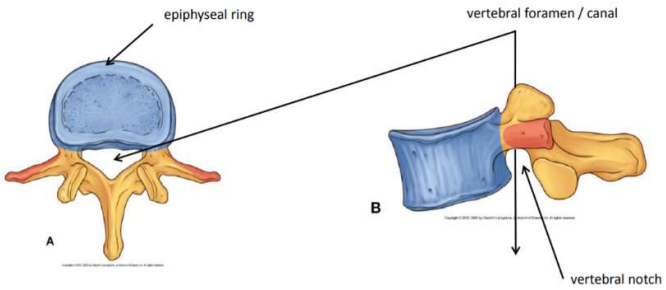
Vertebral Column and Back (Lecture 5.1)

Vertebral column

- Functions:
  - Supporting axis for upper and lower limbs to move on
  - Movement
  - Protection of nervous system i.e. spinal cord
- Has regionally distinct vertebrae with intervertebral joints and discs between each vertebrate such that they articulate together to form vertebral canal and intervertebral foramen.
  - Humans have 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccyx vertebrae.
  - Sacral vertebrae begin as individual bones which then fuse to give pelvis a greater stability.
  - Coccyx forms a vestigial tail in other vertebrates that is lost in humans and is variable in population.
- During development, back develops with a **primary curve/foetal C shaped curve** such that young babies are quite flexed and curved. After a few months, our nervous system and muscles become more developed and we form **secondary lordosis** initially in cervical regions as we begin to extend and look up, and at 12 months of age, pelvic muscles become stronger and we develop lordosis in lumbar regions to be able to walk.
  - **Abnormal lordosis:** swayback; abnormal inward curving of lower back generally found in overweight men and pregnant women since their anterior abdomen are heavier.
  - **Kyphosis:** hunchback, increased primary curve.
  - **Scoliosis:** lateral curvature typically caused by carrying weight on one side e.g. in school children.

Structure of vertebra

- Vertebrae are irregular bones and although we have atypical vertebra, we only need to know basic principles of typical vertebra i.e. lumbar vertebra.
- **Vertebral body** is on the anterior side with a hatched element in the midline and a smoother **epiphyseal ring** in the margins.
  - Articular posterior and inferiorly.
  - Bears weight going through the back and gets larger more distally i.e. cervical is smaller than lumbar, as the weight it bears increases as we move distally. E.g. cervical vertebrae take the weight of the head, thoracic bears weight of head, upper limbs, and thorax.
    - Sacral vertebrae start off large but becomes smaller when it gets to S5 because the lower sacrum and coccyx doesn't bear any weight.

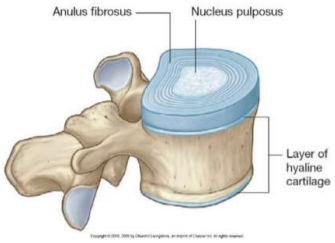


- **Vertebral arch** is on the posterior side and forms the vertebral foramen that protects spinal cord.
  - **Pedicle** comes off the back of the body and the **lamina** is the rounded structure of the arch.
  - 1 **spinous process** come off the arch on the back and 2 **transverse processes** on the side as levers for muscle attachment.
  - 4 **articular processes** branch off superiorly and inferiorly on right and left sides of the arch to form facet joints and guide movement that the back can undertake.
- Having a body and posterior arch results in formation of **vertebral foramen** and when we stack vertebrae up, the foramen becomes a canal and the spinal cord is protected within the canal.
- Vertebrae are regionally distinct:
  - Cervical vertebrae have holes in their transverse processes
  - Thoracic vertebrae have a second set of articulation for the ribs
  - Lumbar vertebrae have the largest body as they bear the most weight
  - Sacrum comprises of 5 fused vertebrae that tuckers down in size as we move distally as articulation with hip bones share the weight load it bears, so it doesn't have to be big.

