



Physiotherapy Department

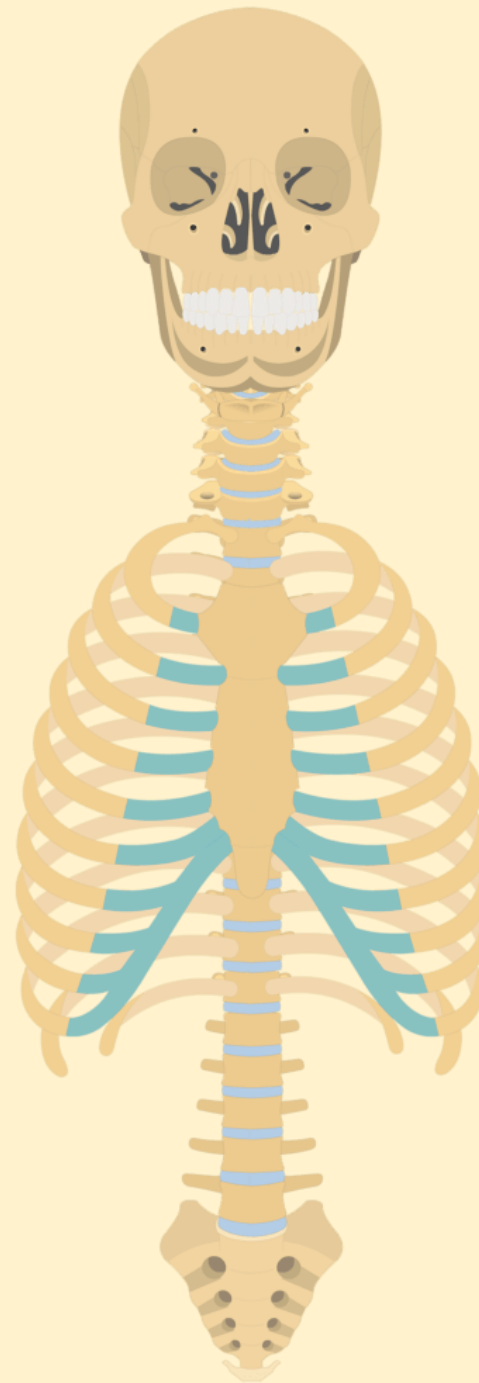
PT201: Biomechanics

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07-11-2023

Biomechanics of the Temporomandibular Joint and Spine



Lecture 6

Biomechanics of the Spinal Joints and Spinal Column

07-11-2023

Synopsis

- Biomechanics of joints of the spinal column
 - Atlanto-occipital
 - Atlanto-axial
 - Facets
 - Intervertebral
- Biomechanics of spinal column

Objectives

By the end of this lecture, students should understand and be able to describe the the following:

- Biomechanics of the joints of the spinal column
 - Atlanto-occipital joint
 - Atlanto-axial joint
 - Facets joint
 - Interbody joint
- Biomechanics of the spinal column as a whole

Overview

- Two main types of articulations are found in the vertebral column:
 - Cartilaginous joints of the symphysis
 - Diarthrodial or synovial joints
- Thus, the vertebral column comprises the following joints
 - Atlanto-occipital
 - Atlanto-axial
 - Interbody (intervertebral)
 - Facets (zygapophyseal/apophyseal)

Biomechanics of the Spine

Atlanto-occipital

- **Articulation:** Convex occipital condyles of the skull and concave superior articular facets of the atlas (right and left joints)
- **Type:** Ellipsoid synovial joints
- **Capsule:** Two roomy and relaxed articular capsules
- **Ligament:** Anterior and posterior atlanto-occipital ligament
- **Osteokinematics:** Flexion, extension, side flexion, and rotation

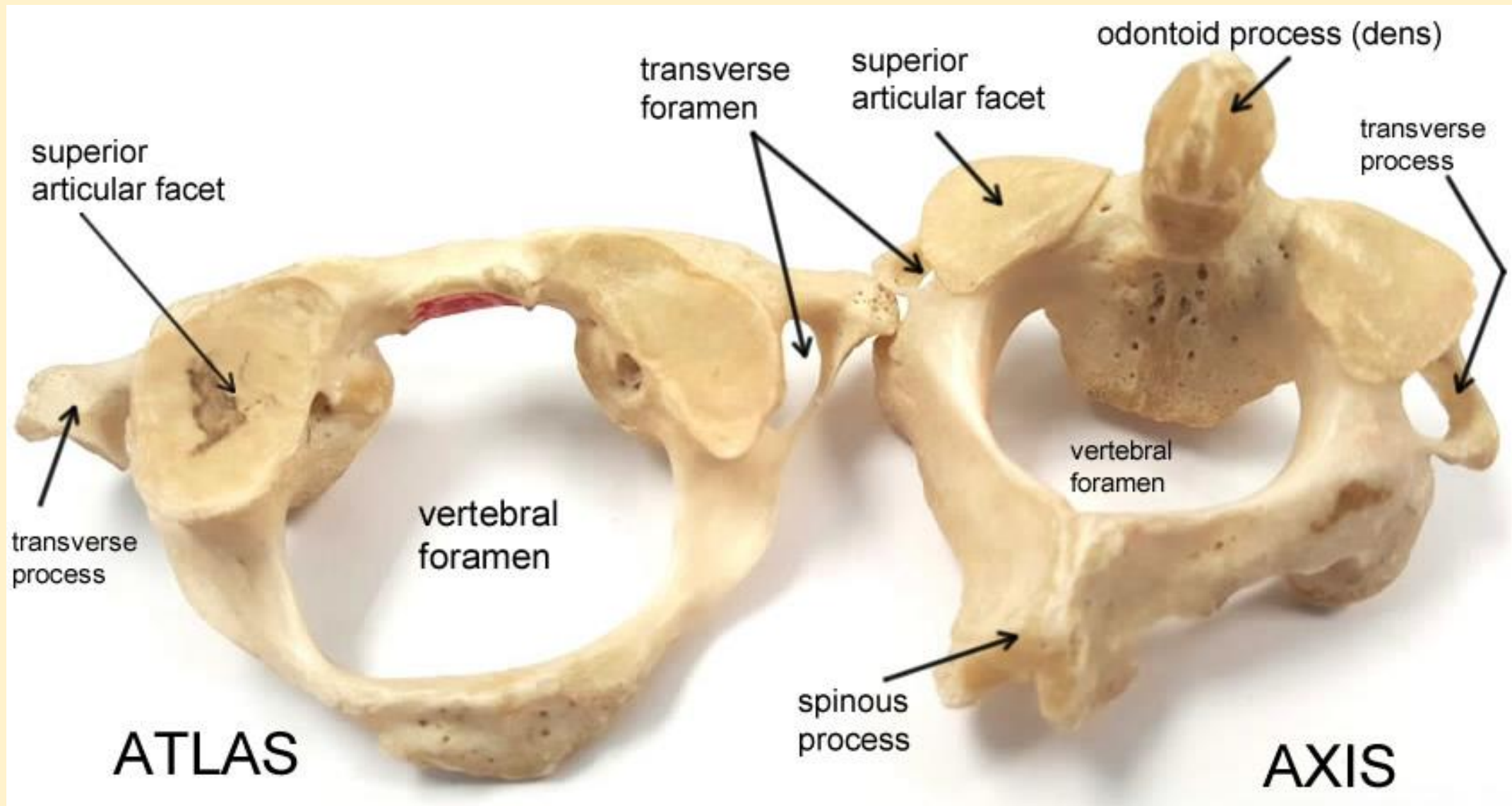
Biomechanics of the Spine

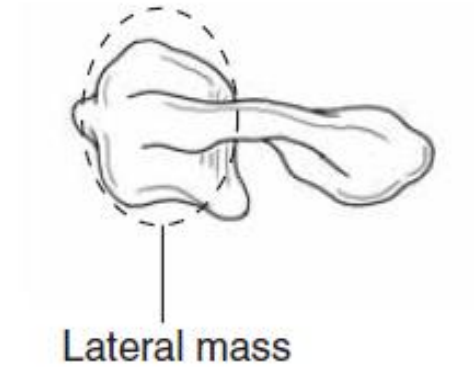
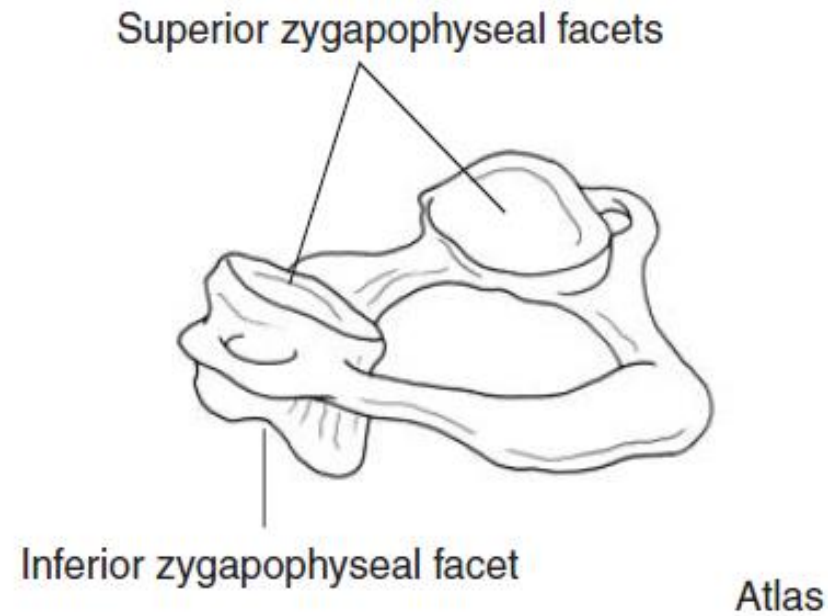
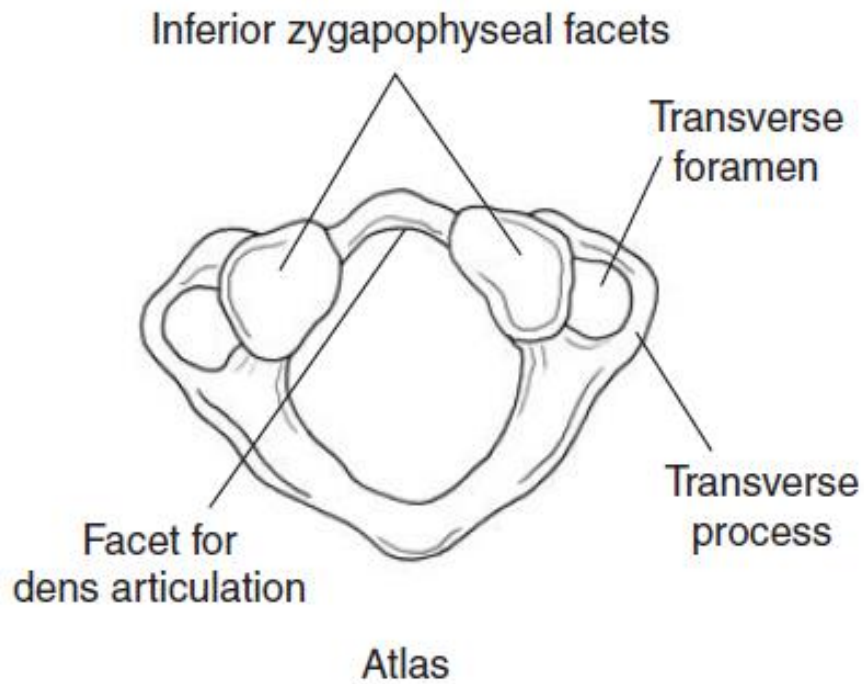
Atlanto-axial

