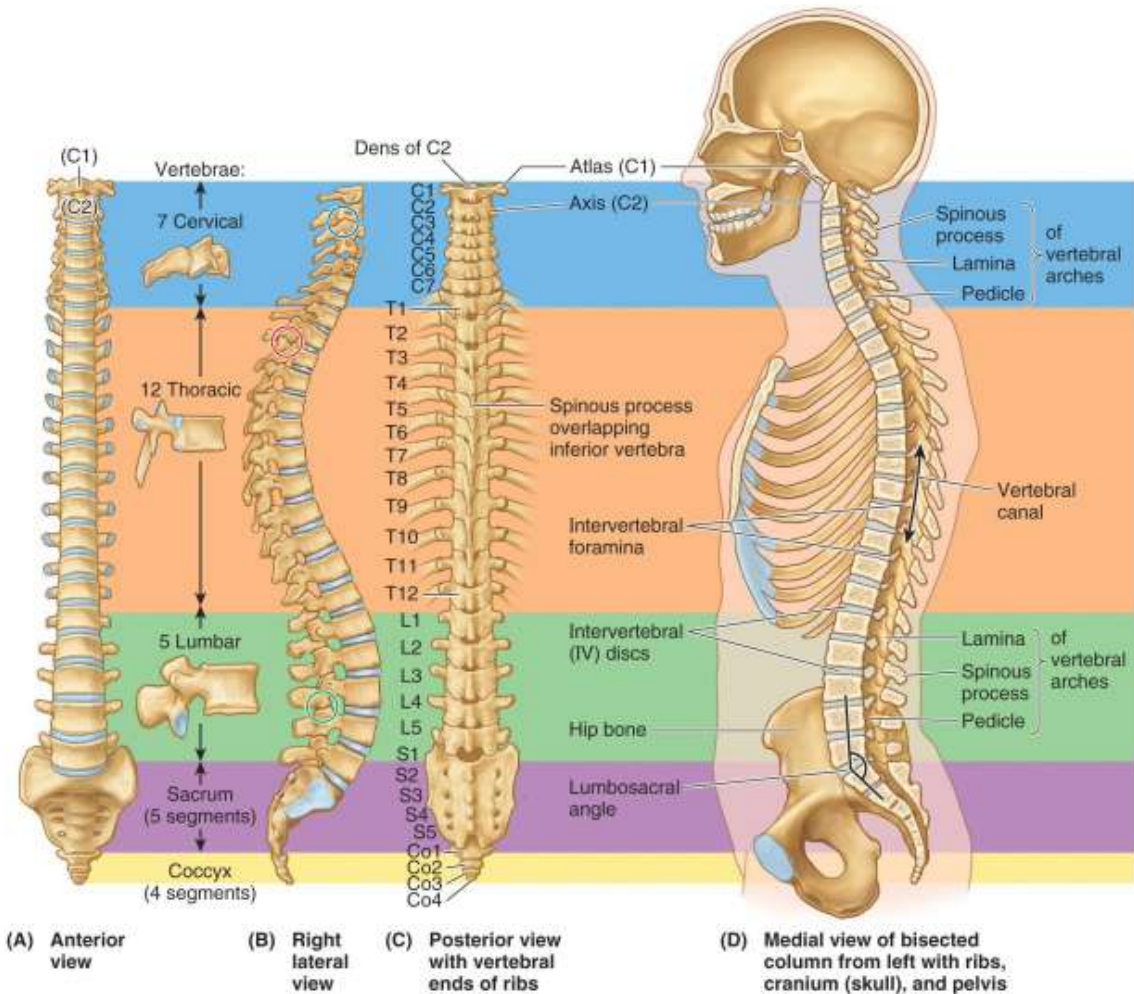




Functional anatomy and biomechanics of the cervical spine

Manos Stefanakis
PT, MManipTher, PhD

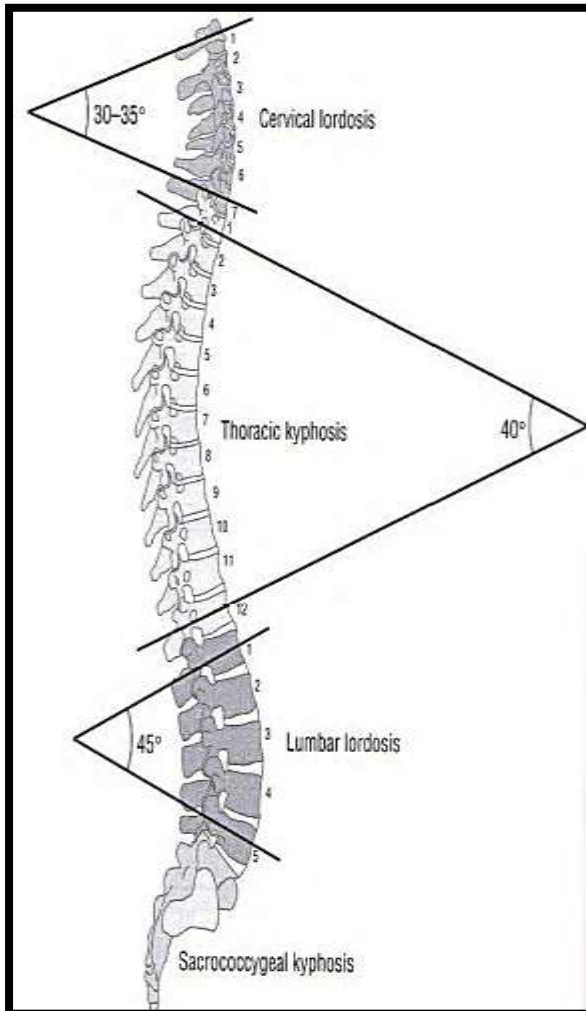
Gross anatomy of the spine



- ❖ Two parts:
 - Mobile part
 - Immobile part
- ❖ Mobile part:
 - Cervical region (7 vertebrae)
 - Thoracic region (12 vertebrae)
 - Lumbar region (5 vertebrae)
- ❖ Immobile part:
 - Sacrum
 - Coccyx



Spinal curvatures



Spine from the side is “S” shaped. It has anterior and posterior facing, alternating curvatures.

The curvature in the cervical spine is called lordosis and it's concave part faces posterior. Similar shape and name has the curvature of the bottom of the spine namely the lumbar spine.

In the middle part, the thoracic spine the curvature is reversed and is called kyphosis.



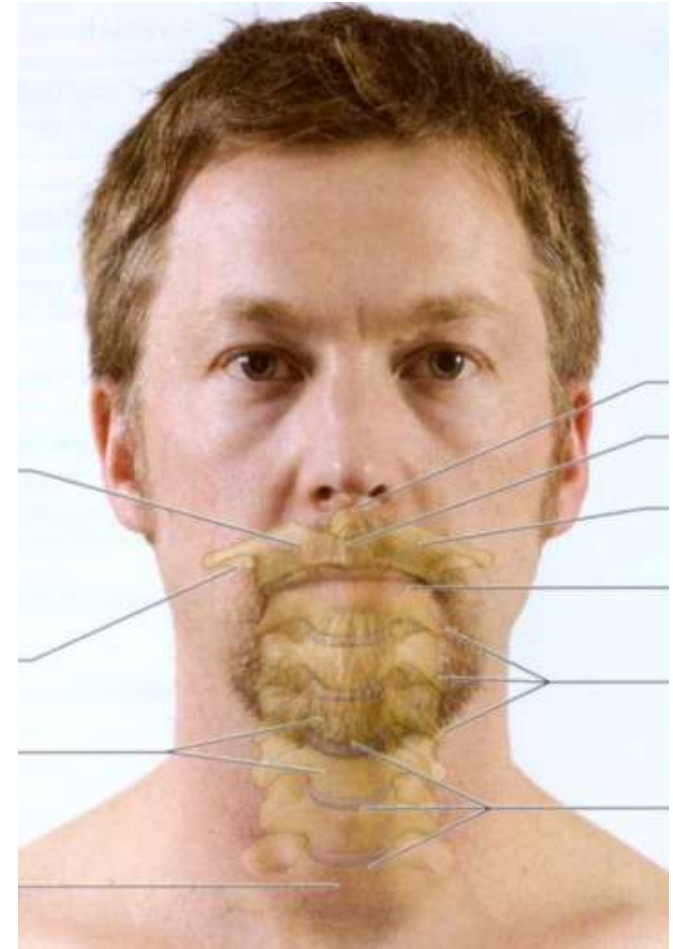
Function of the spine

- ❖ Skeleton of the trunk (axial skeleton)
- ❖ Supports the body and participates in creation of thoracic and pelvic cavity
- ❖ Provides attachments for the ribs and strong muscles
- ❖ Protects viscera (thoracic and pelvic)
- ❖ Protects the spine cord
- ❖ Provides «stable» mobility

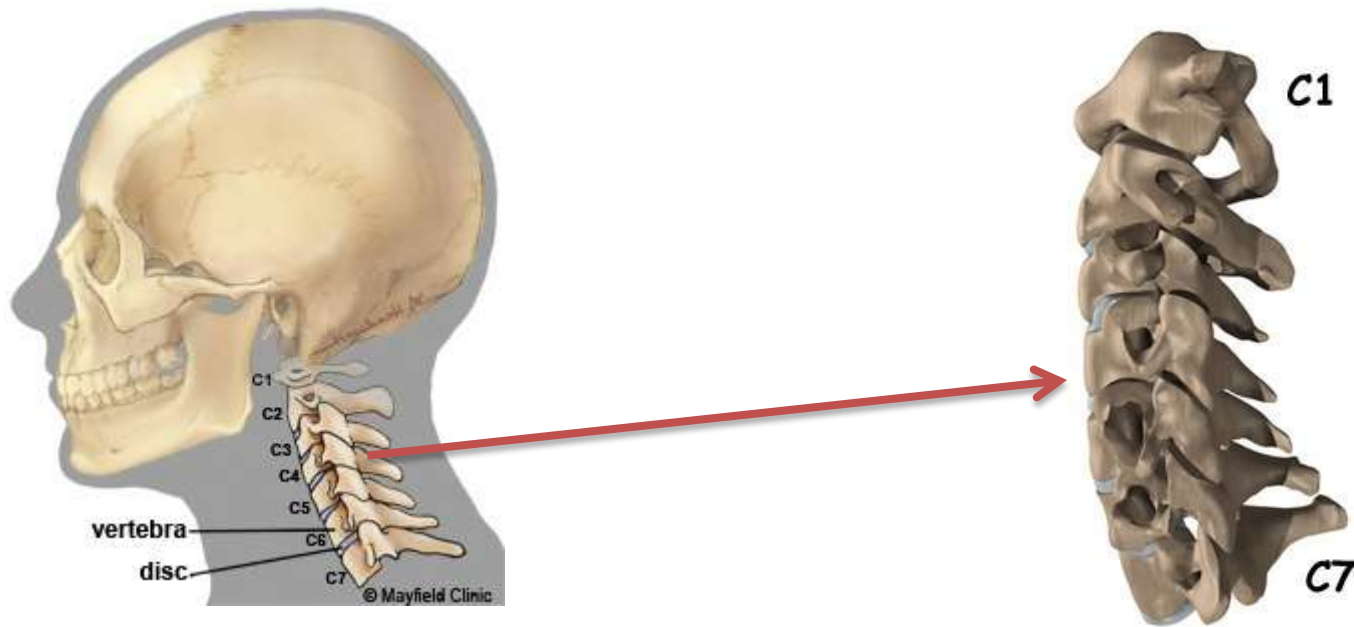


Cervical spine

- ❖ The most mobile region of the spine
- ❖ Supports the weight of the head ($\approx 4\text{Kgr}$)
- ❖ High compressive loading due to strong muscles
- ❖ Protects the spinal cord and part of medulla oblongata
- ❖ Positions the head in space and adapts the visual field according to external stimuli



