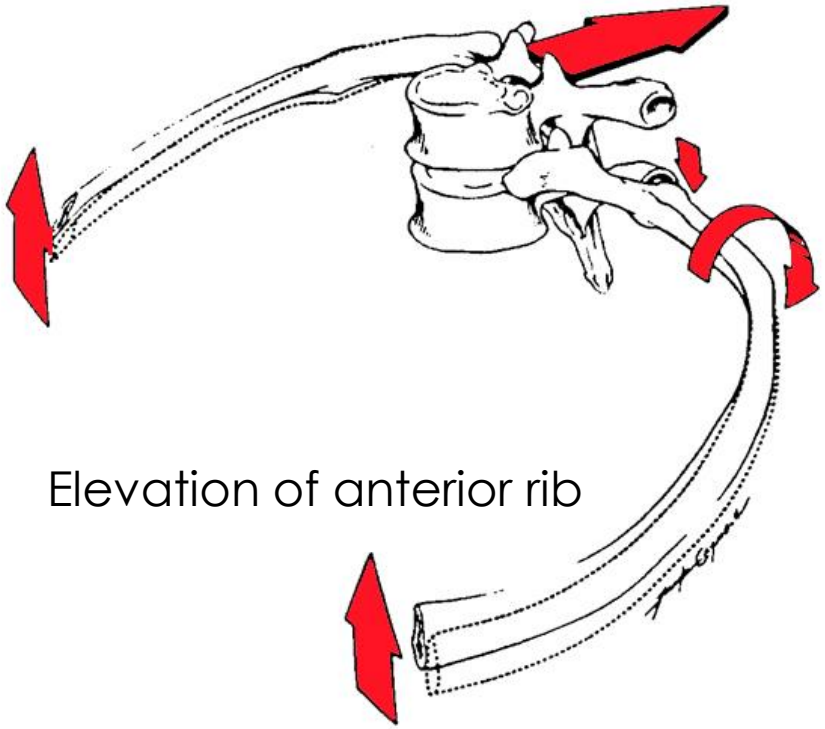
INSPIRATION:T1-T7



- Occurring at vertebral sternal region T1-T7
  - Sternum moves anterosuperior
  - Anterior aspect of rib elevates
  - Posterior aspect depresses
  - Posterior rotation of rib during inspiration
  - "Z" joints may glide inferior during forced inspiration

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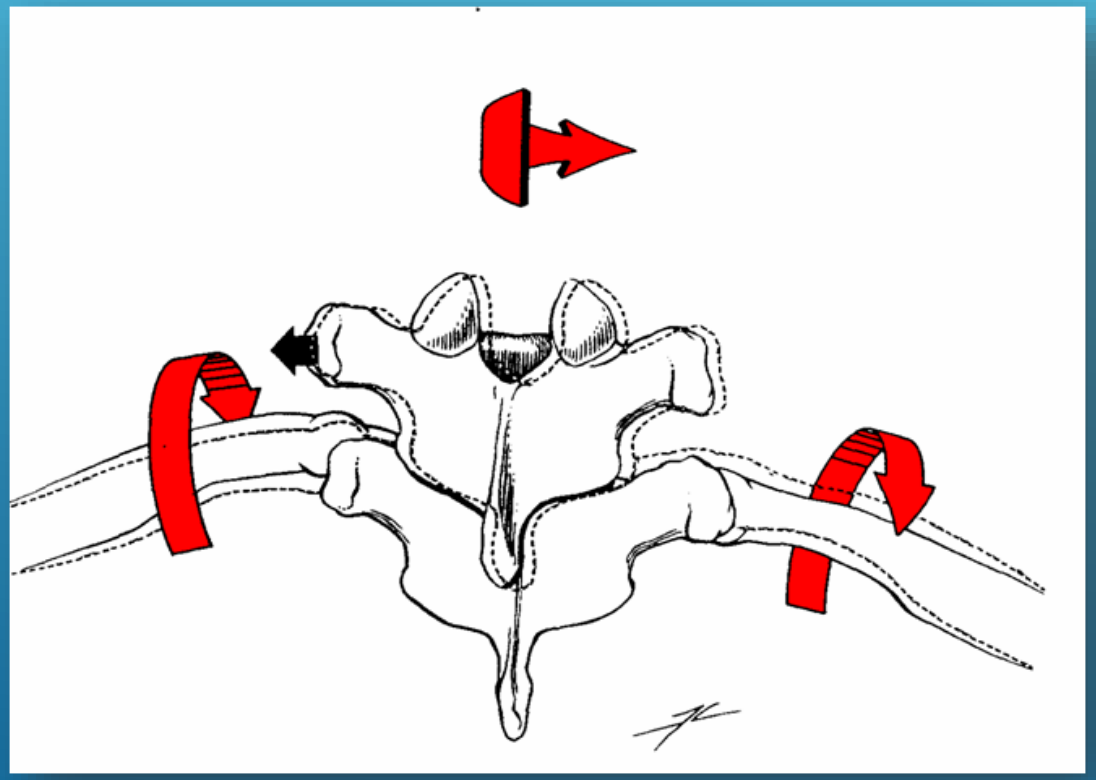
ROTATION: (T1-T7)



- Rotation and sideflexion is coupled to the same side and translation is to the opposite side
- When axial rotation is the first motion, rotation and sideflexion occur to the same side
- Superior vertebrae right rotates and translates to the left
- Pulls left rib forward and produces anterior rotation of left rib
- Pushes right rib backwards and produces posterior rotation of right rib