- A complex joint made up of three synovial joints and constitutes the most mobile articulation of the spine
- **Articulations:**
 - One median atlantoaxial joint between the dens and the atlas
 - Two lateral joints between the superior zygapophyseal facets of the axis and the inferior zygapophyseal facets of the atlas
- **Type:** Synovial (median is pivot, laterals are plane)
- **Capsule:** Thick and loose, and connect the margins of the lateral masses of the atlas with those of the posterior articular surfaces of the axis

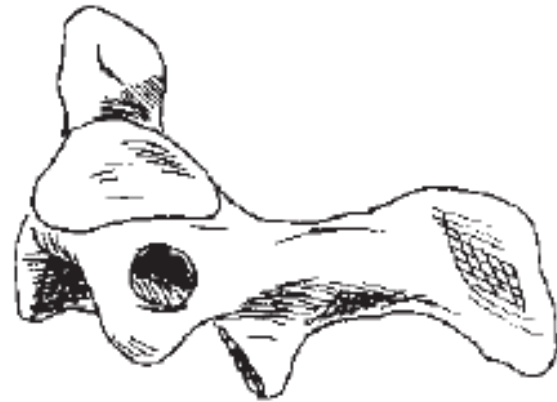
Biomechanics of the Spine

- **Ligament:** Anterior and posterior atlantoaxial ligament, transverse ligament of the atlas, alar ligaments, apical ligament, tectorial membrane, and ligamentum nuchae
- **Osteokinematics:** Rotation (primary movement, 60% of cervical rotation (50°) comes from the atlanto-axial articulation); flexion, extension; side flexion
- **Pathomechanics of the atlanto-occipital and atlanto-axial joints:**
 - Atlanto-occipital dislocation
 - Fracture of the arch of C1 (Jefferson fracture)
 - Fracture of the dens
 - Ligamentous weakness and laxity, etc.



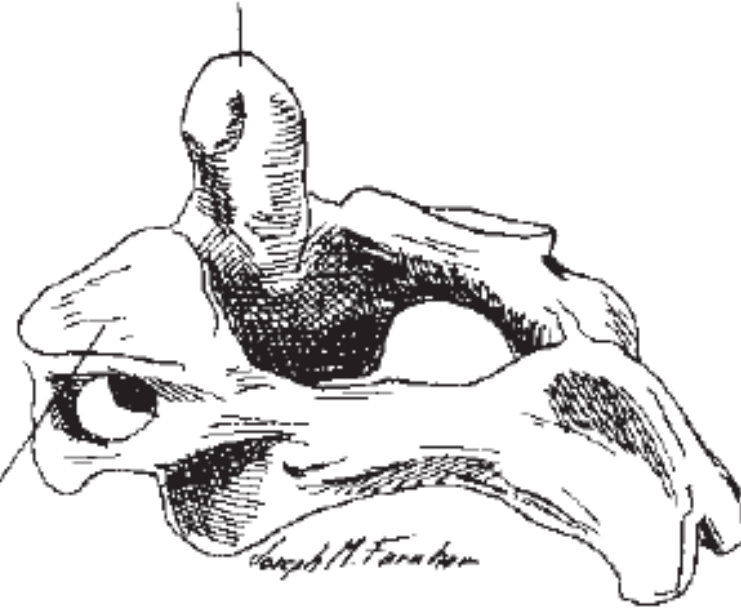


The atlas is a markedly atypical vertebra. It lacks a body and a spinous process



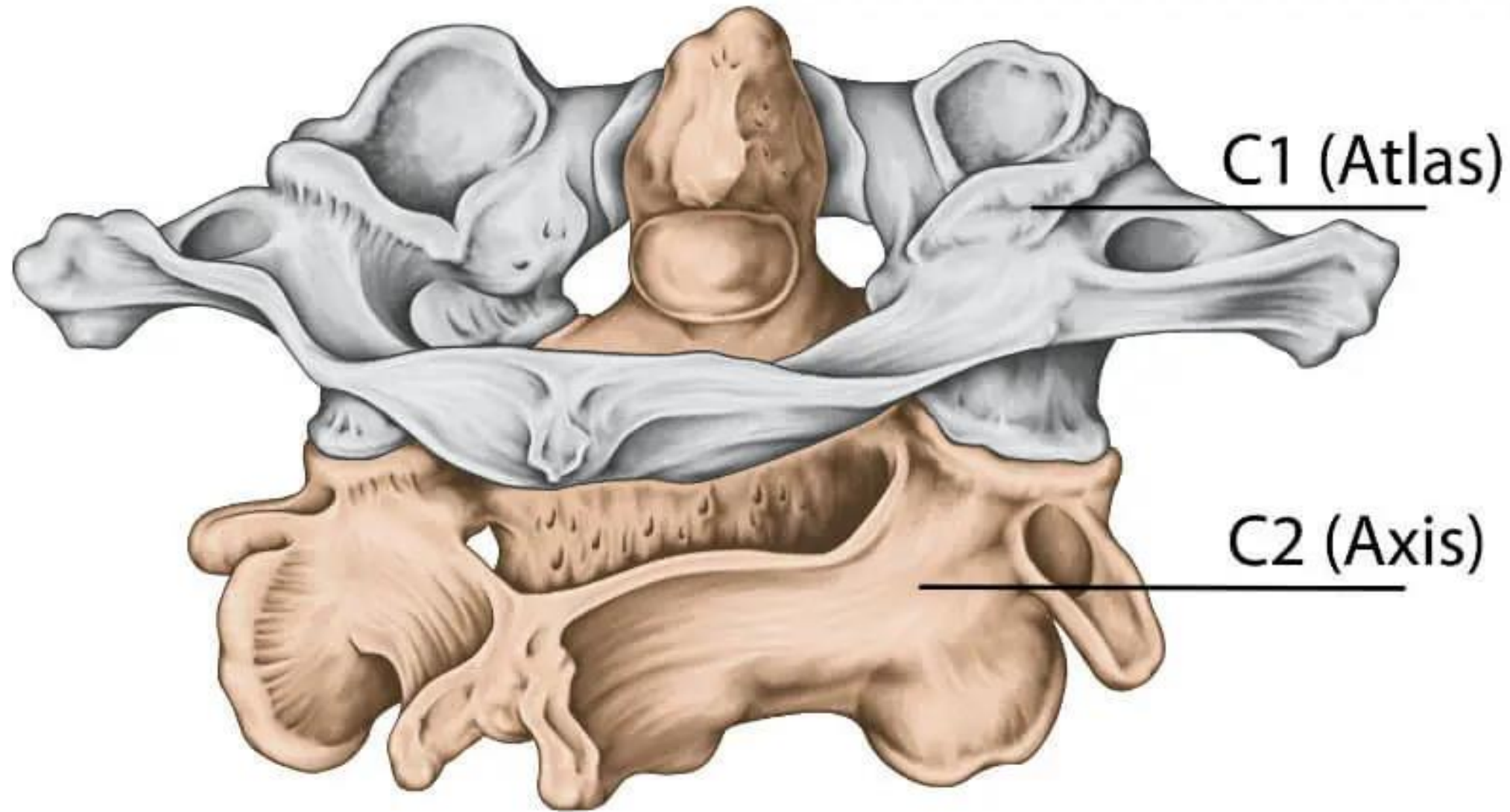
Lateral aspect

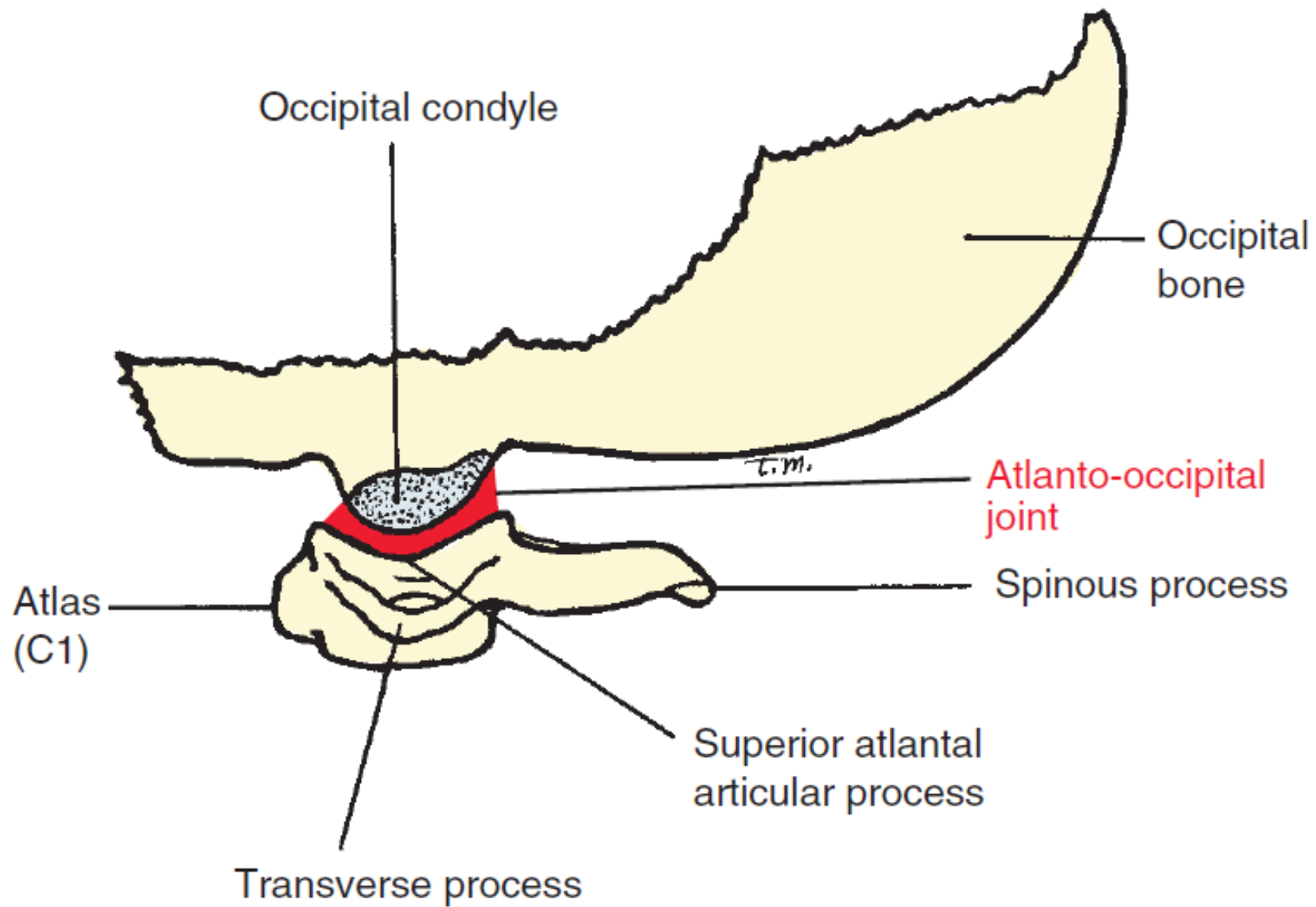
Dens (odontoid process)