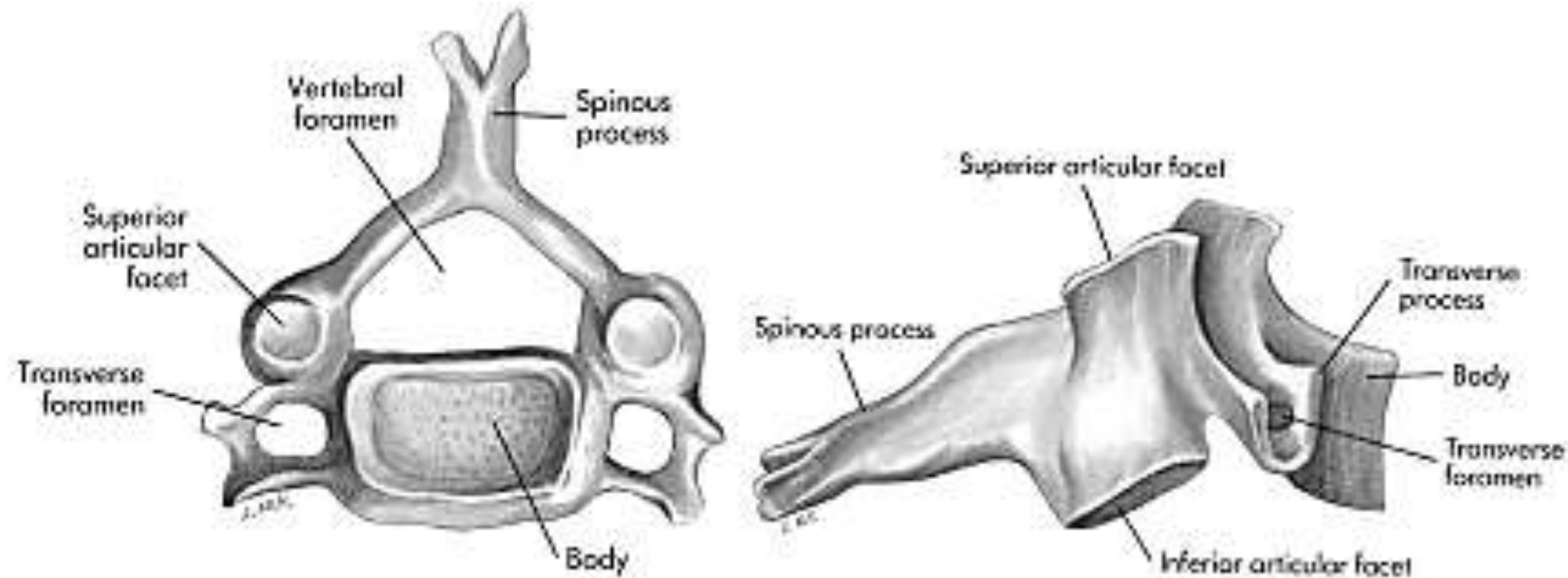
Anatomy of Cx



- ❖ 7 cervical vertebrae
- ❖ Intervertebral discs create space between the bones to allow movement
- ❖ Functionally separated in lower and upper cervical region



Cervical vertebrae

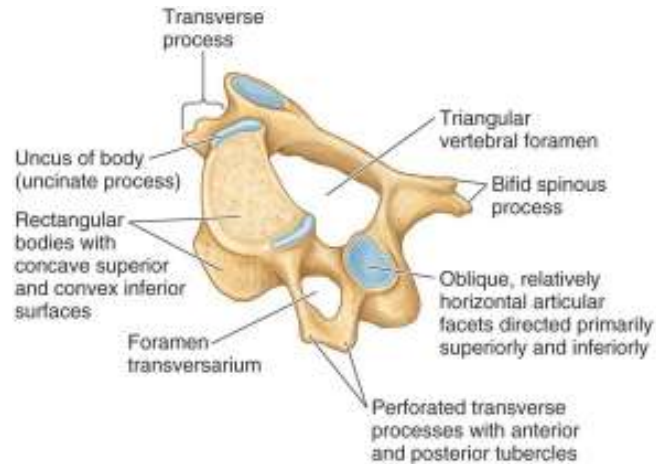


From Floyd R.T, Manual of Structural Kinesiology, 2007 McGraw-Hill

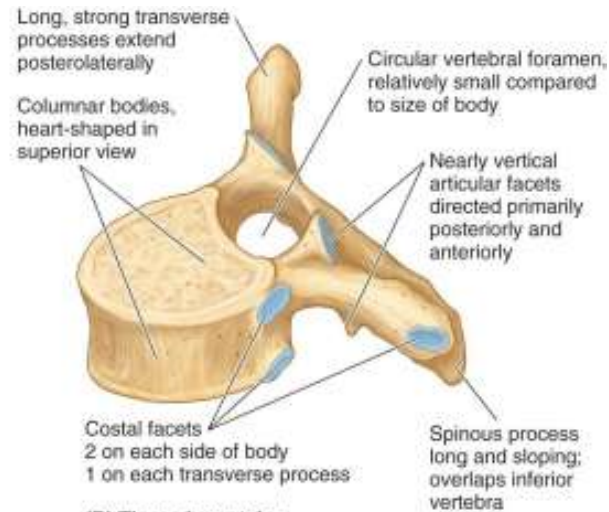


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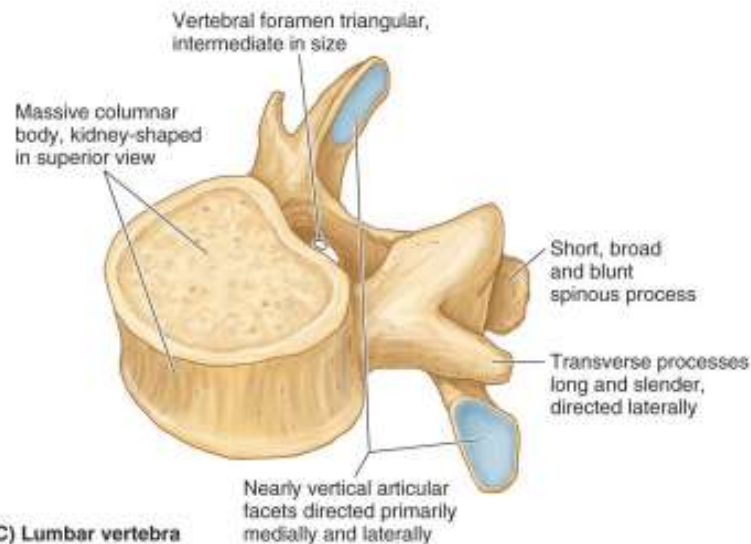
Vertebrae