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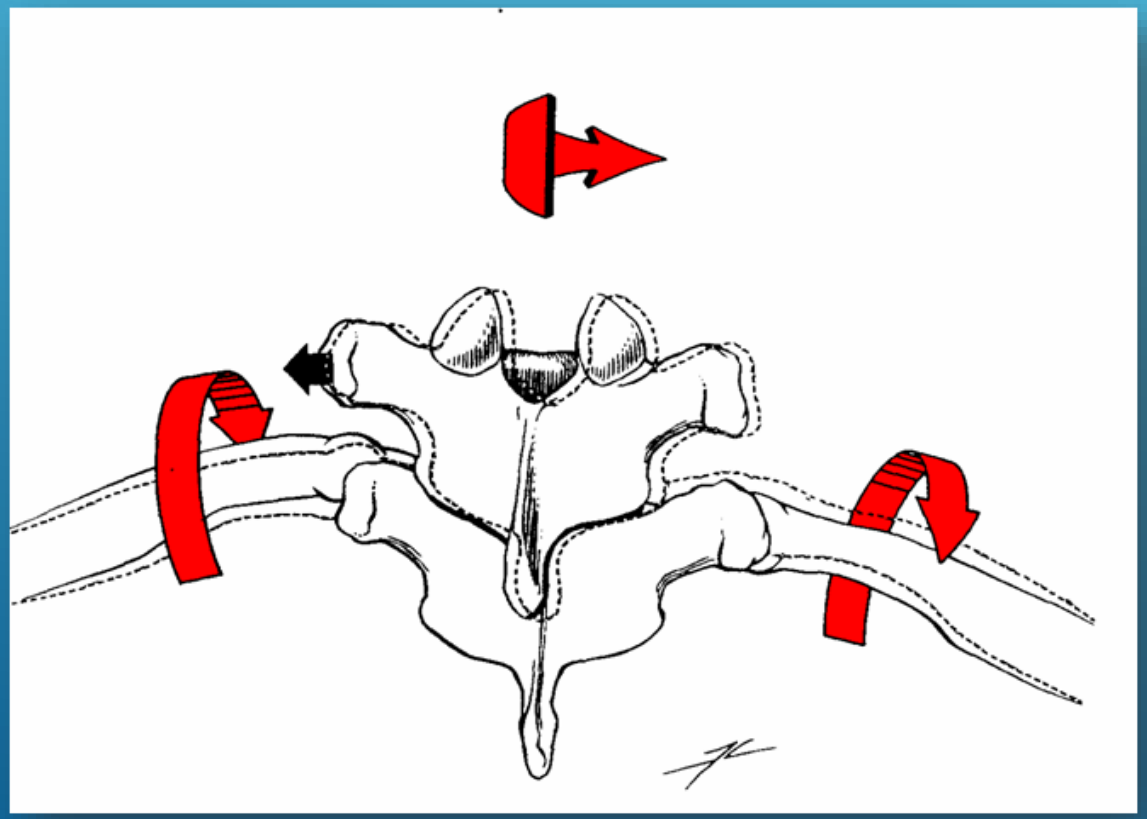
ROTATION



- Once translation limit has been reached all costovertebral and costotransverse ligaments become tensed
- Further rotation of superior vertebrae causes tilting to the right
- Tilting is side flexion to right
- "Z" joints: for RROT
  - Left "Z" joint opens
  - Right "Z" joint closes

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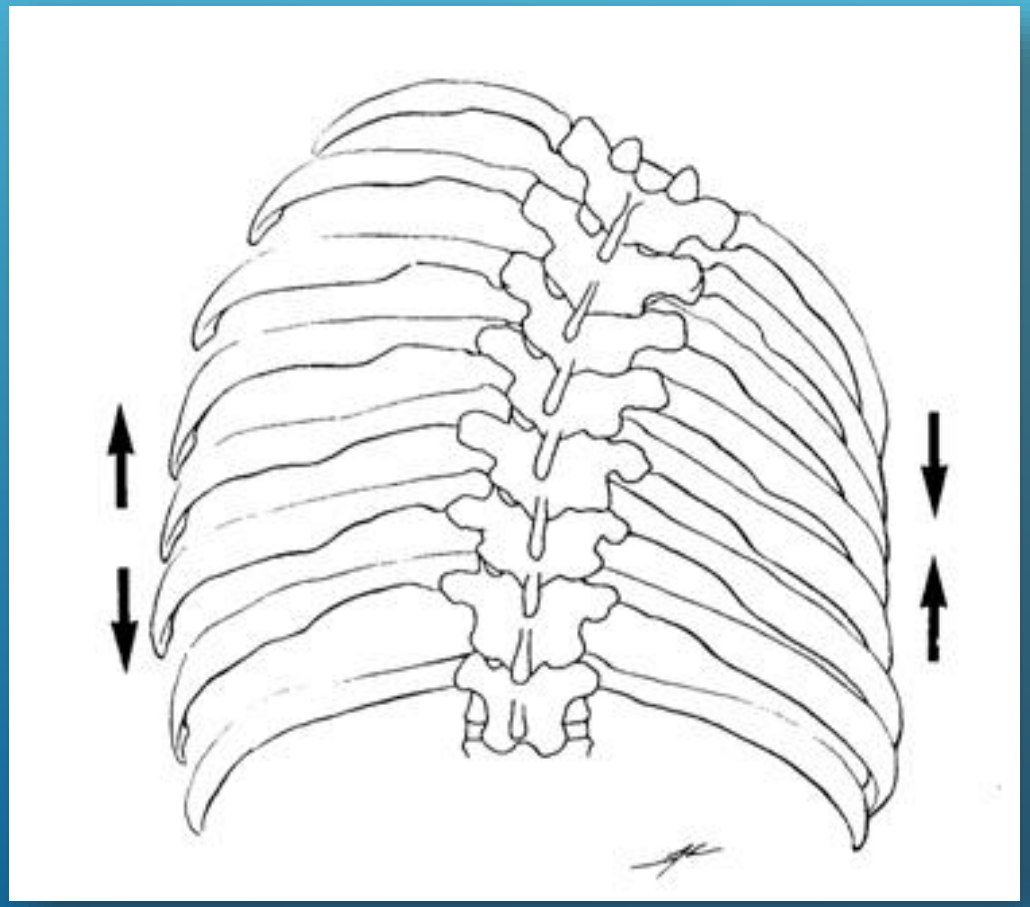
RIGHT SIDE FLEXION T3 AND BELOW



- Side Flexion causes ribs to approximate with each other on right and separate on left

- Ribs on the right will stop moving in respect to thoracic spine during sideflexion to the right.