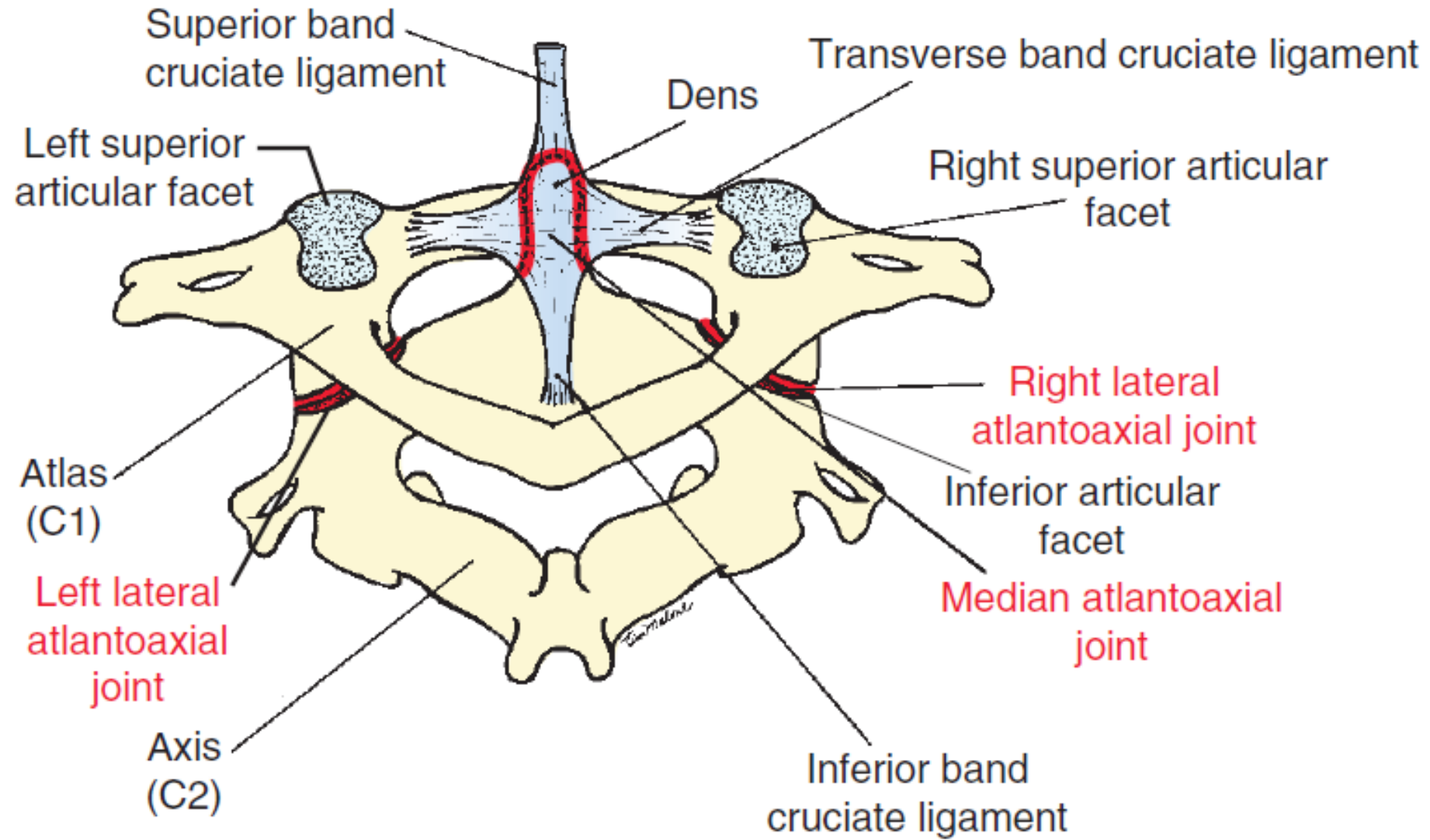
Superior zygapophyseal facets

AXIS

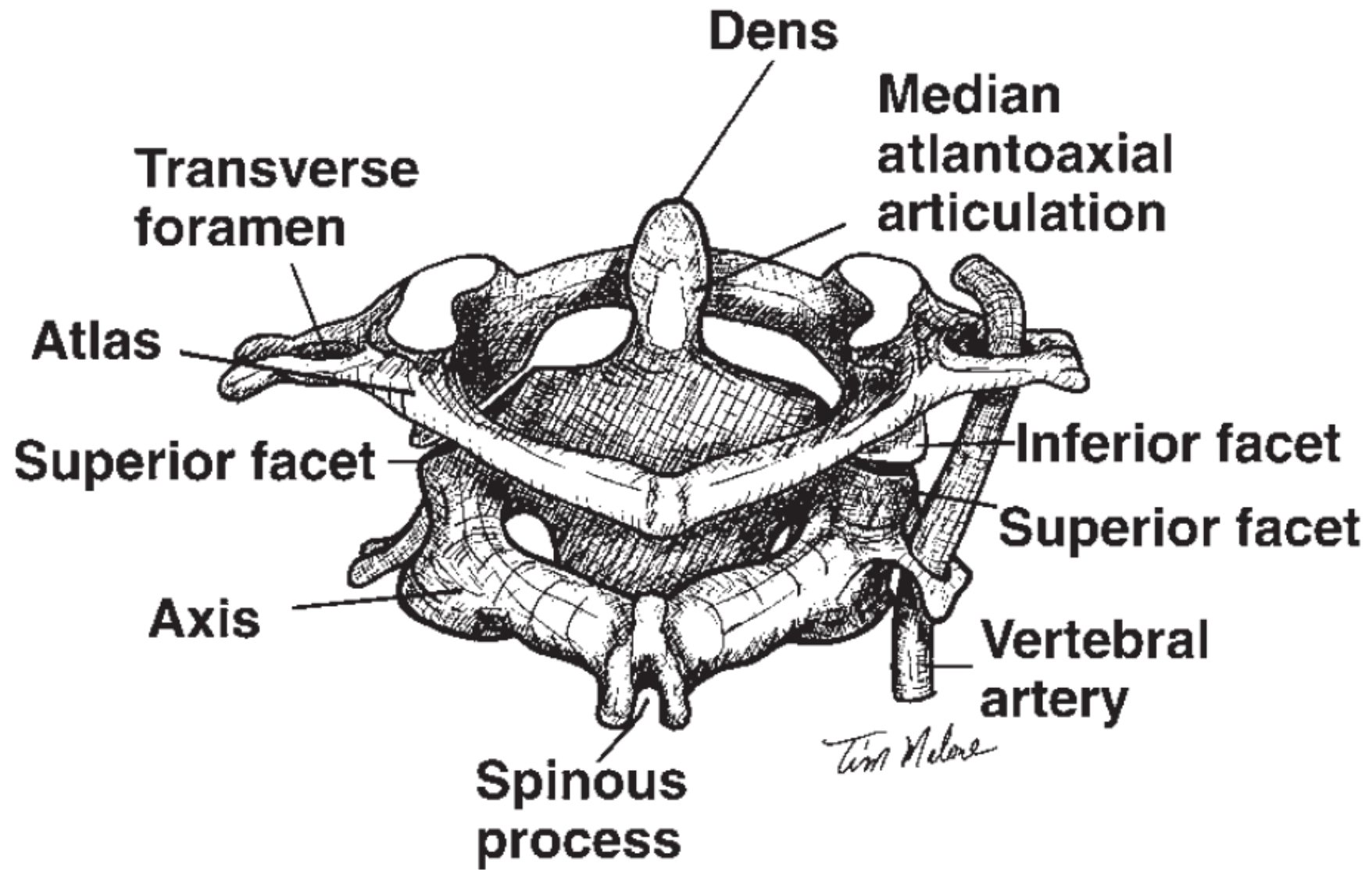




Atlanto-Occipital Joint

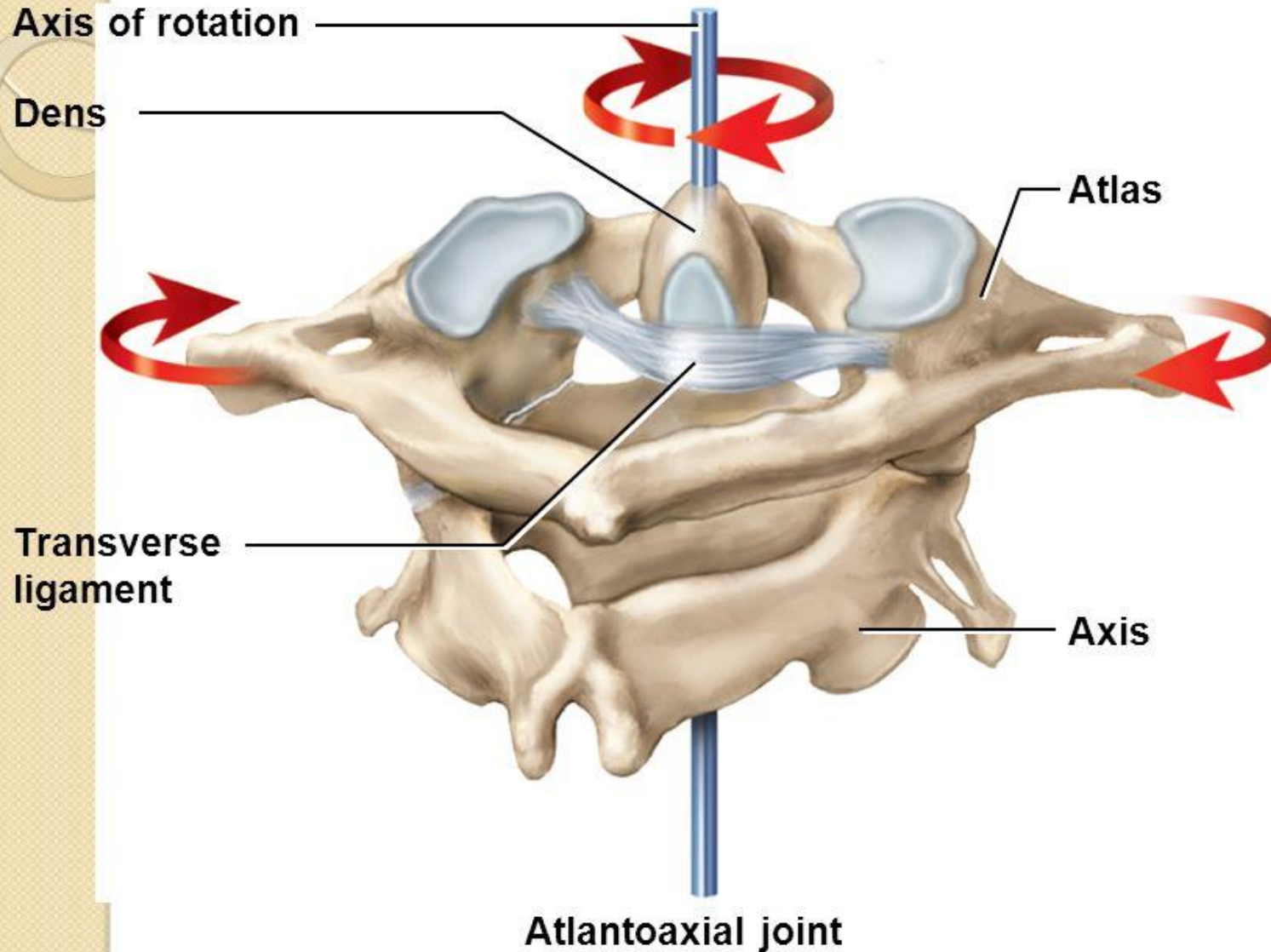


Atlanto-Axial Joint



Atlanto-Axial Joint

Atlas and Axis Articulation



Biomechanics of the Spine

Zygapophyseal joints

- **Articulation:** Between the right and left superior articulating facets of a vertebra and the right and left inferior facets of the adjacent cranial vertebra
- **Type:** Plane synovial
- **Capsule:** Each joint has its own capsule and capsular ligaments, which are lax and permit a relatively large ROM. The ligamentum flavum helps to reinforce the joint capsules

Biomechanics of the Spine

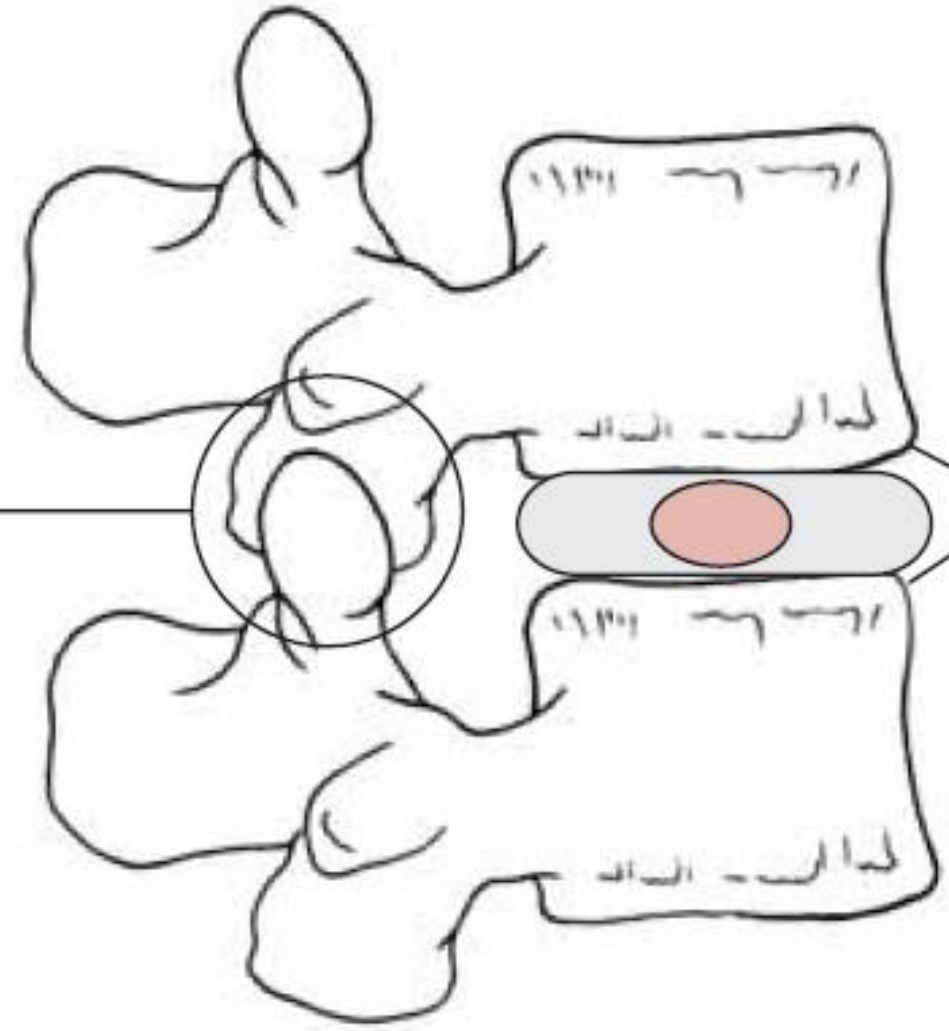