(A) Cervical vertebra



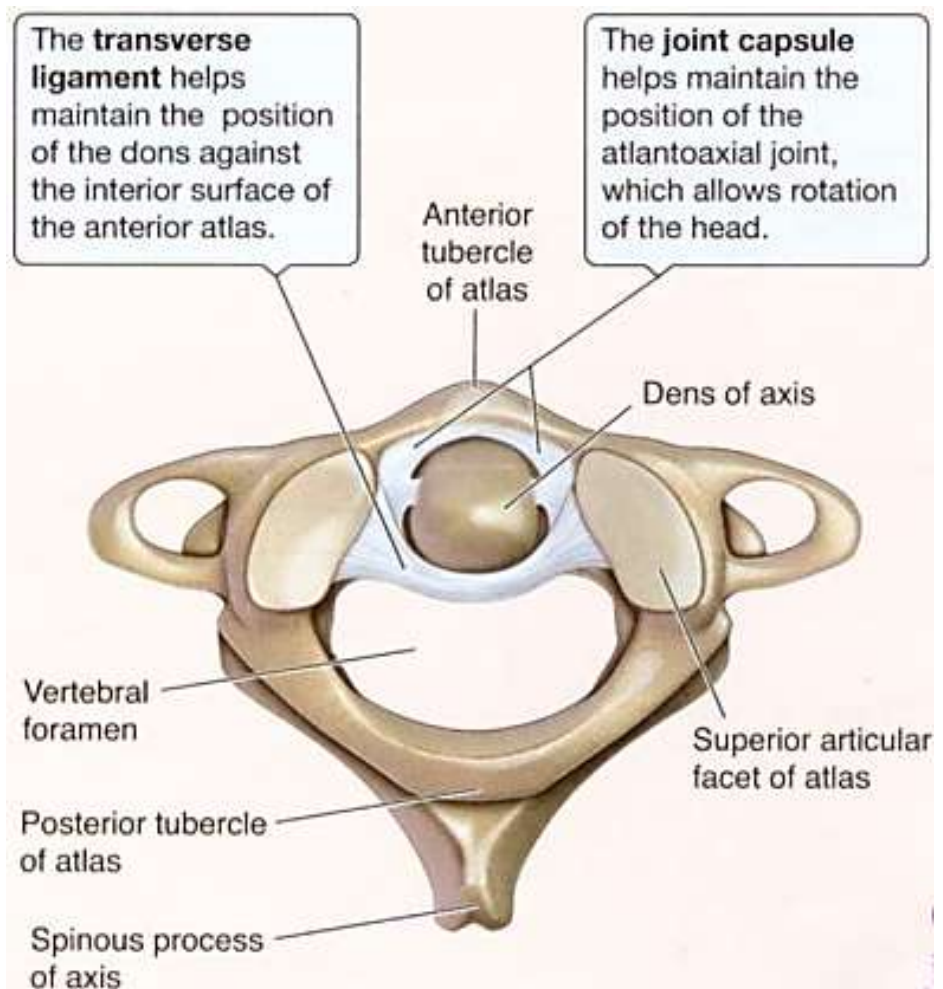
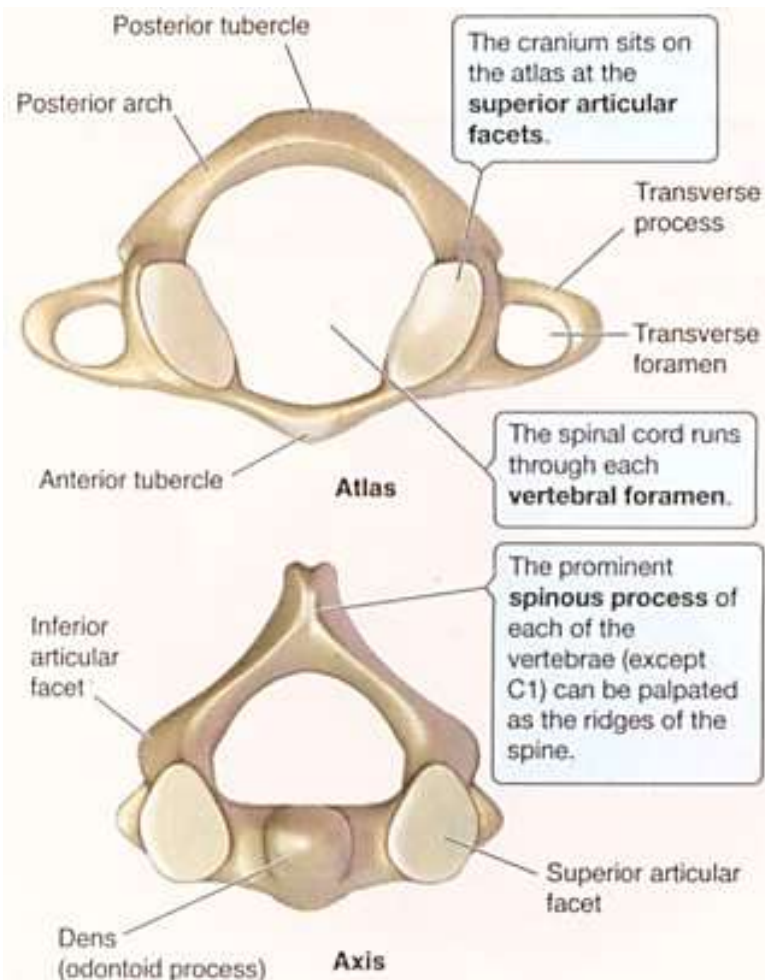
(B) Thoracic vertebra



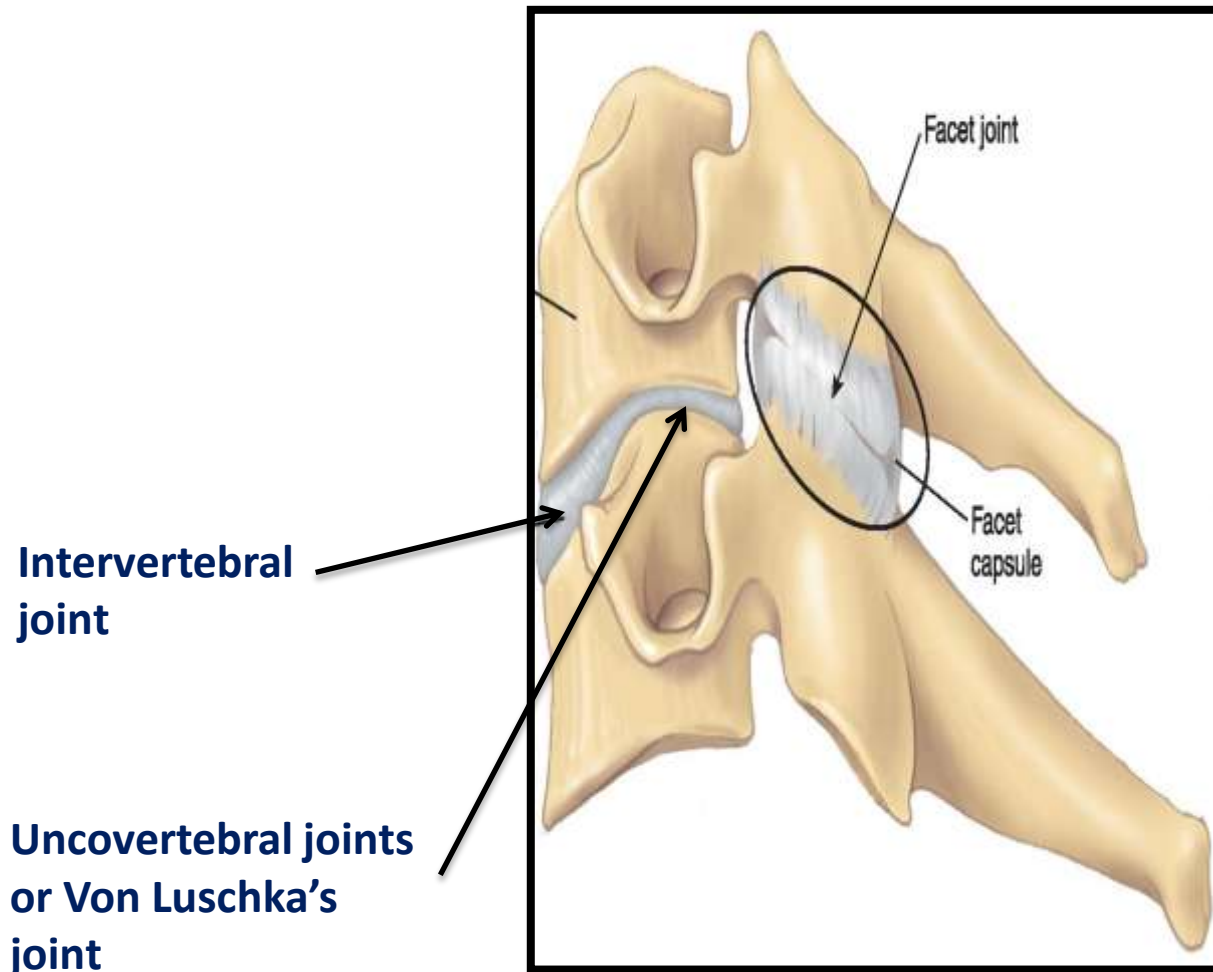
(C) Lumbar vertebra

From: Moore et al,
Clinically Oriented
Anatomy 7th
Edition, 2013, LLW

Atlas & axis

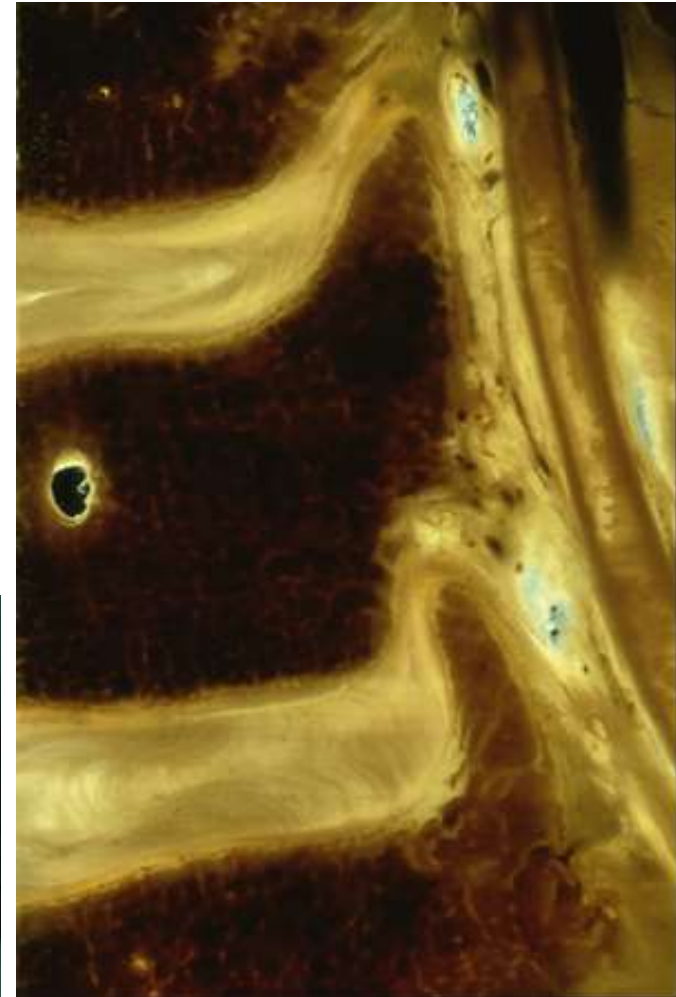


Joints



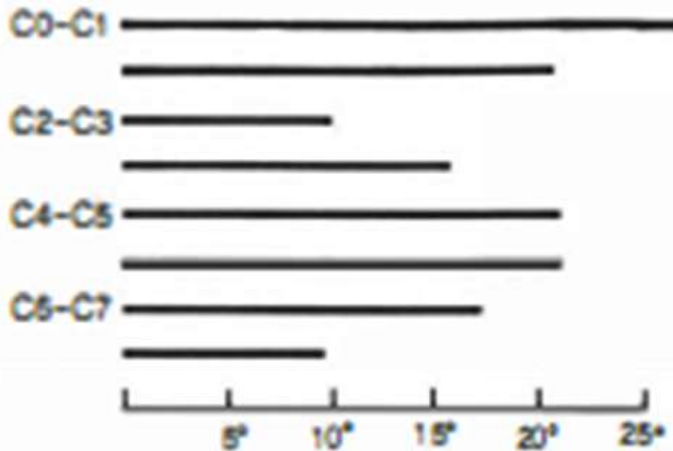
Von Luschka's joints

- ❖ Uncovertebral joints or Von Luschka's joints control rotation and lateral flexion
- ❖ Shock absorption by the curvatures of the spine not the disc



Range of movement (ROM)