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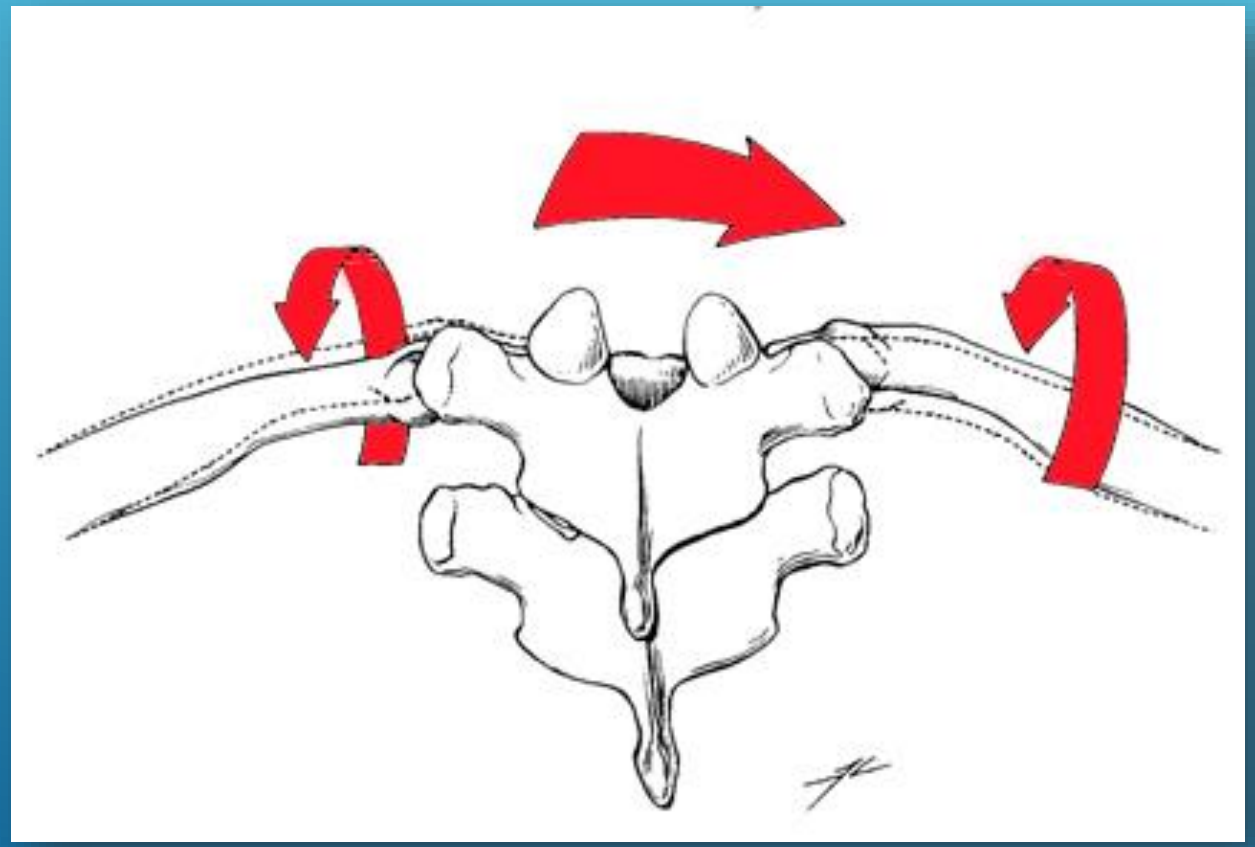
RIGHT SIDE FLEXION



- Once the ribs can no longer move the thoracic vertebrae continue to sideflex right on immobile rib.
- This causes the right rib to anteriorly rotation and the left rib to posteriorly rotate
- This action bilaterally causes the vertebrae to rotate to the left

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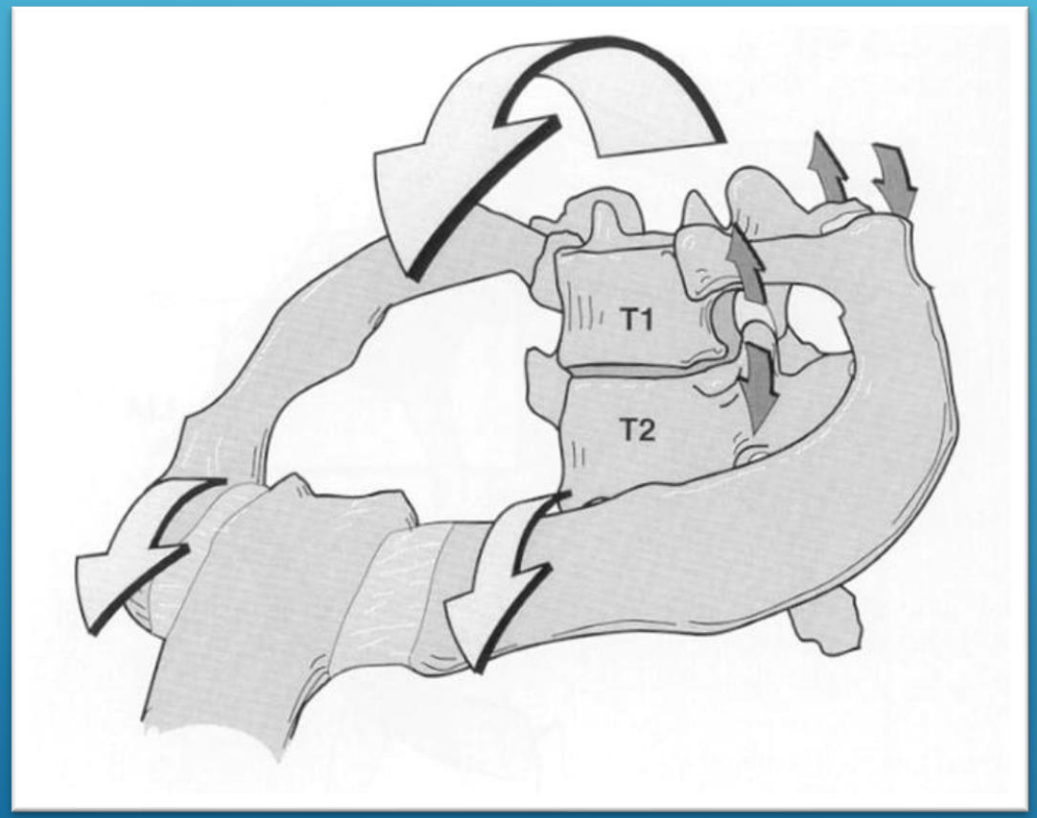
VERTEBROMANUBRIAL BIOMECHANICS FLEXION: T1-3