- **Ligaments:** Anterior and posterior longitudinal ligament, ligamentum nuchae, ligamentum flavum, supraspinous and interspinous ligaments
- **Osteokinematics/Arthrokinematics:**
 - Guide and constrain the motion of the vertebrae
 - Facilitate the transmission of the loads applied to the spine
 - Maintain the stability of the spine
 - Permits flexion, extension, and rotation of the spine

Biomechanics of the Spine

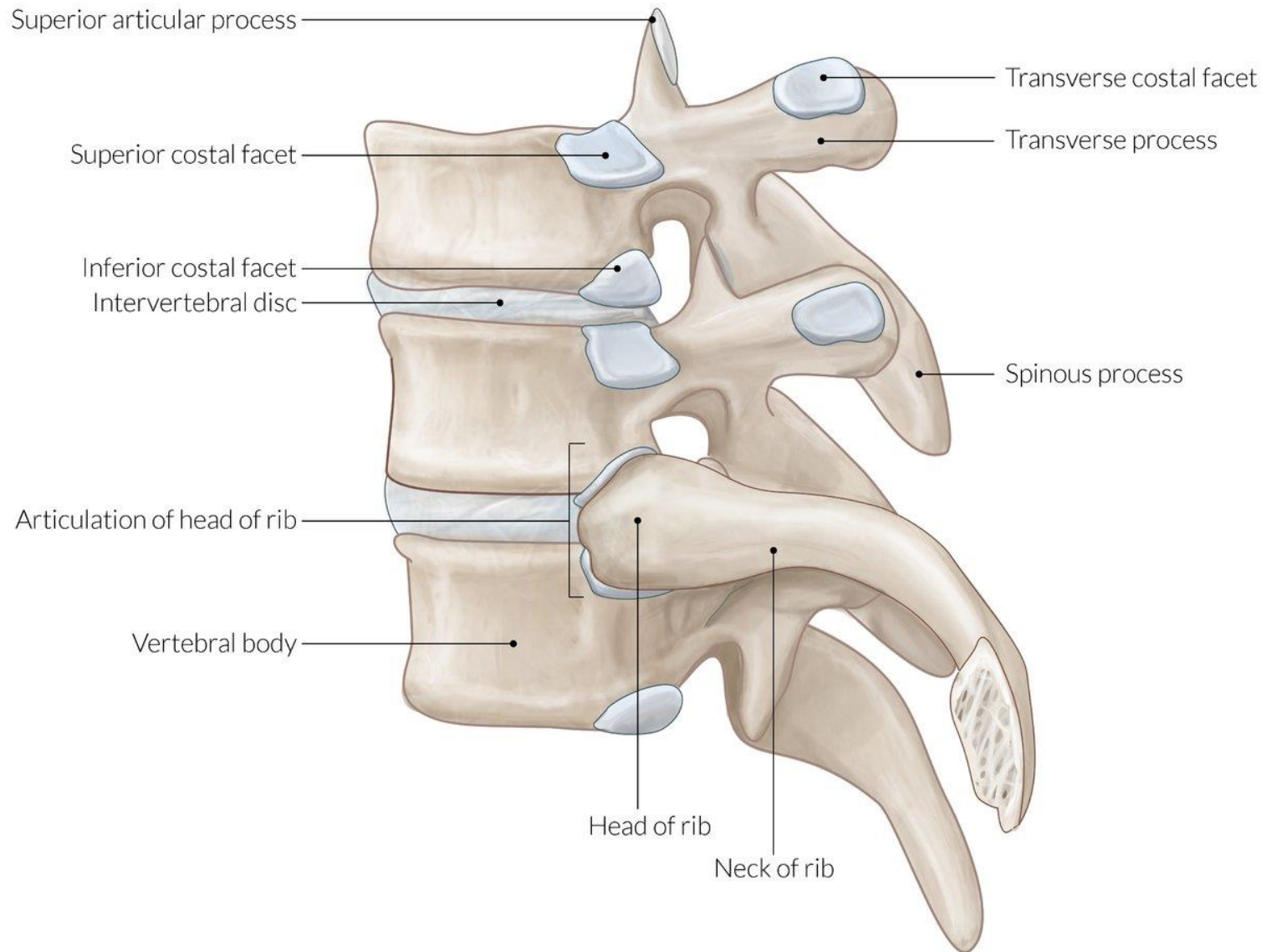
Interbody joints

- **Articulation:** Superior and inferior surfaces of the vertebral bodies and the adjacent intervertebral discs
- **Type:** Fibrocartilaginous (symphysis)
- **Ligaments:** Anterior and posterior longitudinal ligament, ligamentum nuchae, ligamentum flavum, supraspinous and interspinous ligaments
- **Osteokinematics/Arthrokinematics:** Gliding, distraction, compression, and rotation