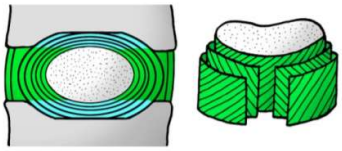
Intervertebral foramen, canal, and spinal cord

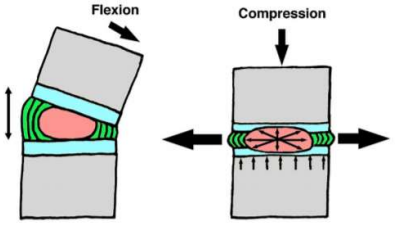
- As the arch is smaller than the body, a **vertebral notch** is formed under the pedicle and as we stack vertebrae up, the notches form **intervertebral foramen** as a hole appears between 2 adjacent vertebrae.
    - Has bony borders superior and inferior, facet joint in posterior, and vertebra and intervertebral disc in anteriorly, so it is constrained in size.
    - Between each successive pair of vertebrae, we have a pair of spinal nerve root coming out left and right, vessels coming into the spinal cord to provide nourishment, and dorsal root ganglion as part of sensory nervous system.
- Spinal cord is polarised so motor neurons are anterior/ventral while sensory neurons are posterior/dorsal.
    - **Ventral motor root** contains the cell bodies of motor neurons in ventral horn of spinal cord.
    - **Dorsal sensory root** contains the cell bodies of sensory neurons in a ganglion adjacent to spinal cord.
- Mixed spinal nerves emerge bilaterally from intervertebral foramen and divide into two major branches:
    - **Posterior ramus** innervates everything behind spinal cord i.e. intrinsic back muscles, associated facet joints and overlying skin on the back.
    - **Anterior ramus** innervates most other skeletal muscles and remaining skin areas
- Nerve roots are named from the region they emerge from.
    - C1 nerve emerges above C-I vertebra so C2-7 nerves emerge superior to their corresponding vertebra while C8 nerve emerges inferior to C-VII vertebra, so there are 8 cervical nerves but only 7 vertebrae.
    - Other nerve roots emerge inferior to their corresponding vertebra.

Intervertebral joint



- Secondary cartilaginous joint in the midline with an **intervertebral disc** between two adjacent vertebral bodies.
    - **Annulus** is the outer fibrous part with concentric rings of fibrous cartilage that attach to the epiphyseal ring of adjacent vertebrae to keep them together.
    - **Nucleus** is a highly hydrated mucoid proteinaceous gel encapsulated within annulus fibres. It keeps vertebra apart as it consists almost entirely of water that is incompressible.
- During the day, due to effect of gravity on vertebra, water is pushed out of the nucleus and is gained back during sleep. With age, the nucleus dries out and annulus start to fissure, and we don't fully gain back the water we lose during the day, so we get shorter as we age.
- Functions:
    - Annulus has concentric fibrous rings oriented at right angles such that each layer is oblique to the adjacent layer so during rotation half of the rings slacken and the other half tightens. Thus, it enables movement in all directions without tearing but still resists excessive movement.
    - Nucleus is deformable but not compressible, can move within the annulus to enable flexion and compression, and acts as a shock absorber.





Facet/zygapophyseal joints

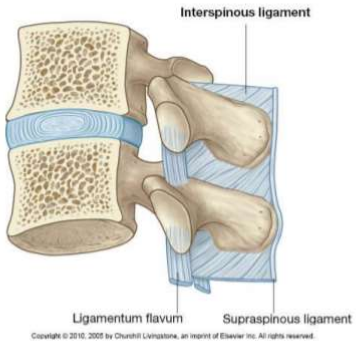
- Articular processes coming off vertebral arches form plane synovial joints that permit uniaxial gliding.
    - Joint capsule is lined by synovial membrane that secretes synovial fluid into joint space, and articular processes are covered by hyaline cartilage.
- Movement is determined by shape and depth of articular processes.
- Orientation of facet differs regionally as rotation is not uniform throughout vertebral column:
    - *Cervical:* allows all movements i.e. neck is most mobile
    - *Thoracic*: oriented in coronal plane, permits rotation and lateral flexion.
    - *Lumbar*: oriented in sagittal plane, permits flexion/extension.