- Ribs 1 and 2 are not as mobile as ribs 3-7
- Superior vertebrae anteriorly rotates and anteriorly translates
- "Z" joint opens
- Pulls rib into anterior rotation
- Ribs move inferiorly at anterior aspect and superiorly at posterior aspect

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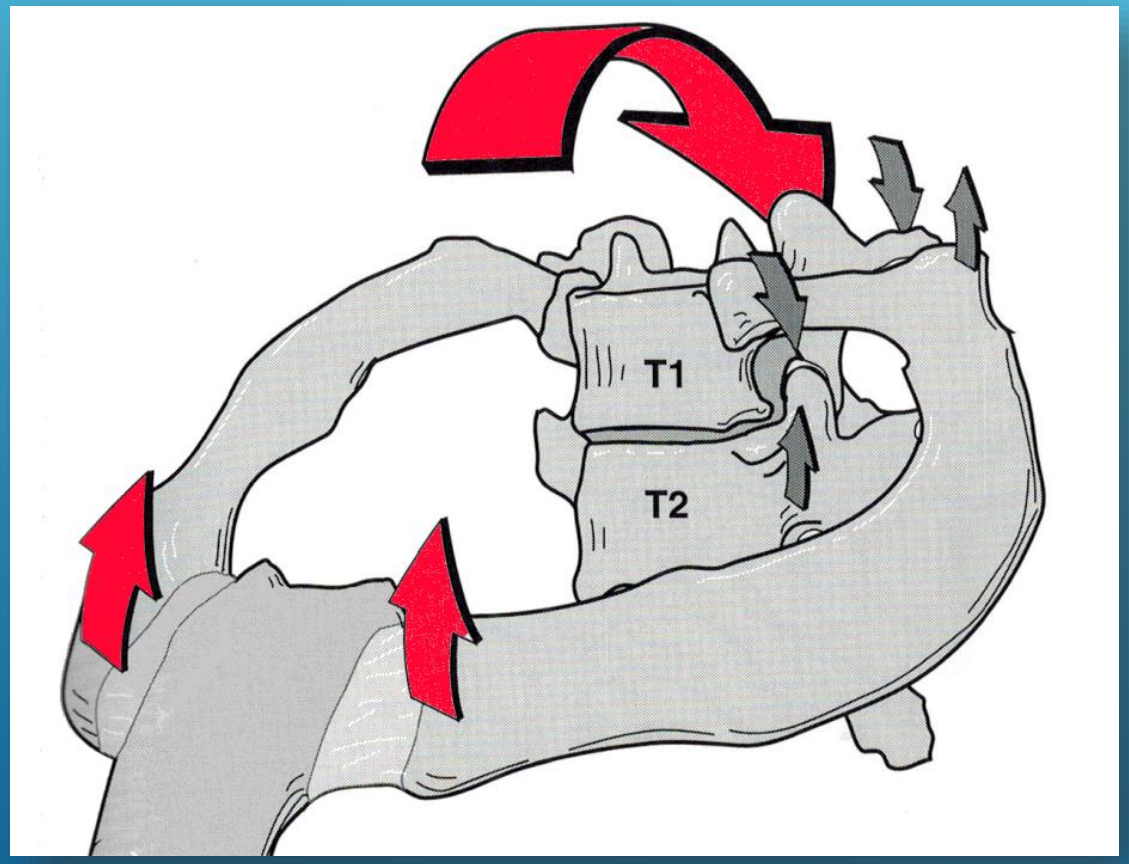
VERTEBROMANUBRIAL BIOMECHANICS EXTENSION:T1-3



- Superior vertebrae posteriorly rotates and posteriorly translates
- "Z" joint closes
- Rib is forced into a posterior rotation
- Anterior aspect of the rib rises superiorly and posterior aspect of the rib drops inferiorly

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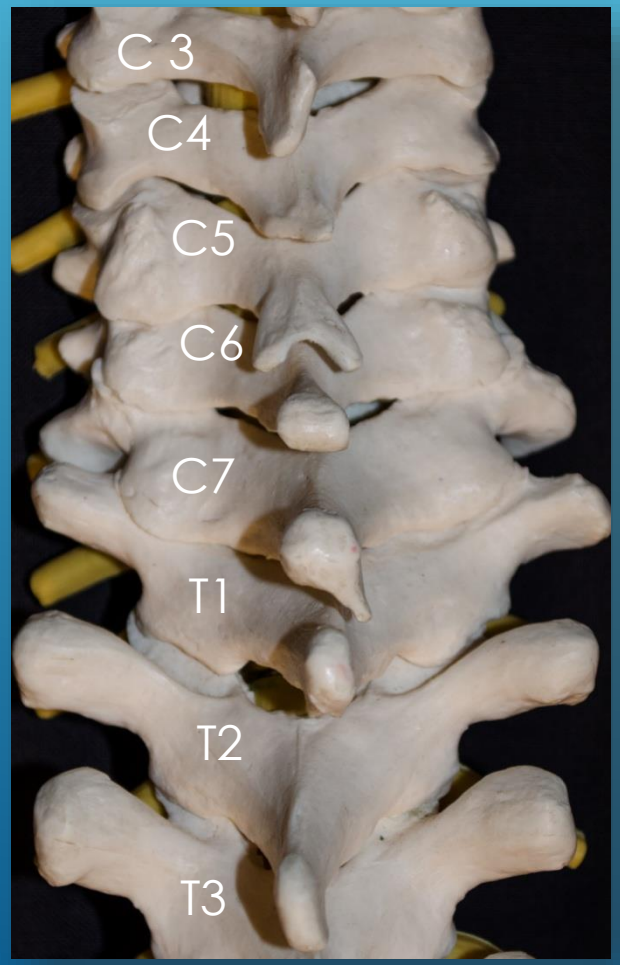
ROTATION OR SIDE FLEXION FIRST

- Right rotation of C7/T1
  - Right "Z" joint closes
  - Left "Z" joint opens
  - Ipsilateral side flexion occurs with rotation
  - Contralateral translation
  - Uncinate processes prevent rib from affecting biomechanics
  - T1T2 couples the same : side flexion same with "Z" joint closing on right and opening on left
- Changes at T2/T3