Zygapophyseal joint



Interbody joint



Biomechanics of the Spine

Ligaments of the spine

- Ligamentous system of the vertebral column is extensive and exhibits considerable regional variability
- Six main ligaments are associated with the intervertebral and zygapophyseal joints
 - Anterior longitudinal ligament
 - Posterior longitudinal ligaments
 - Ligamentum flavum
 - Interspinous ligament
 - Supraspinous ligament
 - Intertransverse ligament
- Three major ligaments run across the entire spine (i.e., from C2 to Sacrum): Anterior longitudinal; Posterior longitudinal; Ligamentum flavum

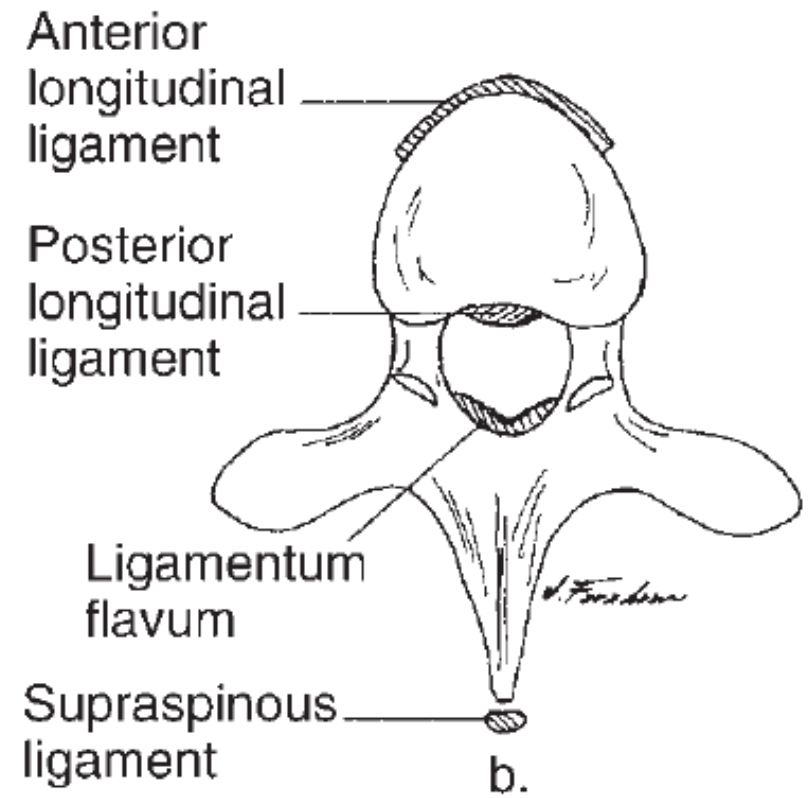
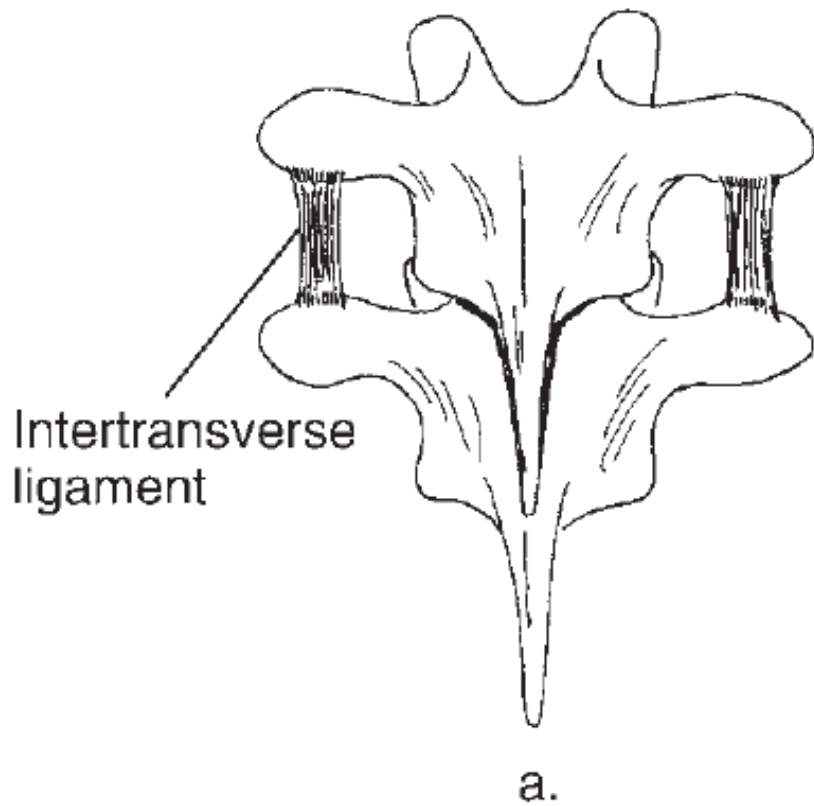
Biomechanics of the Spine

Deep muscles of the back

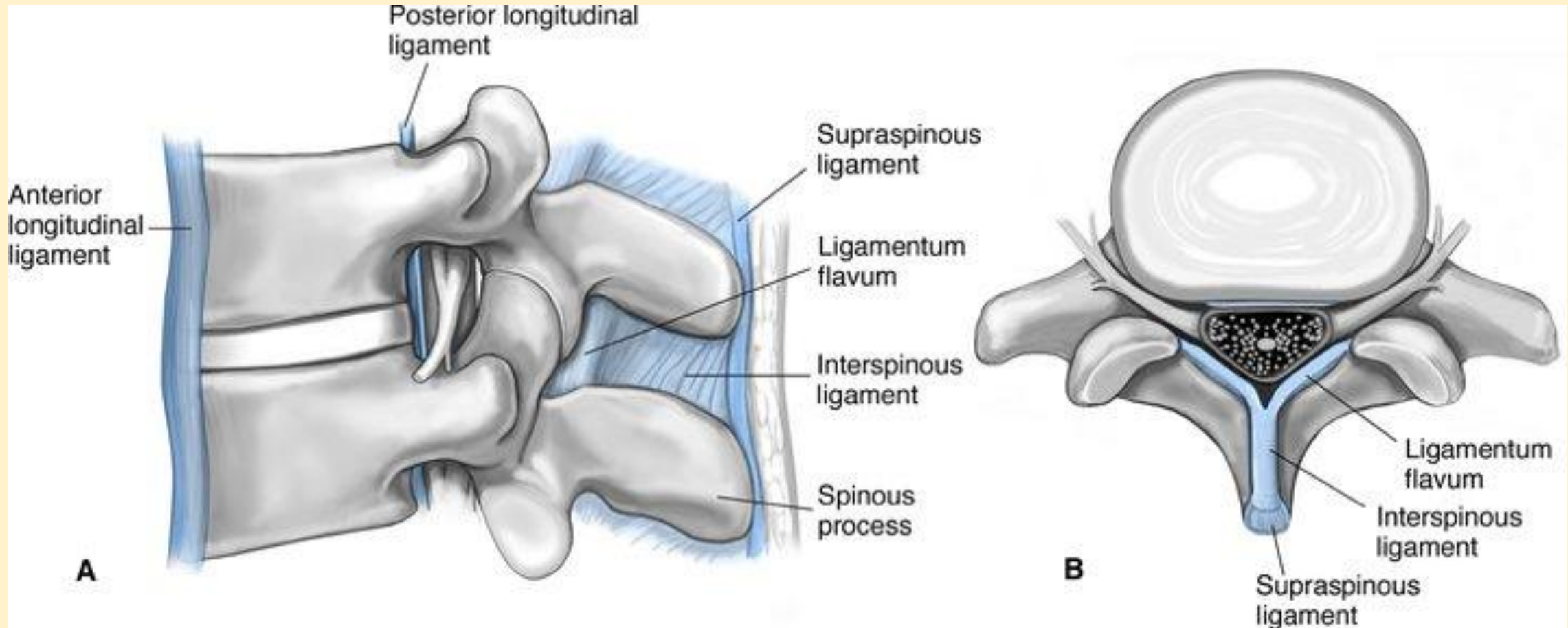
- Provide stability to the spine
- Produces movement of the spine
- Are arranged in four layers and include:
 - Layer 1: Splenius
 - Layer 2: Erector spinae
 - Layer 3: Transversospinales
 - Layer 4: Segmental muscles

Table 4-2 Major Ligaments of the Vertebral Column

Ligaments	Function	Region
Anulus fibrosus (outer fibers)	Resists distraction, translation, and rotation of vertebral bodies.	Cervical, thoracic, and lumbar.
Anterior longitudinal ligament	Limits extension and reinforces anterolateral portion of anulus fibrosus and anterior aspect of intervertebral joints.	C2 to sacrum but well developed in cervical, lower thoracic, and lumbar regions.
Anterior atlantoaxial (continuation of the anterior longitudinal, ligament)	Limits extension.	C2 to the occipital bone.
Posterior longitudinal ligament	Limits forward flexion and reinforces posterior portion of the anulus fibrosus.	Axis (C2) to sacrum. Broad in the cervical and thoracic regions and narrow in the lumbar region.
Tectorial membrane (continuation of the posterior longitudinal ligament)	Limits forward flexion.	Axis (C2) to occipital bone.
Ligamentum flavum	Limits forward flexion, particularly in the lumbar area, where it resists separation of the laminae.	Axis (C2) to sacrum. Thin, broad, and long in cervical and thoracic regions and thickest in lumbar region.
Posterior atlantoaxial (continuation of the ligamentum flavum)	Limits flexion.	Atlas (C1) and axis (C2)
Supraspinous ligaments	Limit forward flexion.	Thoracic and lumbar (C7–L3 or L4). Weak in lumbar region.
Ligamentum nuchae	Limits forward flexion.	Cervical region (occipital protuberance to C7)
Interspinous ligaments	Limit forward flexion.	Primarily in lumbar region, where they are well developed.
Intertransverse ligaments	Limit contralateral lateral flexion.	Primarily in lumbar region.
Alar ligaments	Limit rotation of head to same side and lateral flexion to the opposite side.	Atlas (C1 and C2)
Iliolumbar ligament	Resists anterior sliding of L5 and S1.	Lower lumbar region.
Zygapophyseal joint capsules	Resist forward flexion and axial rotation.	Strongest at cervicothoracic junction and in the thoracolumbar region.