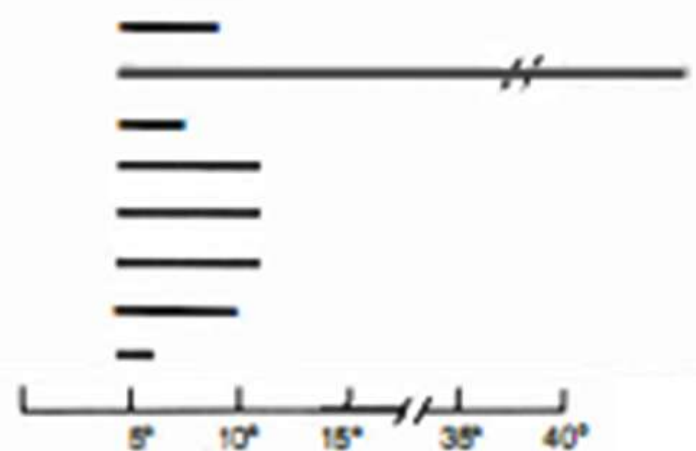
Flexion -extension



Lateral flexion



Rotation



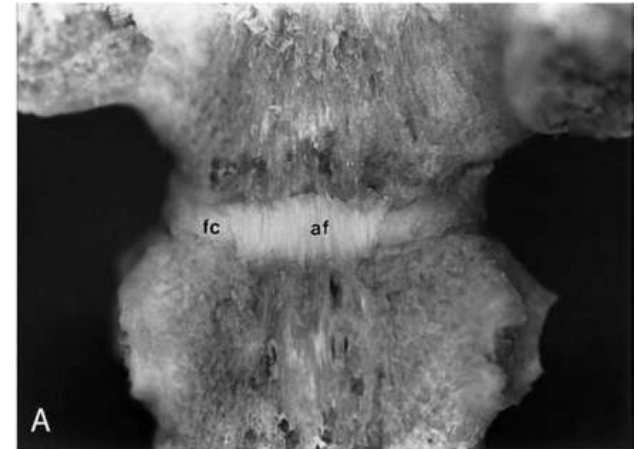
White & Panjabi Clinical Biomechanics of the Spine 2nd Edition

- ❖ 50% of flexion extension happens in the upper cervical
- ❖ 50% of rotation happens in C1-2 level
- ❖ Lateral flexion mostly on the middle part of the cervical spine



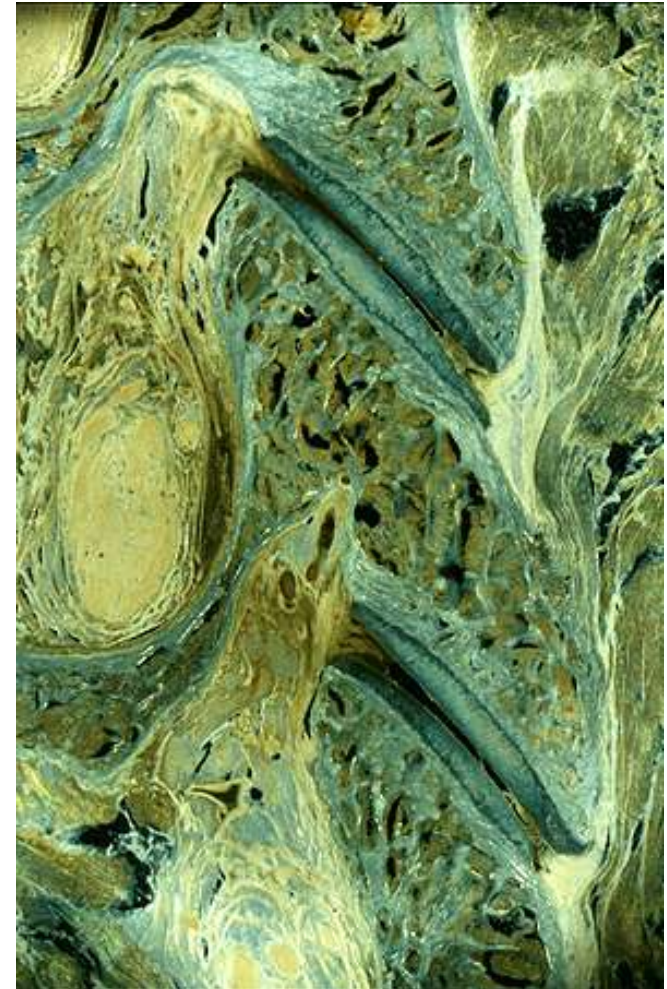
Cervical disc

- ❖ Not the same as lumbar disc
- ❖ There are clefts on the side for the uncovertebral joints
- ❖ It's ring called annulus is weak and not as wide at the back
- ❖ Therefore prone to posterior herniation

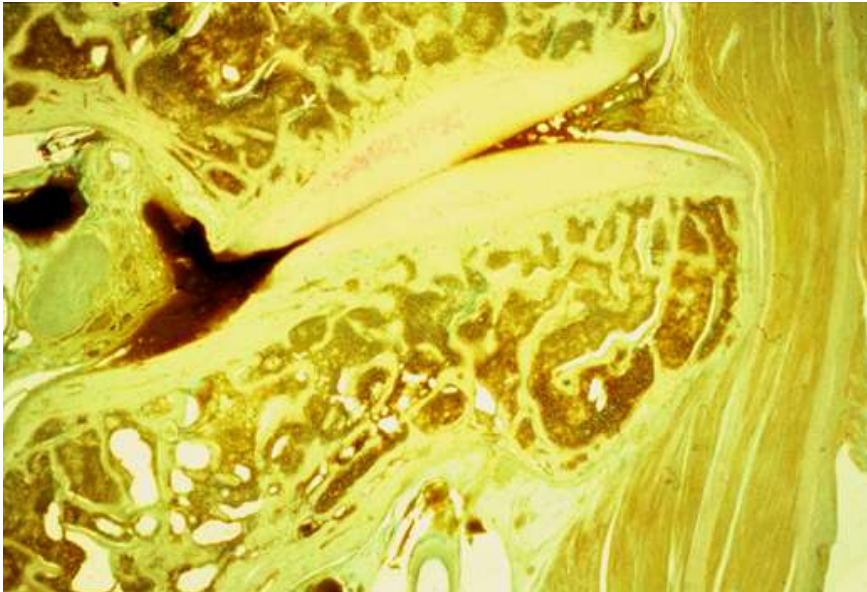


Apophyseal joints

- ❖ 45° angle with transverse plane
- ❖ Their orientation determines movement
- ❖ They are surrounded by a strong connective tissue called capsule
- ❖ Multifidus muscle pulls the capsule during extension and prevents impingement



Miniscoids



Dr JR Taylor 1992-2000

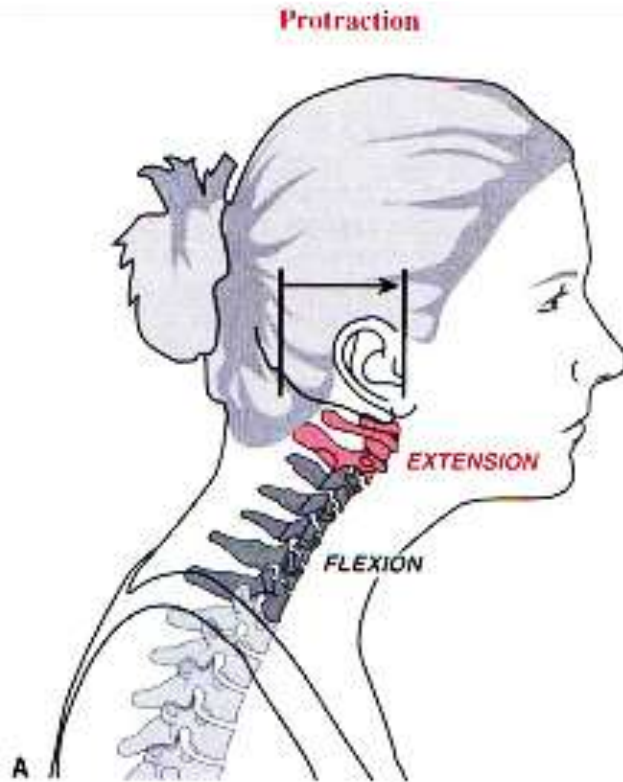
Between the apophyseal joints there are small projections of the capsule infiltrated with fat and blood vessels called the miniscoids. Sometimes they can get trapped and this causes pain and block of movement.

Good news is they can get un-trapped with gentle exercises sometimes (Hint at slide 10).

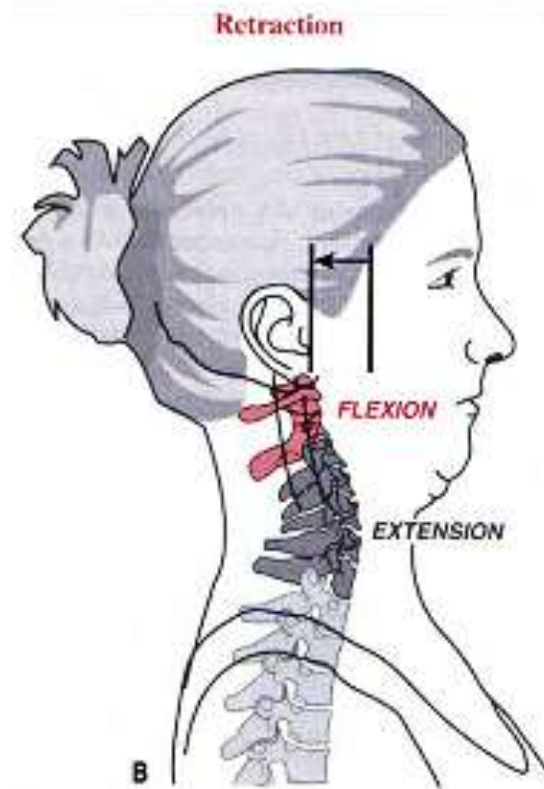


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Arthokinematics in protraction