CERVICAL SPINE BIOMECHANICS

CERVICAL SPINE ARTHROKINEMATICS FLEXION EXTENSION



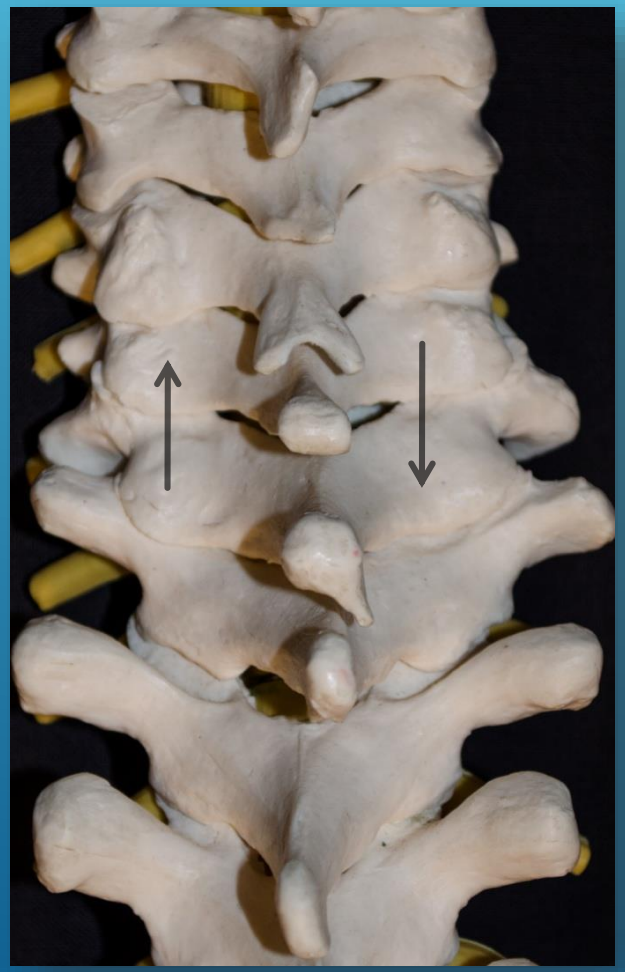
- Maximum mobility C4-C6
- Flexion/anterior translation with opening of "Z" joints
- Extension/posterior translation -closing of "Z" joint ("Z" joint approximation and spinous process approximation)

Same mechanics from C2/3 to L5/S1

Dent 2014

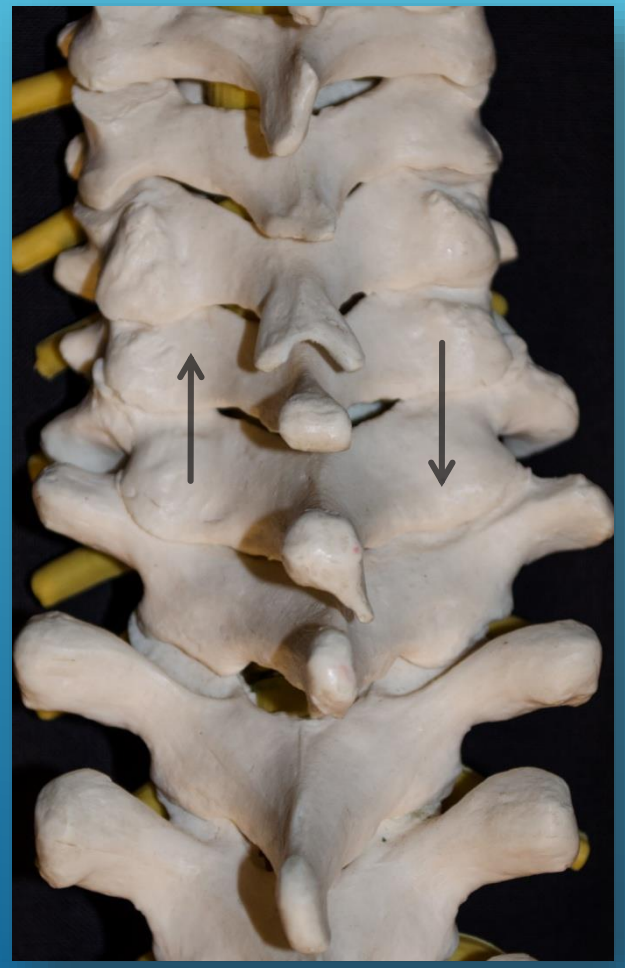
CERVICAL SPINE ARTHROKINEMATICS

RIGHT SIDE FLEXION



Dent 2014

RIGHT ROTATION



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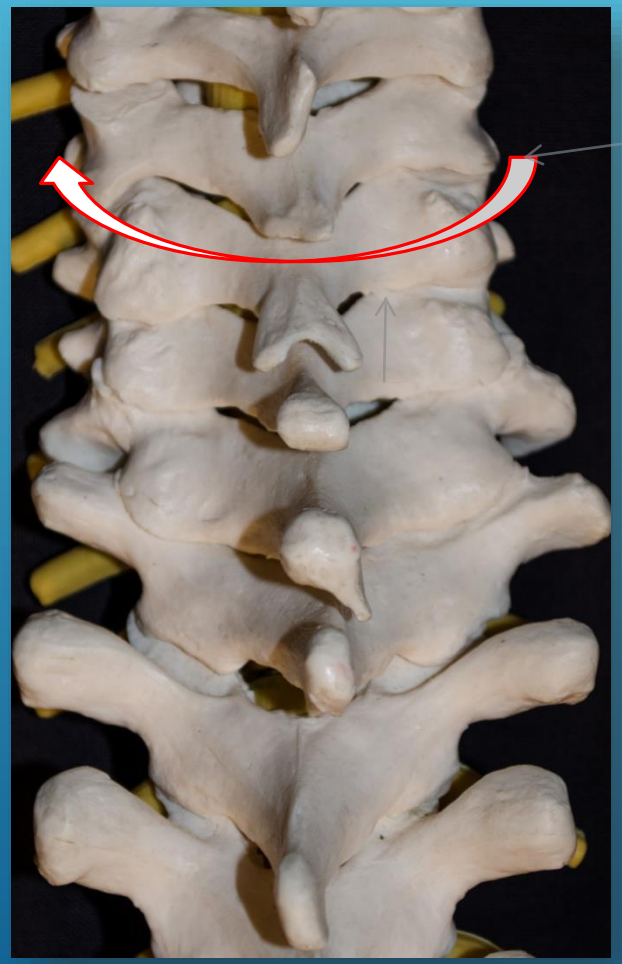
Rotation or Side Flexion