A. Transverse ligament B. Other ligaments



A. Longitudinal ligament B. Other ligaments

Key facts about the deep muscles of the back

Definition and function The deep muscles of the back are a group of muscles that act to maintain posture and produce movements of the vertebral column.

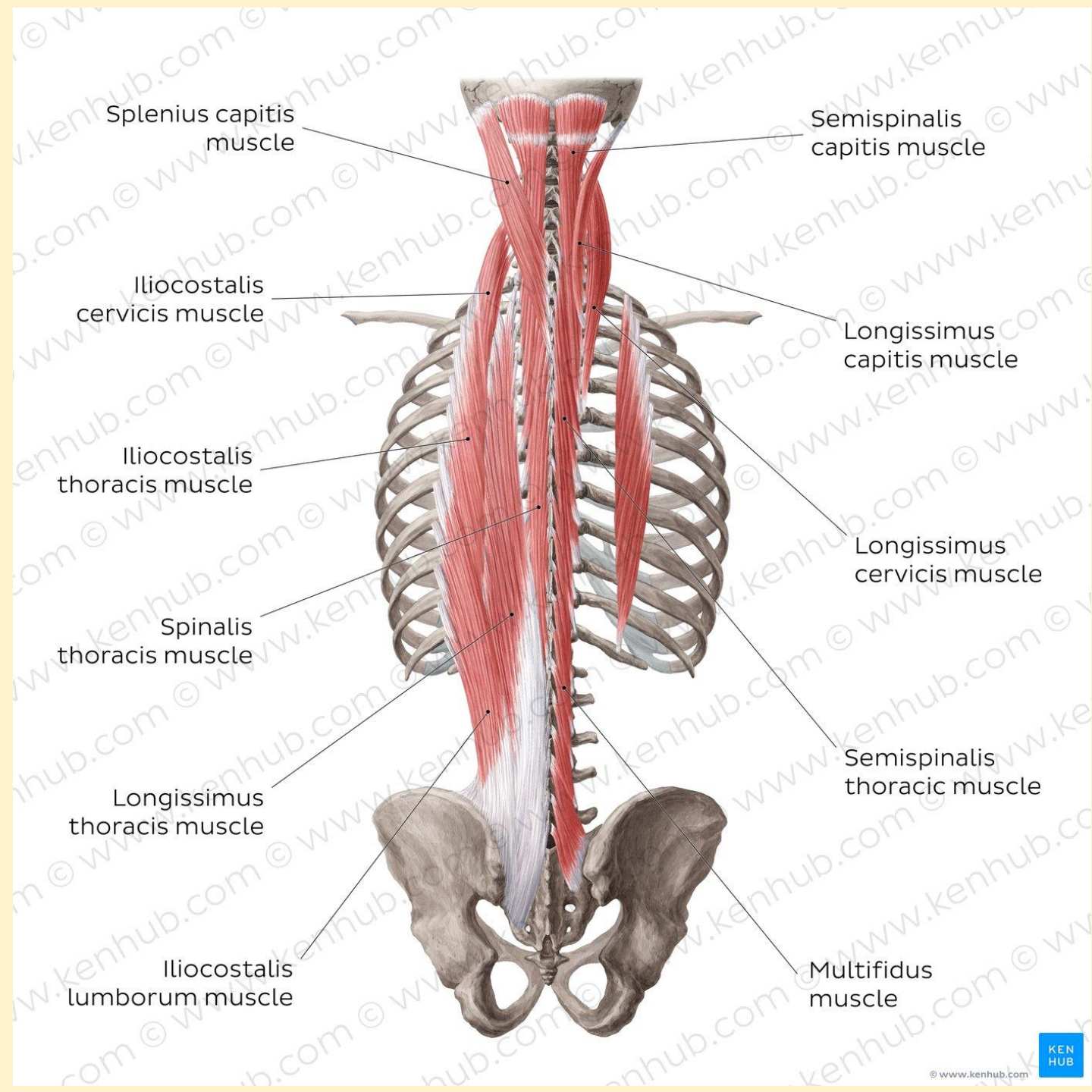
Muscles

Superficial layer: splenius (splenius capitis, splenius cervicis)
Intermediate layer: erector spinae (iliocostalis, longissimus, spinalis)
Deep layer: transversospinales (semispinalis, multifidus, rotatores)
Deepest layer: segmental muscles (levatores costarum, interspinales and intertransversarii)

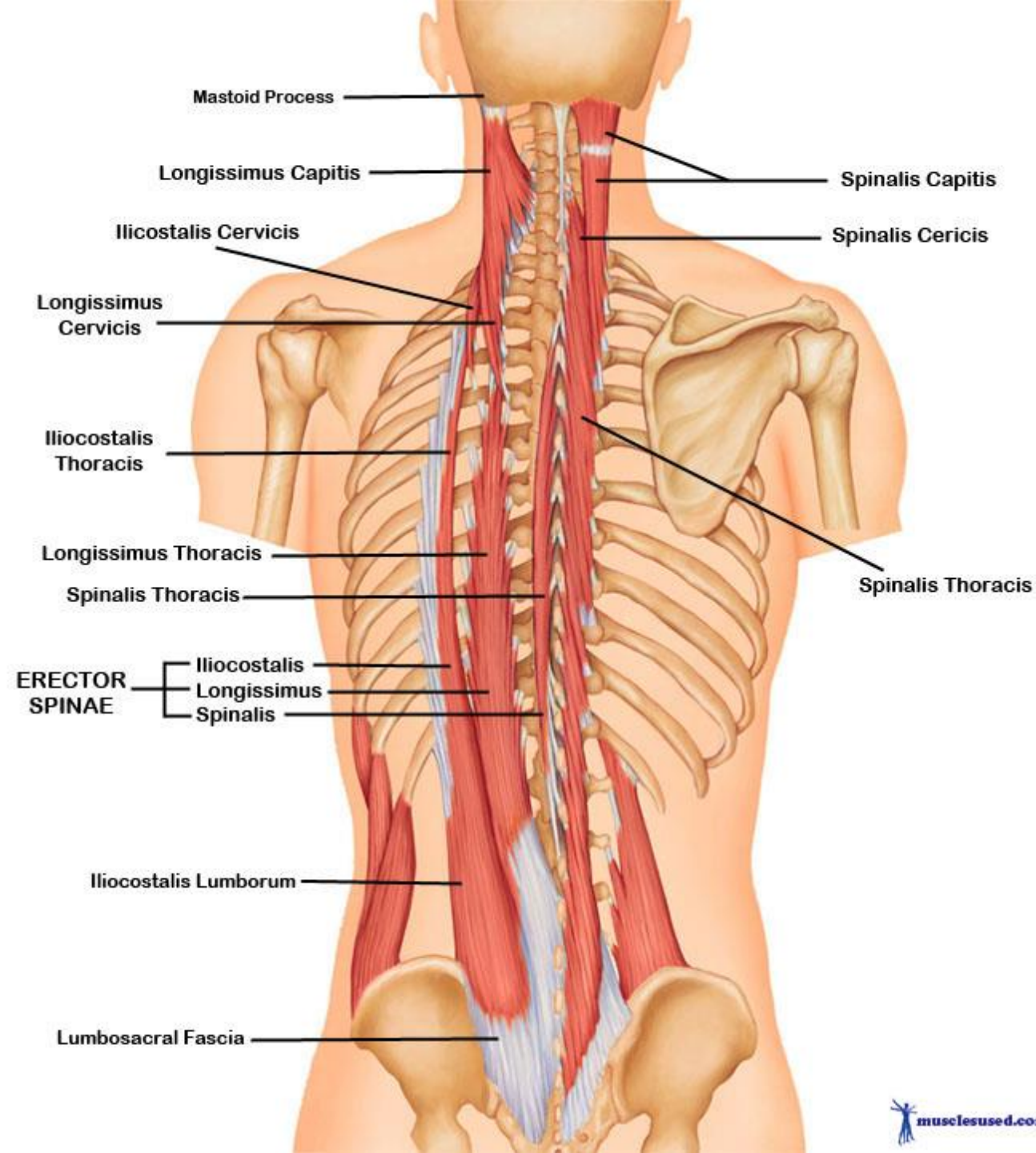
Innervation Posterior rami of spinal nerves

Blood supply Vertebral, deep cervical, occipital, transverse cervical, posterior intercostal, subcostal, lumbar, and lateral sacral arteries