Protraction
Flexion in the lower cervical
and extension in the upper
cervical

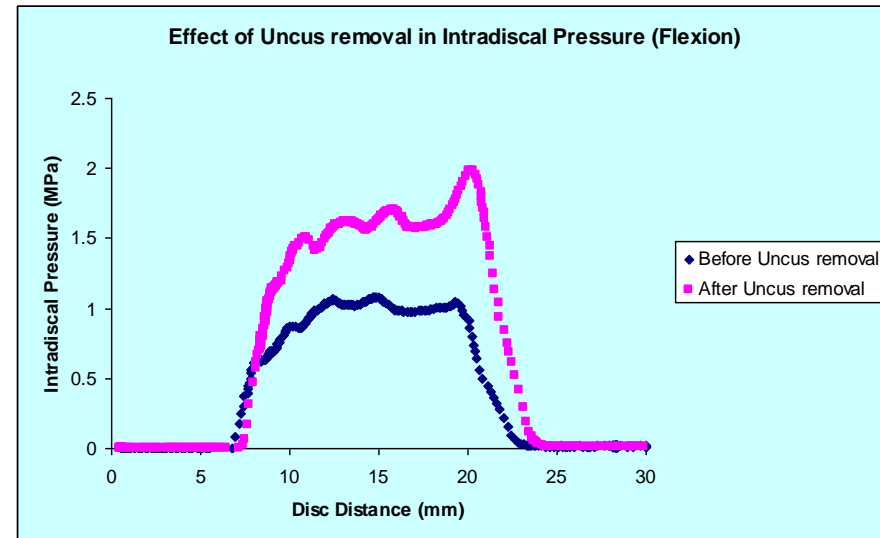


Retraction
Extension in the lower cervical
and flexion in the upper cervical



Compressive load

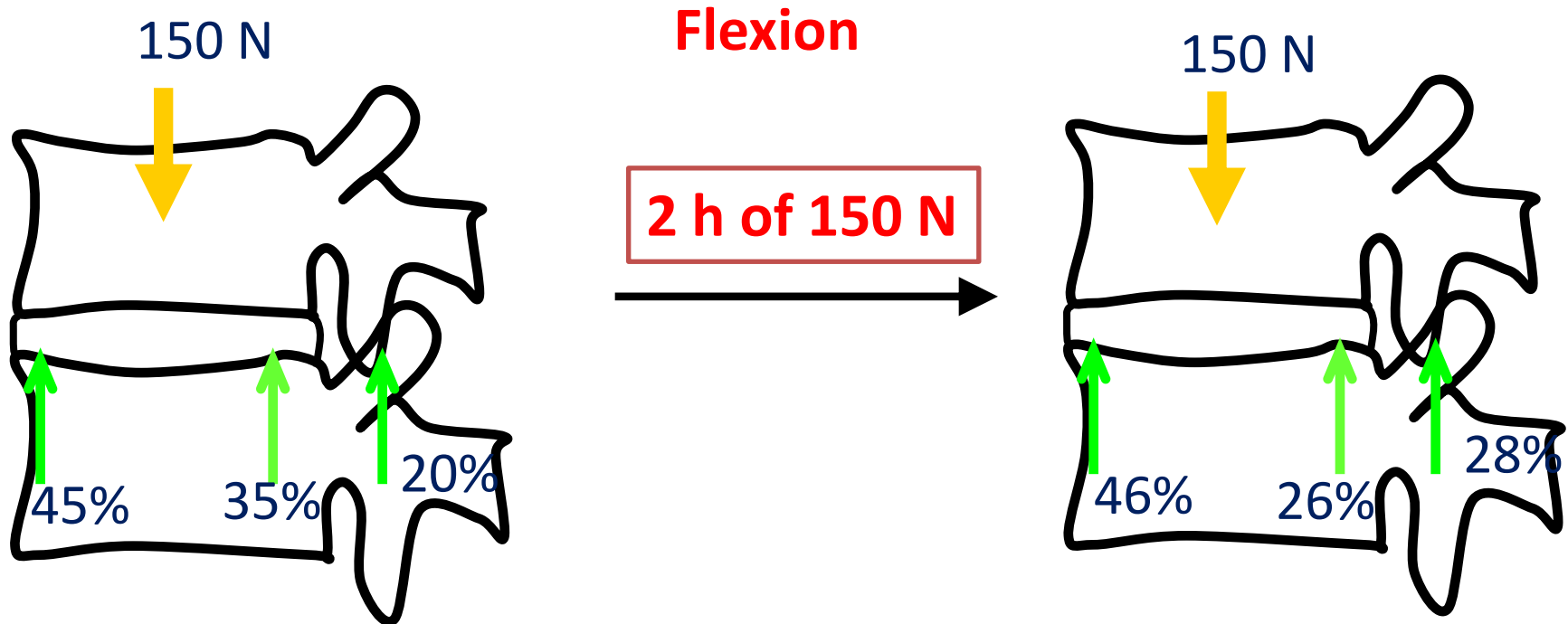
- ❖ Partially shared by the disc-body and the apophyseal joint
- ❖ Uncovertebral joints support approximately 20% of the axial load in flexion



Distribution of stress inside the disc before (blue line) and after (pink line) the removal of uncovertebral joint in flexion