"Z" joints glide open on one side and glide closed on other

CERVICAL BIOMECHANICS



Right side flexion/rotation

- Contra-lateral translation - integral part of movement with either side flexion or rotation initiating the movement
- C2-T3 same biomechanics
- Deviation from these mechanics probably due to degeneration

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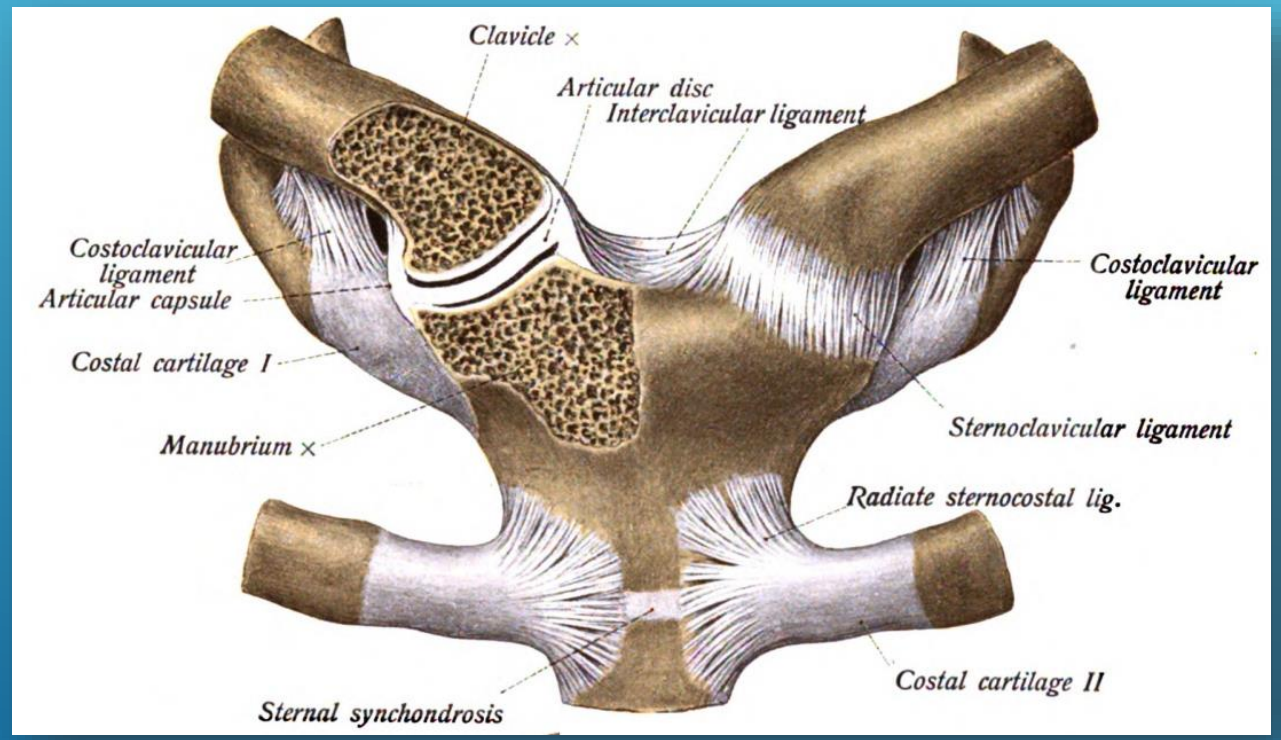
STERNOCLAVICULAR AND MANUBRIAL ANATOMY



By Dr. Johannes Sobotta [Public domain], via Wikimedia Commons

Articular disc divides the joint

Ligaments:

Anterior
- Sternoclavicular

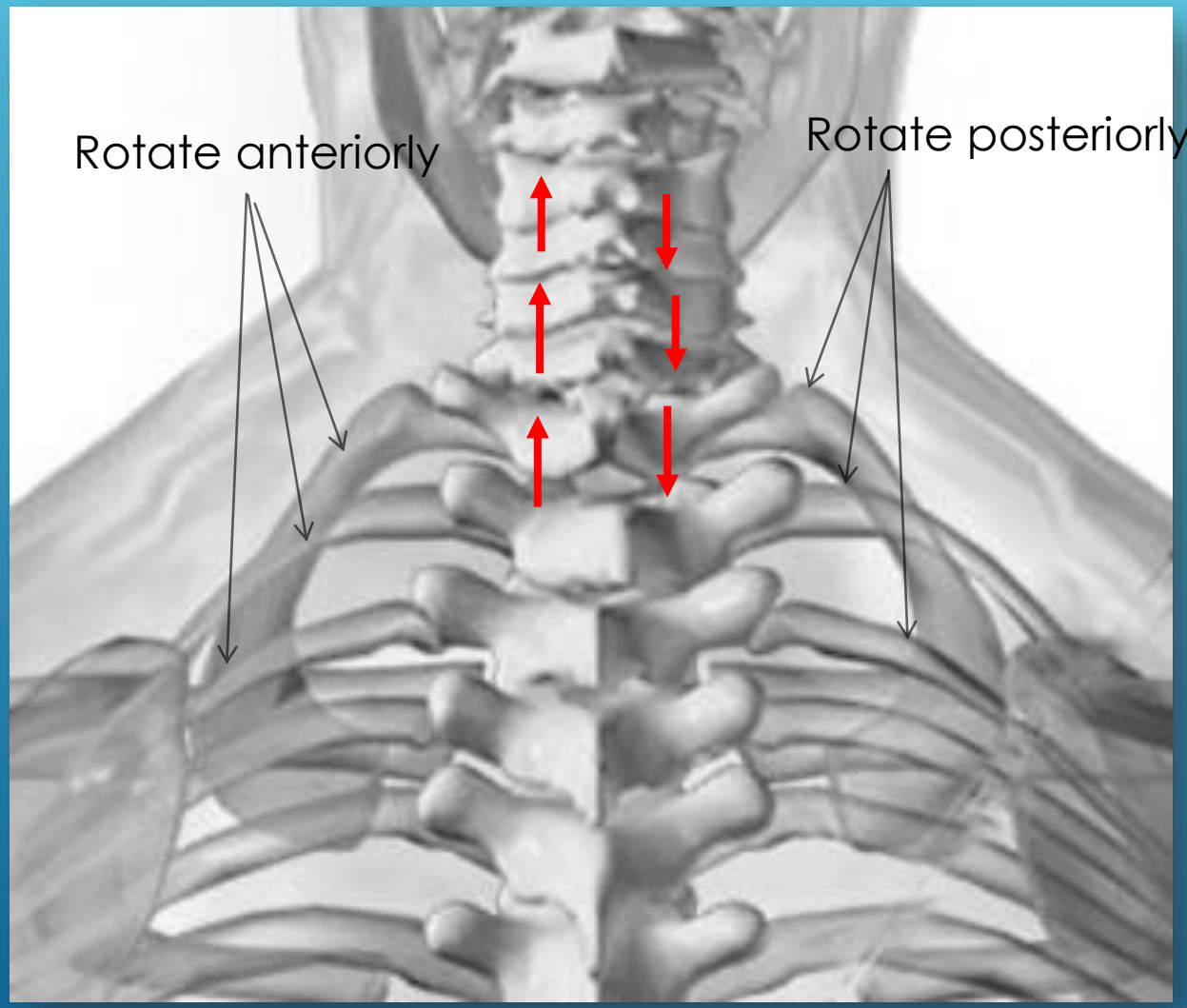
Posterior
- Sternoclavicular
- Interclavicular
- Costoclavicular