Intrinsic back muscles



Intrinsic back muscles



Biomechanics of the Spine

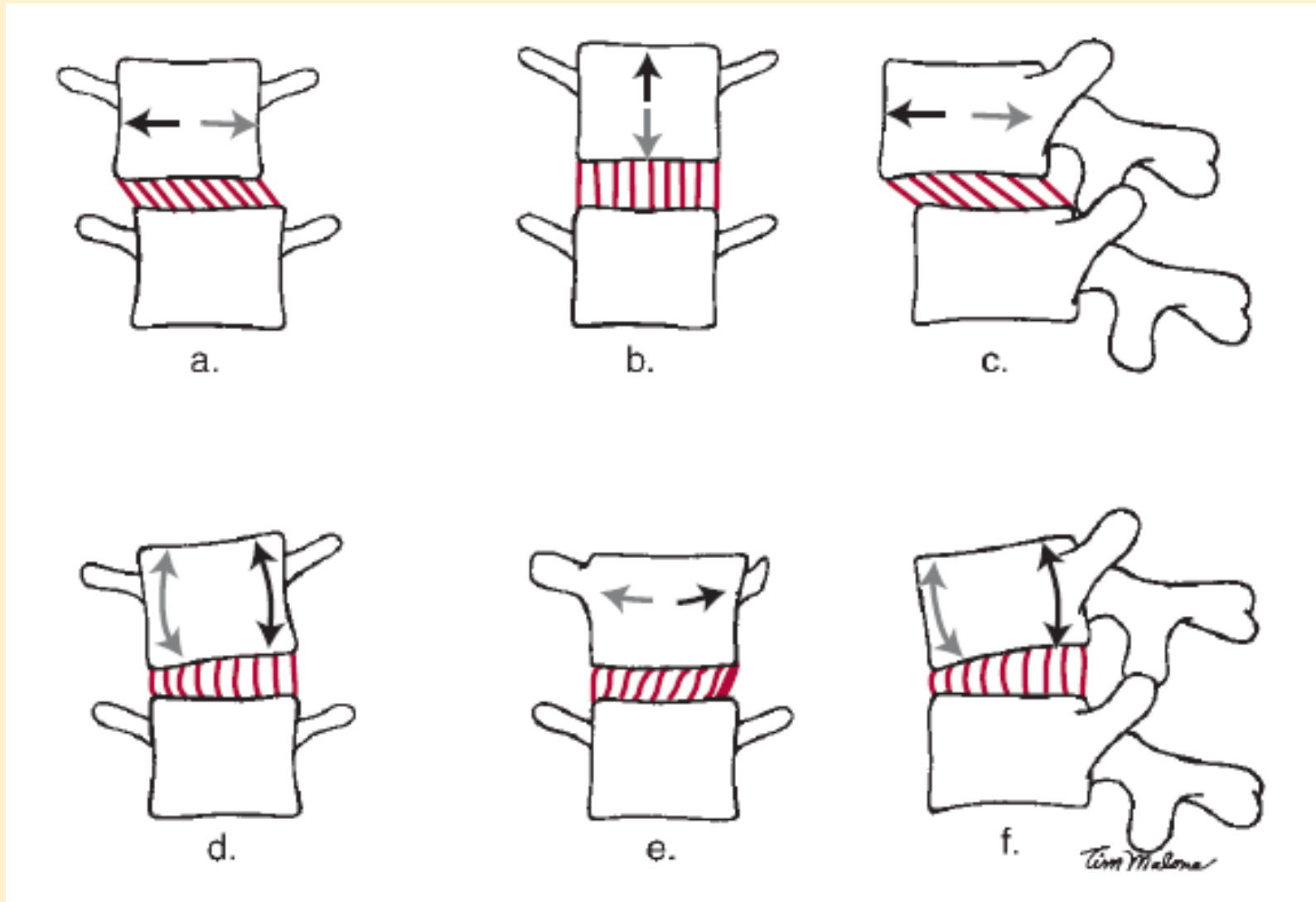
Osteokinematics

- A vertebra can move in relation to an adjacent vertebra in six different directions (three translations and three rotations) along and around three axes
- Compound effects of sliding and tilting (rolling) at a series of vertebrae produce a large ROM for the column as a whole
- Following movement are possible
 - Flexion–extension
 - Lateral flexion
 - Rotation/twisting of the spine

Biomechanics of the Spine

Arthrokinematics of the spine

- Intervertebral joints permit a small amount of sliding and tilting/rolling of one vertebra on another
- Available movements at the interbody joints include gliding, distraction and compression, and rotation (also called tilt or rocking in the spine)
- In all of the motions at the intervertebral joints, the nucleus pulposus of the intervertebral disc acts as a pivot for the tilting/rolling and sliding motions of the vertebrae



Translations and rotations of one vertebra in relation to an adjacent vertebra

Biomechanics of the Spine

- Side-to-side translation (gliding) occurs in the frontal plane
- Superior and inferior translation (axial distraction and compression) occur vertically.
- Anteroposterior translation occurs in the sagittal plane
- Side-to-side rotation (tilting) in a frontal plane occurs around an anteroposterior axis
- Rotation occurs in the transverse plane around a vertical axis
- Anteroposterior rotation (tilting) occurs in the sagittal plane around a frontal axis.

Biomechanics of the Spine

Kinetics

- Vertebral column is subjected to axial compression, tension, bending, torsion, and shear stress not only during normal functional activities but also at rest
- Column's ability to resist these loads varies among spinal regions and depends on:
 - Type, duration, and rate of loading
 - Person's age and posture
 - Condition and properties of the various structural elements (vertebral bodies, joints, disks, muscles, joint capsules, and ligaments)
 - Integrity of the nervous system

Biomechanics of the Spine

Pathomechanics of the spine

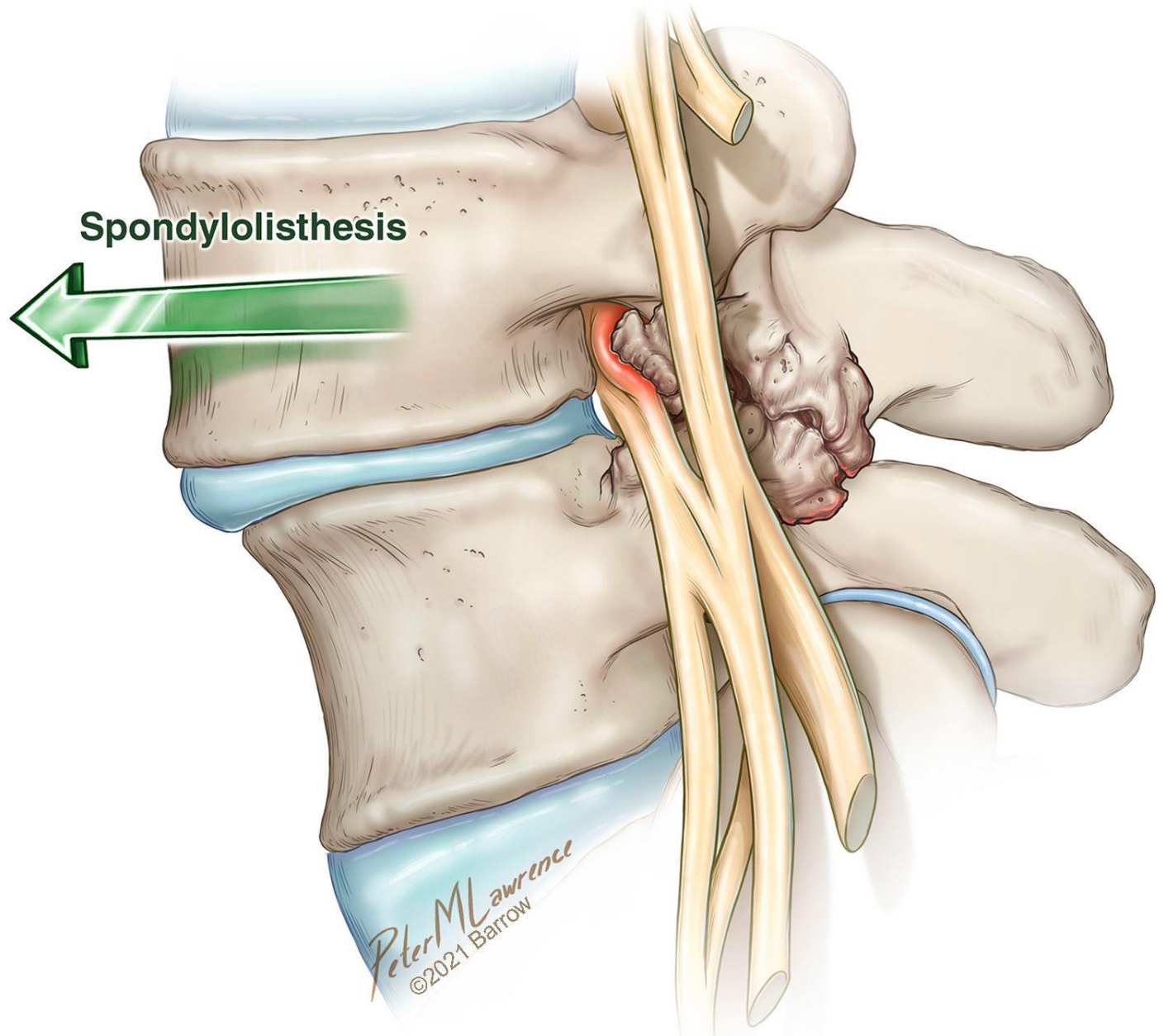
- Lordosis, i.e., increased or decreased
- Kyphosis, i.e., increased or decreased
- Scoliosis, lateral deviation of the spine
- Abnormal posture, e.g., forward head posture
- Degenerative disc disease

Biomechanics of the Spine

- Disc herniation
- Vertebral fracture
- Pott's disease (TB of the spine)
- Osteoarthritis
- Congenital spine deformities
- Baastrup syndrome, also known as kissing spines

Biomechanics of the Spine

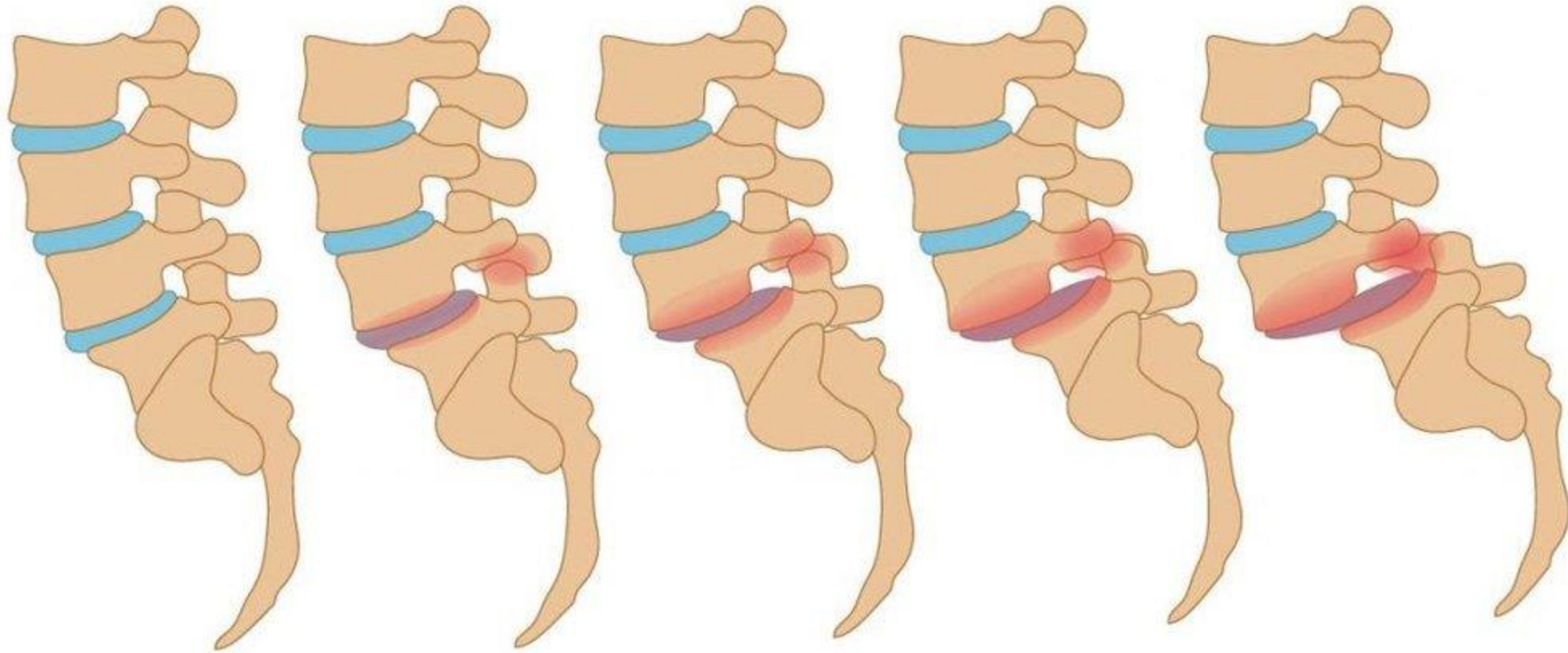
- Spondylolisthesis, slippage of a vertebra with respect to the adjacent vertebra
- Spondylosis, degenerative disease of the spinal joints
- Ankylosing spondylitis, progressive disease, causing stiffness and loss of motion in the joints of the spine
- Spondylolysis, a unilateral or bilateral bony defect in the pars interarticularis or isthmus of the vertebra