Effect of sustained loading on load distribution

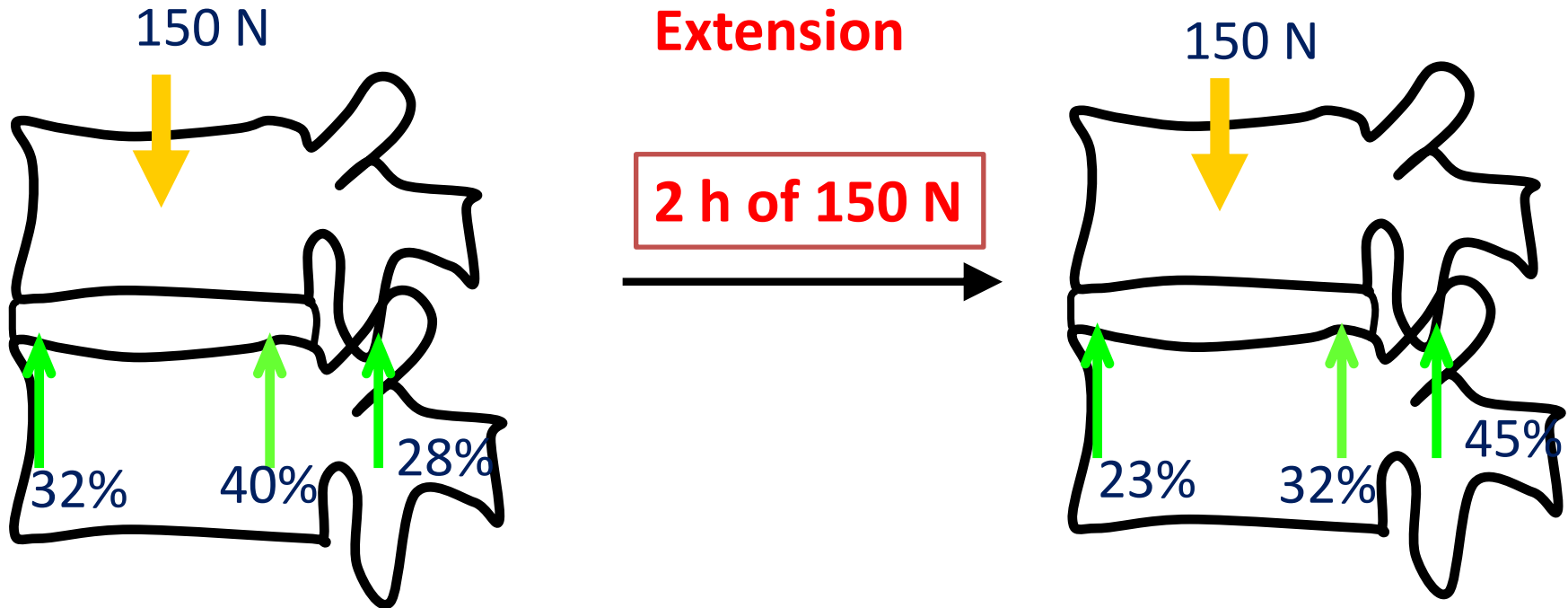


Stefanakis M, Biomechanics of IVD pain. Bristol 2012

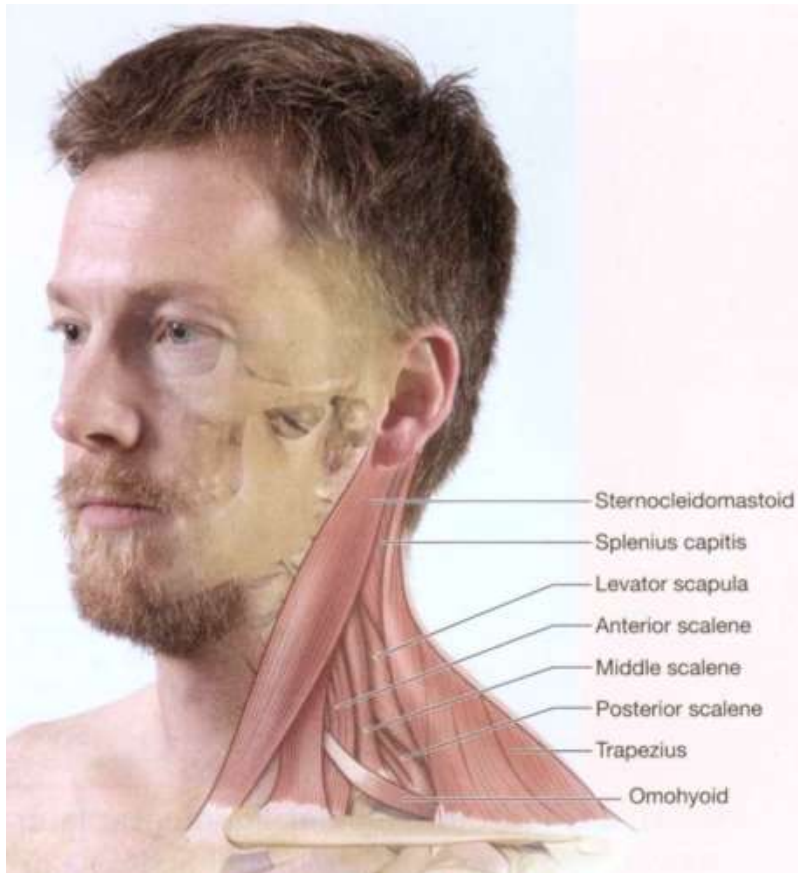


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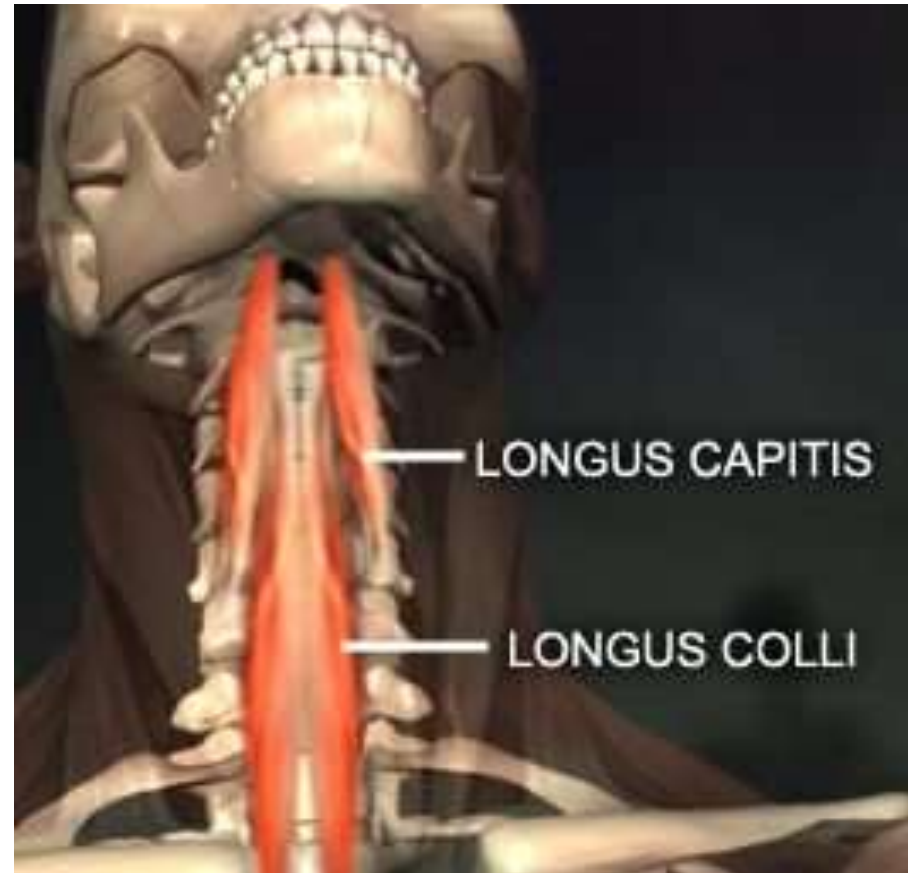
Effect of sustained loading on load distribution



Flexor muscles



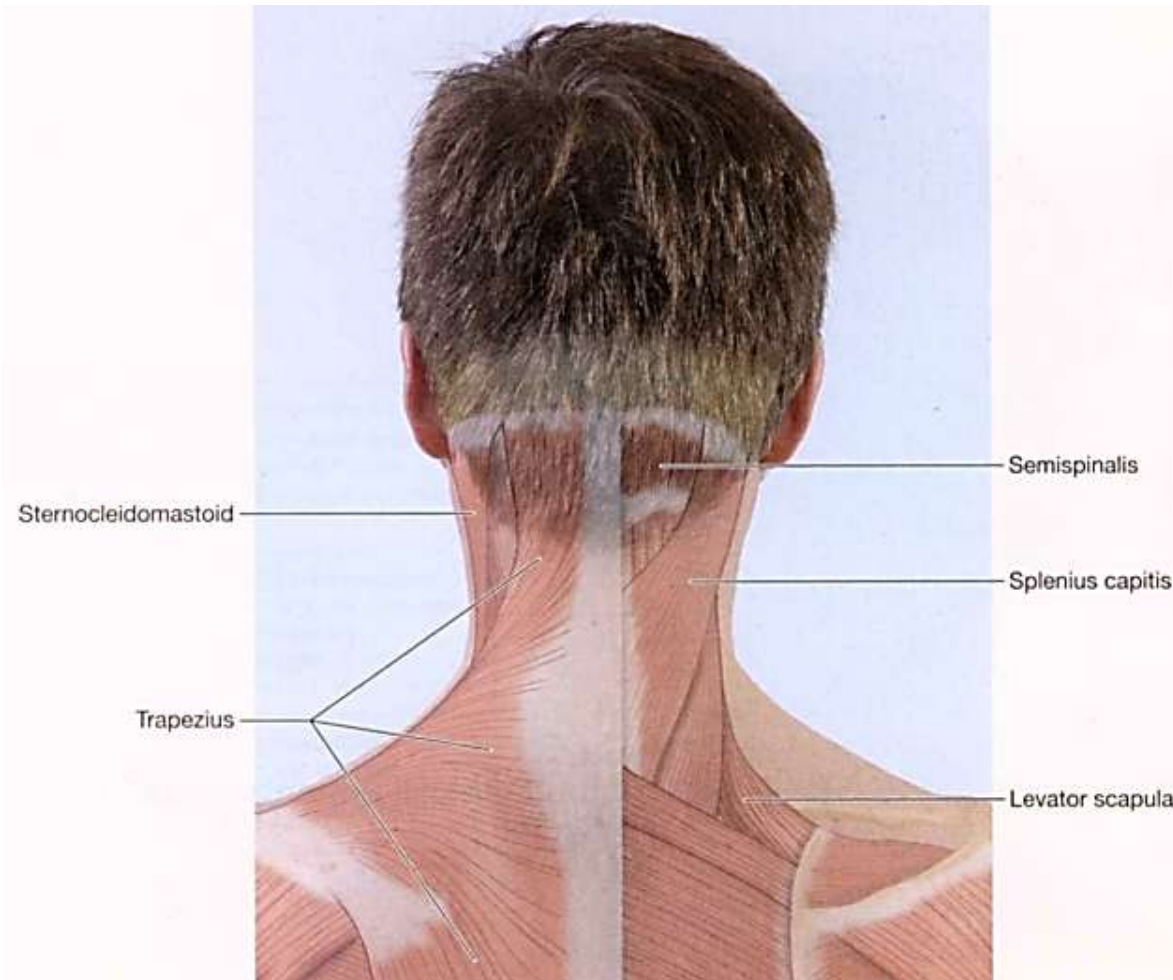
Superficial muscles: Sternocleidomastoid and submandibular muscles prone to tightness



Deep cervical flexors: longus colli and capitis are prone to inhibition



Extensor muscles (superficial)



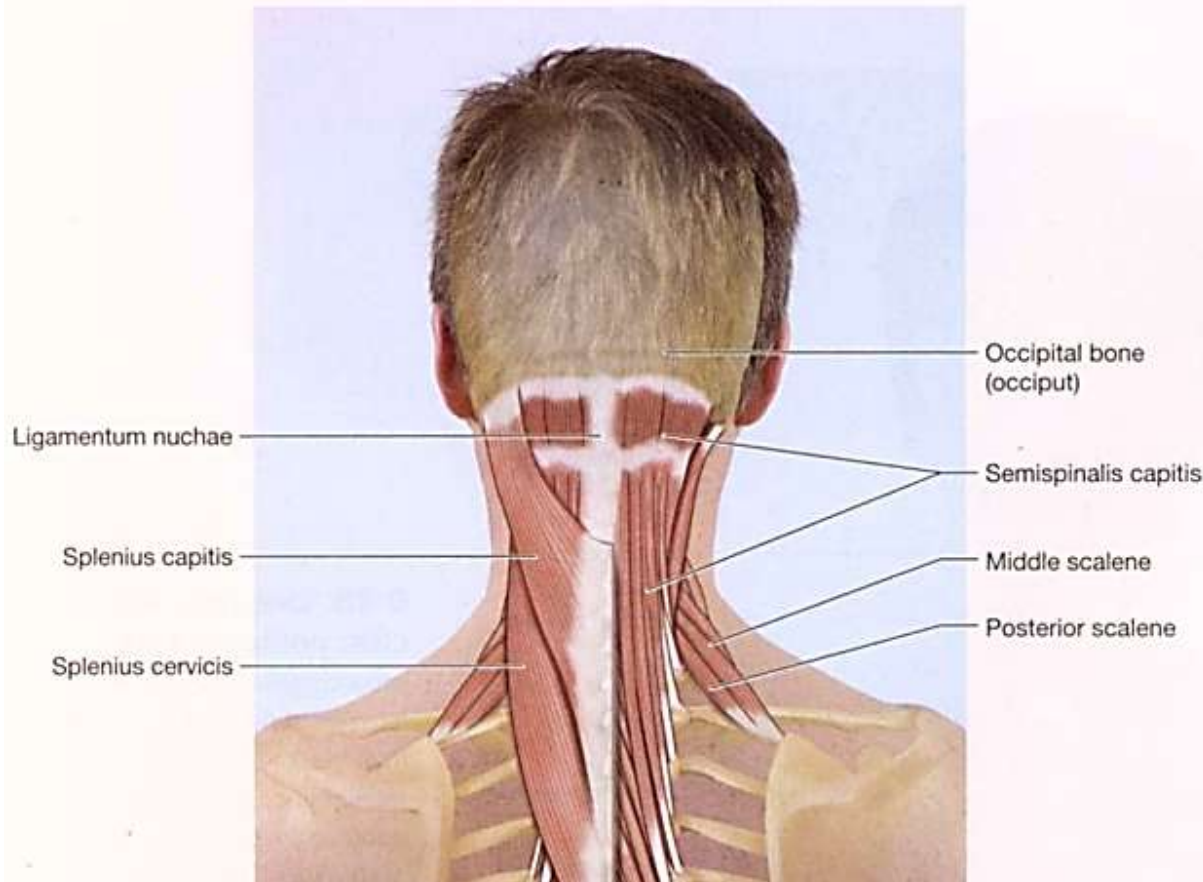
Trapezius: also elevates the shoulder, moves the scapula and side flexes the neck

Levator scapula: mainly elevates shoulder

Picture from: Christy Cael, Functional anatomy: musculoskeletal anatomy, kinesiology, and palpation for manual therapists, 2010 Lippincott Williams & Wilkins



Extensor muscles (middle layer)