- Manubrial-sternal joint flexes and extends and side bends

- Clavicle
    - Elevation-inferior glide
    - Depression-superior glide
    - Protraction-posterior glide
    - Retraction - anterior glide
    - Rolls anterior and posterior

STERNOCLAVICULAR AND MANUBRIAL BIOMECHANICS

Right Arm Elevation:



RIGHT ARM ELEVATION

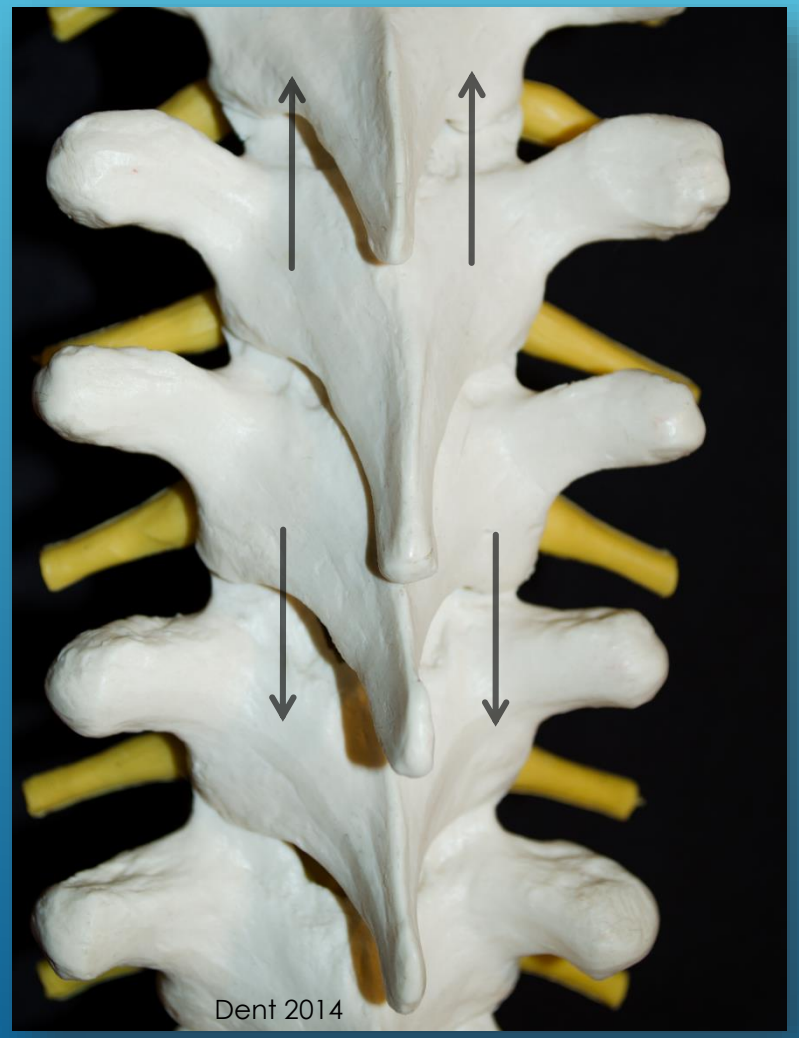
- RROT, RSF and EXT in the cervical and upper thoracic spines
- Right "Z" joints close/extend
- Left "Z' joints open/flex
- Posterior rotation of the right three ribs and anterior rotation of the left upper three ribs
- Rib Rings translate to the left
- Right clavicle elevates and posteriorly rotates- SC joint glides inferiorly
- Left Clavicle anteriorly rotates
- Manubrium will side bend to the right