SPONDYLOLISTHESIS STAGES



DOCTORS OF FOSTEO



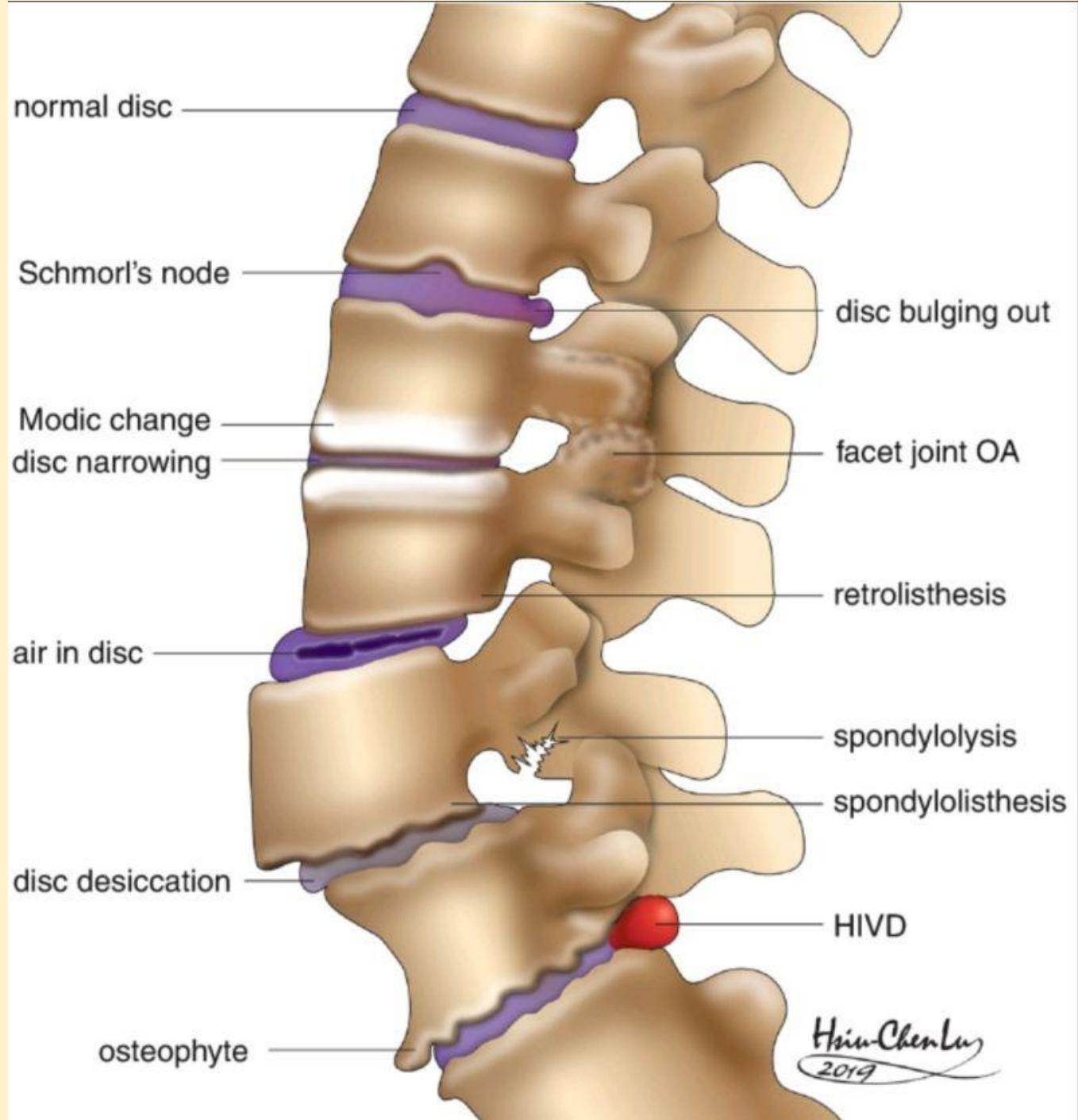
Healthy spine

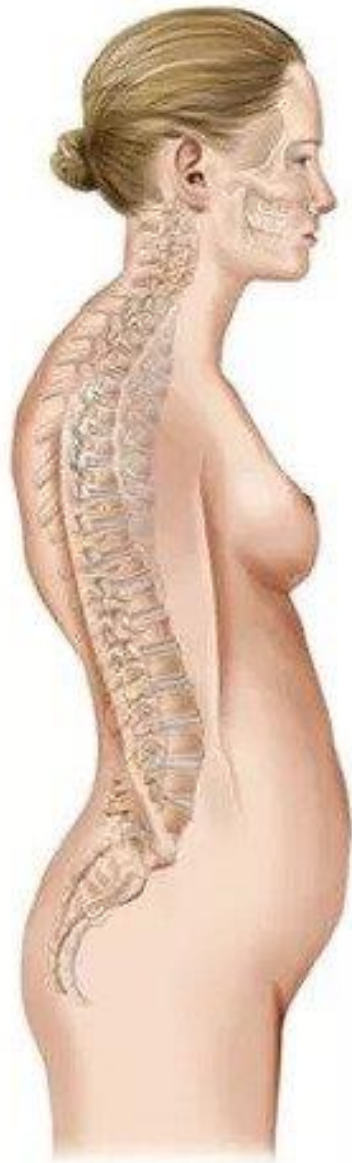
Grade 1: <25%

Grade 2: 25-50%

Grade 3: 50-75%

Grade 4: >75%





Kyphosis
(excessive posterior thoracic
curvature - hunchback)



Lordosis
(excessive anterior lumbar
curvature - swayback)

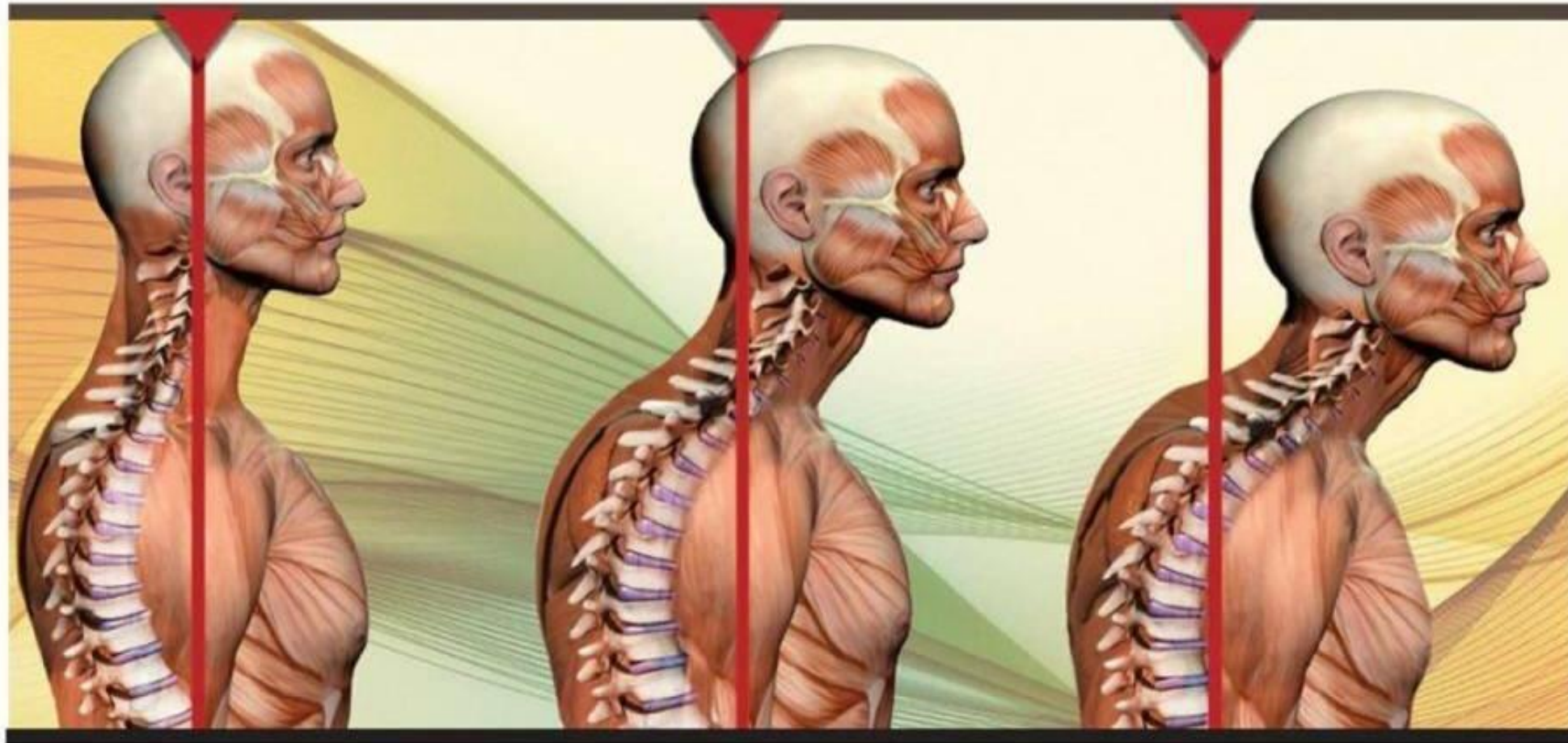


Scoliosis
(lateral curvature)

12 lbs.

32 lbs.

42 lbs.



NORMAL POSTURE

2 INCHES FORWARD

3 INCHES FORWARD

For every inch in Forward Head Posture, it can increase the weight of the head by about 10-12 lbs

Questions



Tishk
International University



References

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