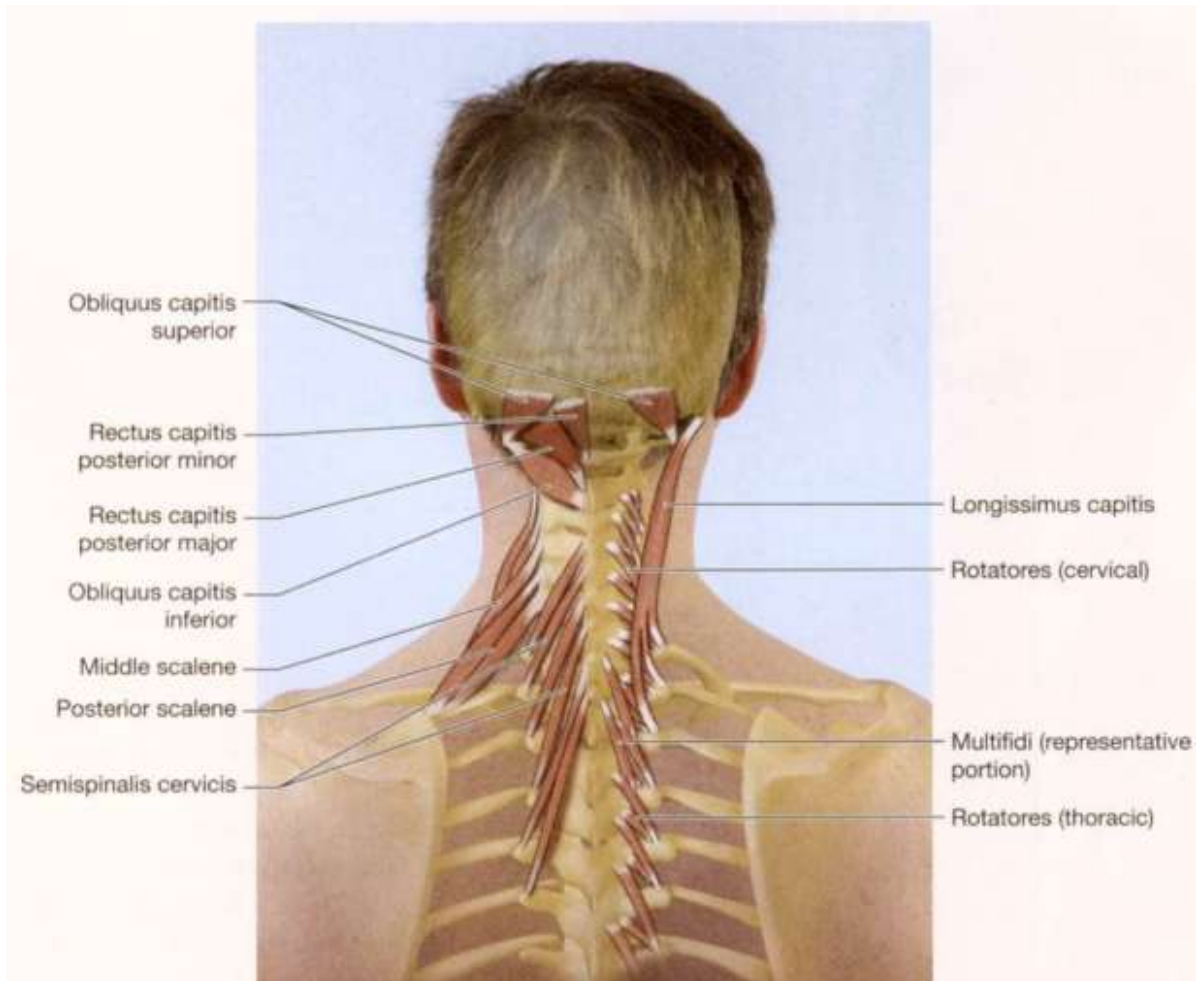
Splenius capitis: extends, side flexes and rotates the head towards the shoulder

Splenius cervicis: extends, side flexes and rotates the neck to the shoulder

Picture from: Christy Cael, Functional anatomy: musculoskeletal anatomy, kinesiology, and palpation for manual therapists, 2010 Lippincott Williams & Wilkins



Extensor muscles (deep layer)



Semispinalis capitis and semispinalis cervicis: extend, side flex and rotate the neck to the shoulder (weak action)

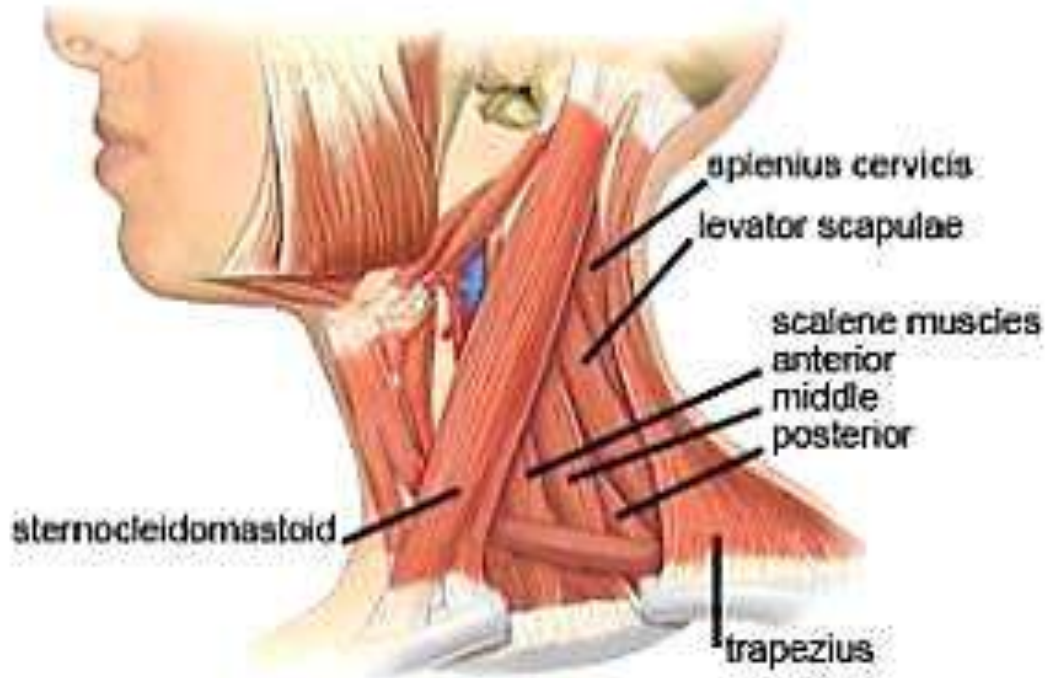
Stabilize the individual segments

Provide proprioceptive input

Picture from: Christy Cael, Functional anatomy: musculoskeletal anatomy, kinesiology, and palpation for manual therapists, 2010 Lippincott Williams & Wilkins



Lateral flexors



Scalenes: 3 muscles anterior, posterior and middle scalene

Both anterior scalenes working together can flex the neck and both posterior scalenes working together can extend the neck

Also accessory respiratory muscles normally activated only during deep breathing



Cx and breathing

- ❖ Diaphragm the main respiratory muscle is innervated by phrenic nerve (C4 level)
- ❖ Pathology of the neck might affect the nerve and therefore breathing
- ❖ Alternatively breathing with a lot of scalenes action (accessory muscles) increases cervical loading



Stress and breathing

- ❖ During stress breathing becomes shallow and fast
- ❖ Diaphragmatic breathing is replaced by thoracic breathing
- ❖ Sometimes this becomes habit
- ❖ Chronic respiratory dysfunction leads to increased exhalation of CO_2
- ❖ This leads to respiratory alkalosis ($\text{pH} > 7.4$)
- ❖ Alkalosis leads to contraction of vessels and increase affinity of hemoglobin and O_2
- ❖ So less blood and O_2 reaches the muscles and less O_2 is released to the muscles
- ❖ This leads to muscle fatigue, general fatigue and mental fatigue (clearly important in office workers)



Response to breathing dysfunction

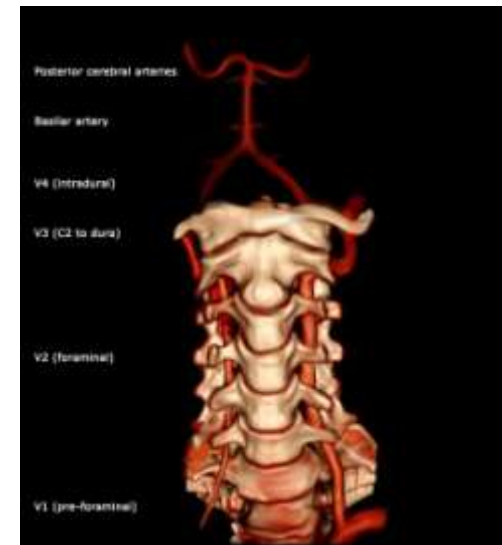
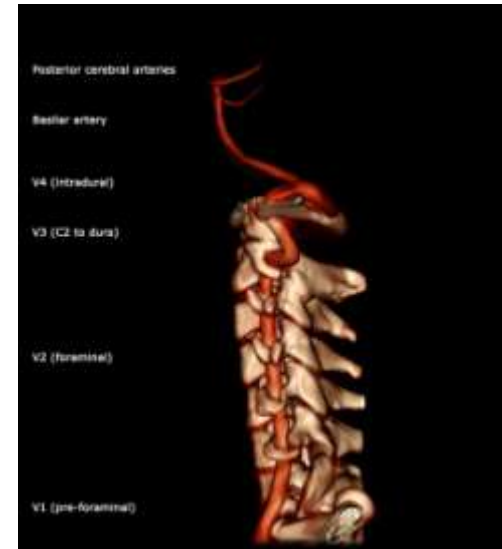
- ❖ Increased secretion of HCO_3^- by the kidneys
- ❖ This disturbs calcium- magnesium balance
- ❖ This imbalance affects neural and muscular function
- ❖ Increase in pain due to Trigger Points

Take home message: breathing affects both loading of the Cx spine and muscular pain



Vertebral artery

- ❖ Goes through the cervical spine and supplies blood to the brain
- ❖ Pathology of the cervical spine can affect the blood flow to the brain
- ❖ Important to send for medical examination of VA involvement is suspected



"Vertebral artery 3D AP" by Frank Gaillard -



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Symptoms of vertebral artery

❖ 5 D

- ☐ Diplopia
- ☐ Dysarthria
- ☐ Dysphagia
- ☐ Drop attacks
- ☐ Dizziness

❖ 2 N

- ☐ Nystagmus
- ☐ Nausea

❖ 1 T

- ☐ Tinnitus (“bees in your ear”)