LEFT ARM ELEVATION

THORACIC SPINE BIOMECHANICS LOWER THORAX

Flexion

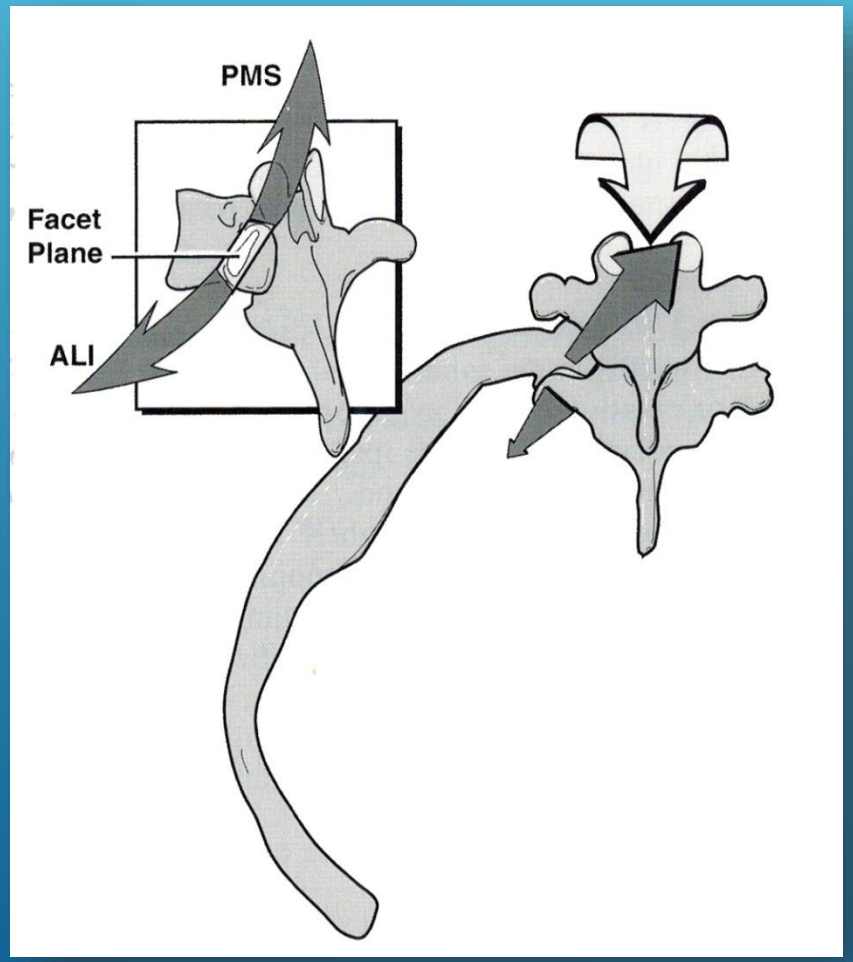
Extension



- Costotransverse Joint facets of TVP are planer and are oriented in superolateral direction

- Minimal rotation of rib in this region

THORACIC SPINE BIOMECHANICS LOWER THORAX



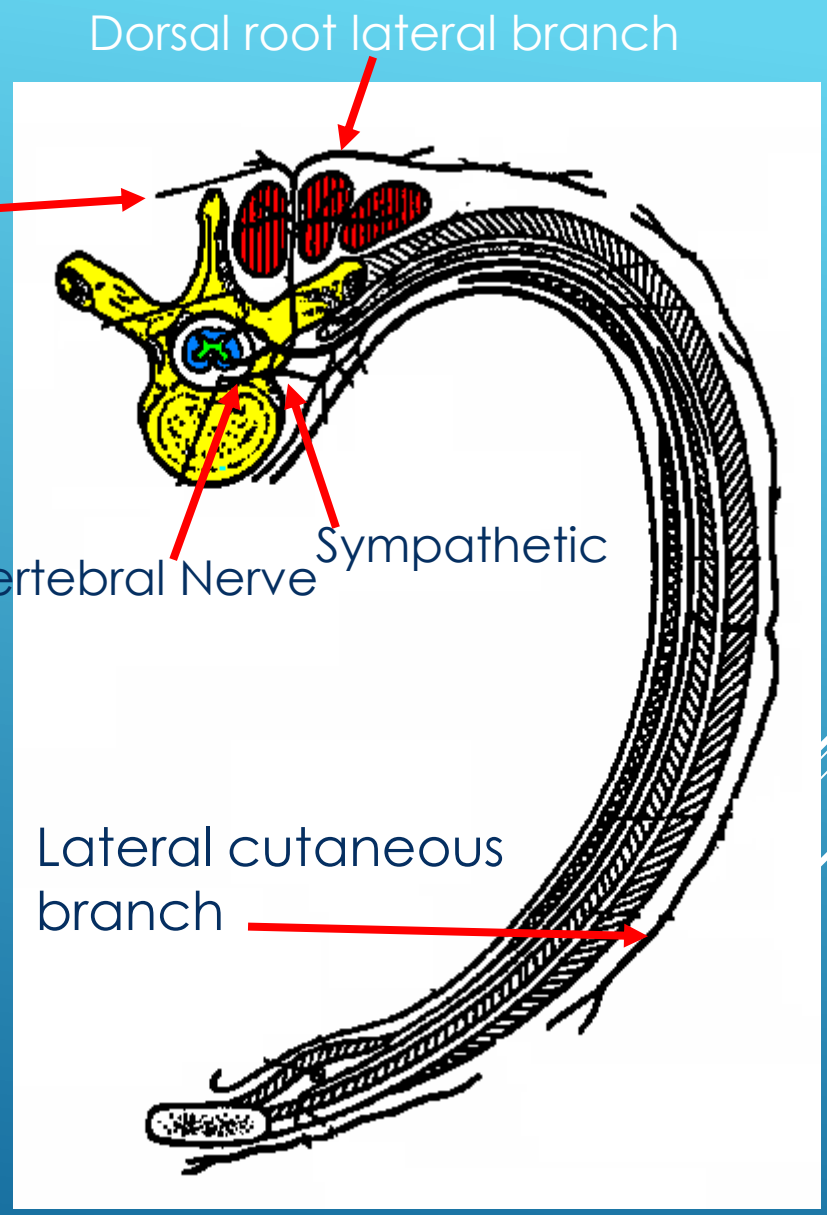
- Posteromediosuperior (PMS) glide of the tubercle of the rib occurs with flexion

- Anterolateroinferior (ALI) glide of the tubercle of the rib occurs with extension

Lee, Diane. Manual therapy for the thoracic spine, a Biomechanical Approach. DOPC, Delta, BC, 1994

Innervation:

- Ventral nerve roots
- Dorsal nerve roots
- Sympathetic ganglion
- Sinuvertebral nerve



CASE HISTORY
SHOULDER IMPINGEMENT

IMPINGEMENT

- 10 year history of impingement right shoulder
- Profession PT Home Health
- Age 58
- OE:
  - Restricted chest expansion lateral costally
  - Rib cage generally tight and restricted with upper chest breathing
  - Poor general trunk rotation
  - Rib Rings 2 and 3 are literally shifted to the right.

Just Breathe 101 Program

You have completed Biomechanics of the Region: Cervical, Thoracic/Rib and Shoulder Girdle

- Function of Respiration
- Physiology of Respiration
- Altered Breathing Patterns and Somatic Dysfunction
- Altered Breathing Effects on the Spine and Trunk
- Sleep Apnea
- Breathing Theories

IN CLOSING