Ligaments of vertebral column

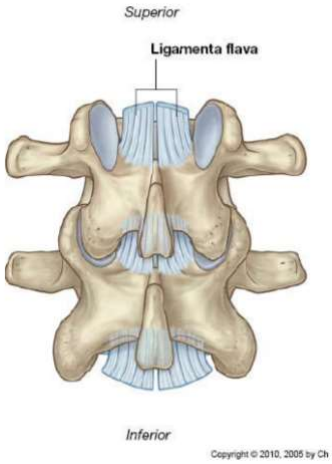
- **Anterior** and **posterior** longitudinal ligaments
    - Posterior runs within the vertebral canal along the back of vertebral bodies
- **Supraspinous** and **interspinous** ligaments
- **Ligamenta flava**: attaches adjacent lamina within the vertebral canal.
    - High in elastic fibres and stretches during flexion and recoils via elastic memory during extension.
    - Evolutionarily important so the ligament is not loose and floppy and won't irritate spinal nerves.

Anterior and Posterior Longitudinal Ligaments

Interspinous and Supraspinous Ligaments

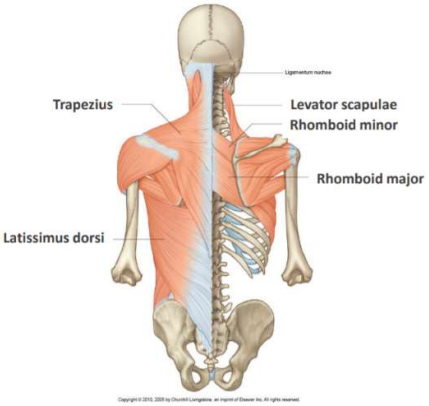


Ligamenta Flava

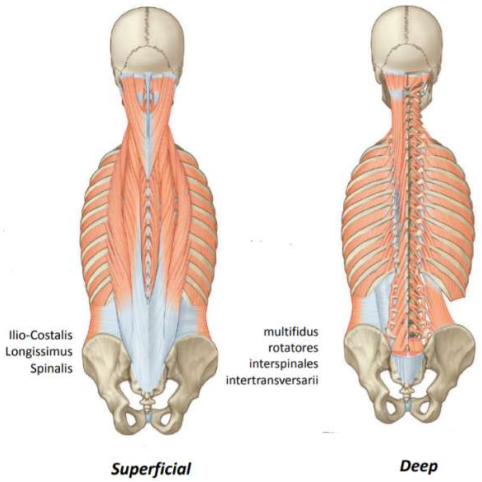


Muscles of the back

- Extrinsic muscles of the back:
    - Muscles all attach and act on upper limb
    - Have on attachment to back and the rest is attached to upper limb; not true back muscles.
    - Can act on the back, e.g. coordinating movements between two muscles during upper limb movement.
    - Innervated by anterior rami.
    - **Trapezius:** elevate/depress and retract scapula
    - Brain codes for movement not muscles as a whole



- Intrinsic muscles of the back:
  - Muscles all attach to and act on the back
  - Innervated by posterior rami
  - **Erector spinae:** superficial prime movers
    - Keep back extended; concentrically return flexed trunk into upright posture
    - Works eccentrically to control flexion
    - Long and powerful; span multiple segments.
    - E.g. illio-costalis, longissimus, spinalis
  - **Transversospinalis:** deep stabilisers
    - Short muscles, not providing power.
    - Prevent excess movement
    - Prone to injury and atrophy rapidly after injury
    - E.g. multifidus, rotatores, interspinales, intertransversarii



- Lumbar fascia
  - Provides attachments for erector spinae
  - Forms tight compartment for intrinsic muscles to enhance their actions
  - Continuous with erector spinae and transverspinalis, and abdominal wall.
    - When lifting, we tighten abdominal muscles, so the fascia is pulled tight. Intrinsic back muscles are stretched and reflexively contract so they are primed to protect and work more efficiently.

<u>Applied anatomy of back</u>

- Disc prolapse
  - Nucleus is deformable, so when we take load we put force through nucleus. Poor lifting can cause nucleus to be pushed posteriorly and annulus get slightly kinked. If annulus has fissures, nucleus can extrude from annulus and cause **herniation**.

  - Extrusion of nucleus into intervertebral foramen can impinge on nerves and cause pain.
- Joint degeneration without disc prolapse
  - Thinning of joint space over time due to dehydration of the disc.
  - As you move, margins can brush against each other and bony outgrowths (**osteophytes**) form.
  - Osteophytes may encroach on adjacent structures e.g. spinal canal or intervertebral foramen and impinge on the nerves.
  - Irritating nerve root will cause referred pain.
  - Severe pain especially with movement or weight bearing.