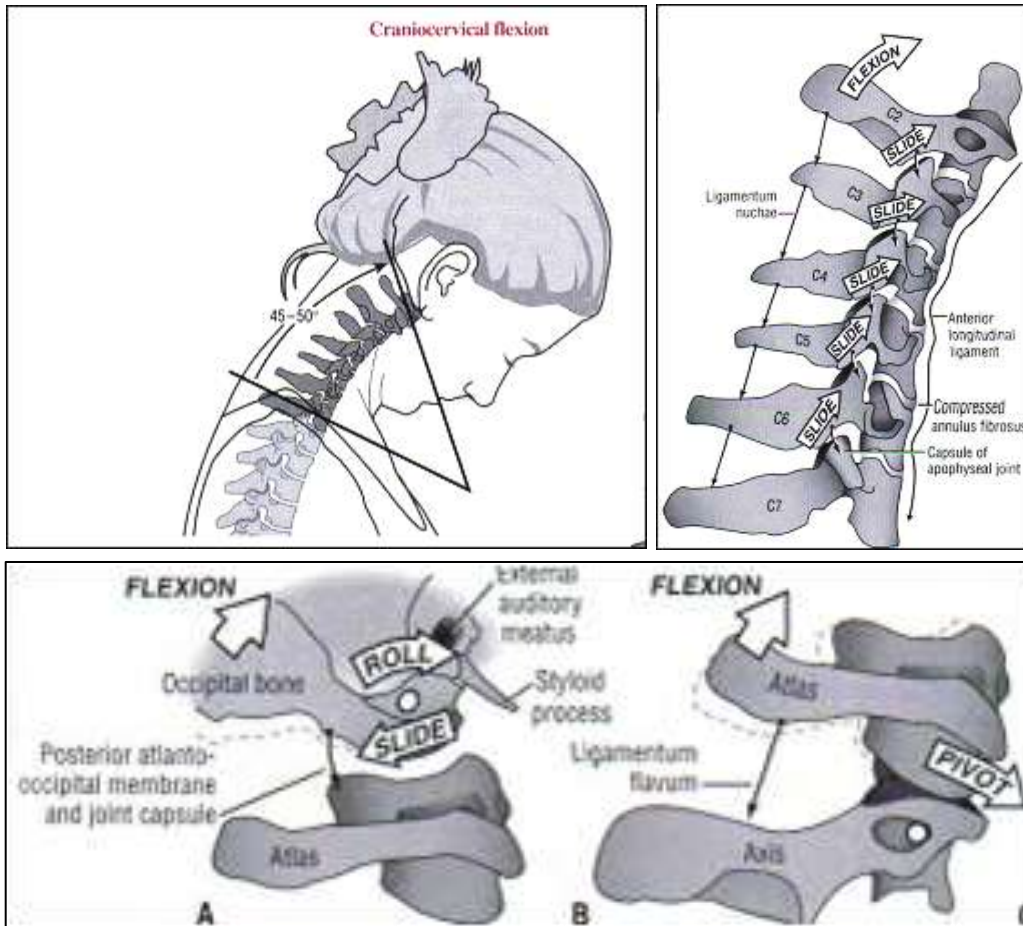


End

Breathe you made it...!



Arthokinematics in flexion



Head slides back and roll forward on top of C1

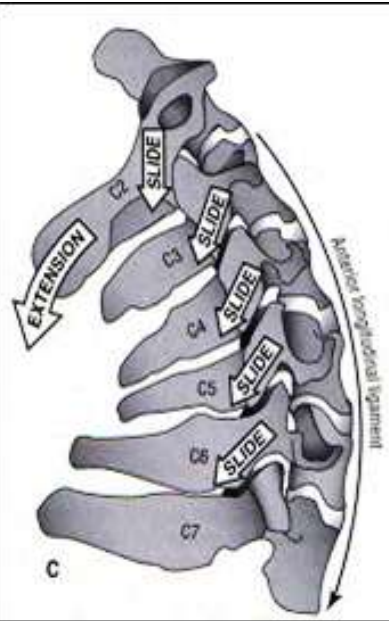
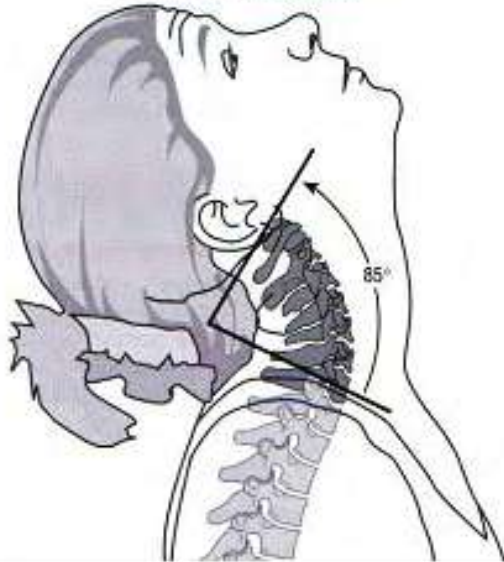
C2-7: top facet glides anterior and upward on the inferior facet

Apophyseal joints act like rails that guide movement

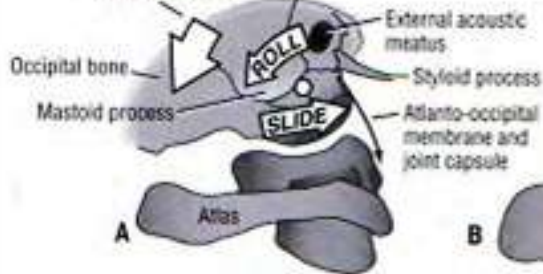
Arthokinematics in extension

Exactly the opposite of flexion

Craniocervical extension



EXTENSION



Atlanto-occipital joint

EXTENSION

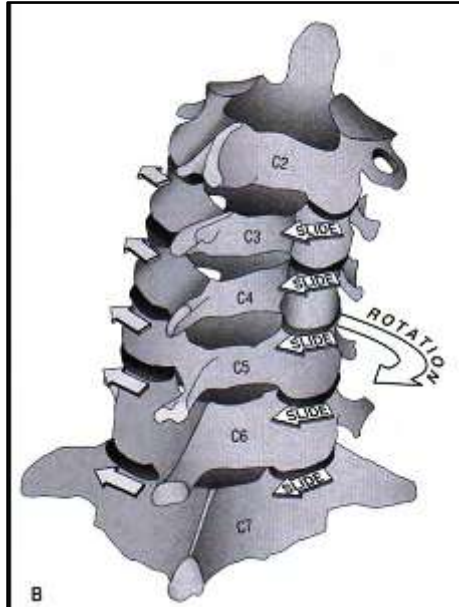
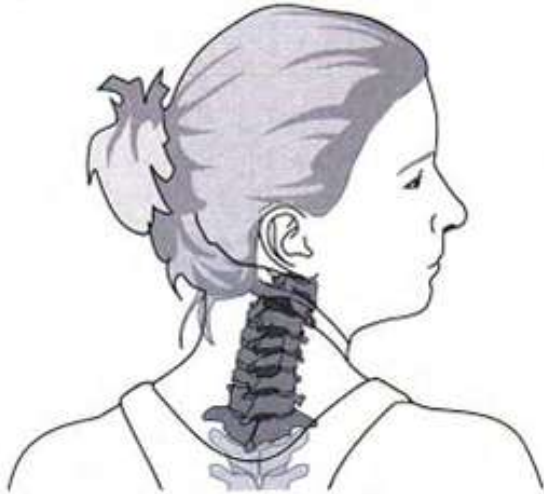


Atlanto-axial joint complex

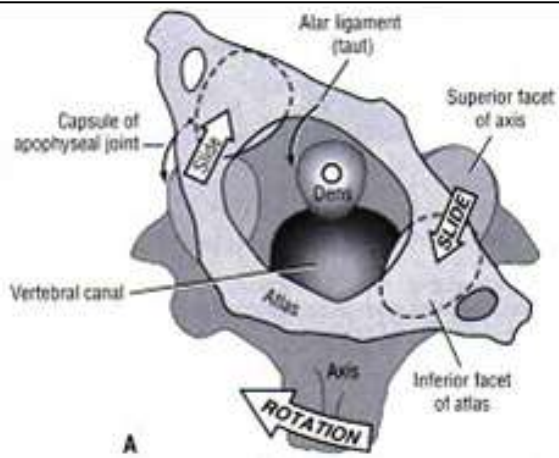


Arthokinematics in rotation

Craniocervical axial rotation



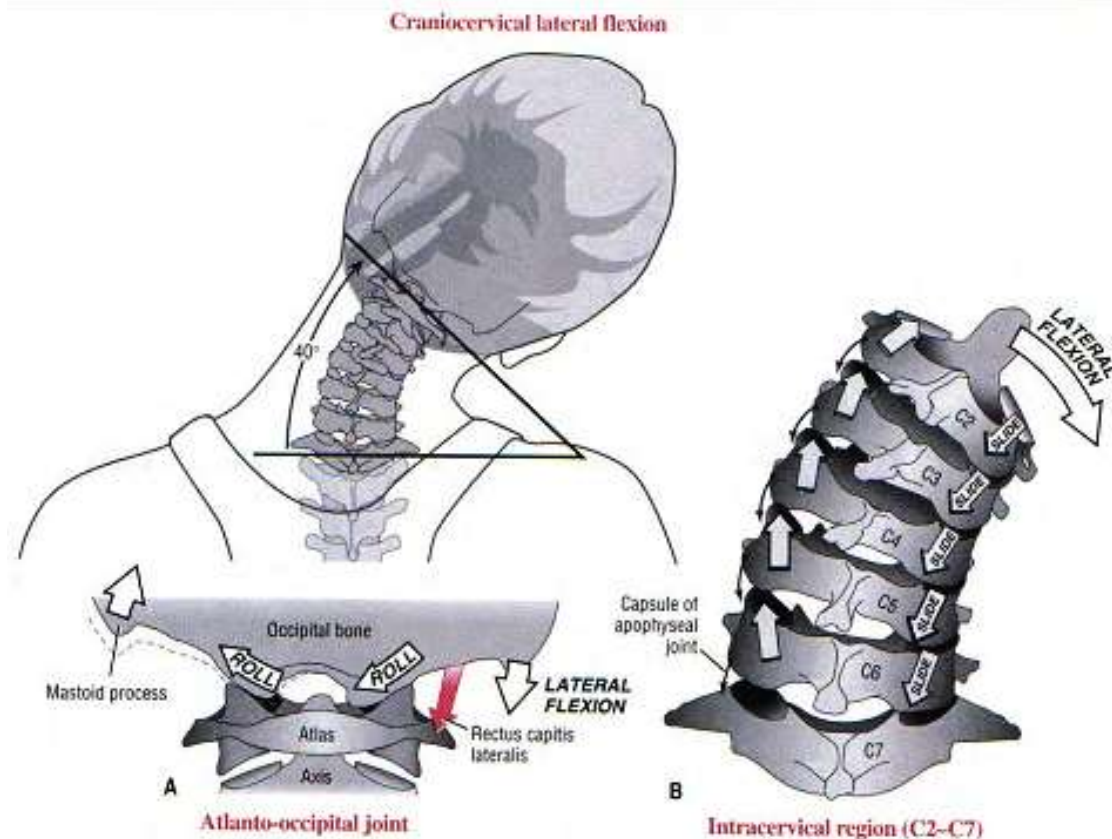
During right rotation
apophyseal joints
on the right side do
extension and on
the left flexion



Opposite happens
during left rotation



Arthokinematics in lateral flexion



During right lateral flexion apophyseal joints on the right side do extension and on the left flexion

Combined with same side rotation

