

VERTEBRAL COLUMN (parts 1 and 2)

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I. VERTEBRAL COLUMN - functions to support weight of body and protect spinal cord while permitting movements of trunk and providing for muscle attachments.

A. Typical vertebra

1. A typical vertebra (by convention thoracic or upper lumbar) consists of a body (anterior) and a vertebral arch (posterior) surrounding the vertebral canal (houses spinal cord).
2. The vertebral arch is composed of pedicles (projecting from the body) and laminae (uniting arch posteriorly).
3. Transverse processes (arising from arch laterally) and spinous processes (arising from arch posteriorly) provide for attachments of muscles and ligaments.
4. Spinal nerves exit the vertebral canal via intervertebral foramina (between pedicles of vertebrae) that are bordered by superior and inferior vertebral notches.
5. Superior and inferior articular processes - provide for joints between adjacent vertebrae; located at junction of pedicles and laminae; orientations of articular processes (also called facets) determine the types of movements that occur between vertebrae.
6. Bodies of adjacent vertebrae are also joined by intervertebral discs (see below).

B. Regional Variations - vertebral column is divided anatomically into regions; in each region, vertebrae are numbered superior to inferior:

Cervical - 7 vertebrae numbered C1-C7 (cervical means neck)

Thoracic - 12 vertebrae numbered T1-T12 (thorax means chest)

Lumbar - 5 vertebrae numbered L1-L5 (lumbar means lower back)

Sacral - 5 fused vertebrae, individual parts still numbered S1-S5 (sacrum means pelvis)

Coccyx - 3-5 fused vertebrae (parts Co1-Co3) (coccyx means tail)

1. Cervical vertebrae (7) - typically have small bodies; transverse processes have openings called Foramina Transversaria for vertebral arteries and veins (small in C7); spinous processes are bifid (divided into two parts at their distal ends) for Ligamentum Nuchae (see below); articular processes are oriented at an angle (tilted superiorly and medially) permitting considerable freedom of movement. Specialized cervical vertebrae are:

a. First Cervical Vertebra (C1 = Atlas) - has no body; is only a ring of bone with anterior and posterior arches and a lateral mass; bumps on arches at midline called Anterior and Posterior Tubercles; articular facets on upper surface articulate with occipital bone of skull; joint permits only flexion-extension movements (as in nodding head when saying 'yes').

b. Second Cervical Vertebra (C2 = Axis) - has peg-like Odontoid process (=

Dens) superior to its body (may represent fused body of atlas); articulates with atlas above forming Atlanto-axial joint [C1-C2]; this joint (classed as a pivot joint) allows only rotational movements, as in shaking head when saying 'no'.

c. Seventh Cervical Vertebra (C7 = Vertebra prominens) - has long spinous process which is not bifid; process can be palpated externally and used to identify vertebral levels; foramina transversaria are small and only transmit vertebral veins (vertebral artery only passes through cervical vertebrae C1-C6; vertebral vein through C1-C7).

Clinical Note: The long spinous process of the seventh cervical vertebra (**C7**, Vertebra prominens) is **palpable** can be used to **identify the level of injury** (ex. physical examination for disc herniation after minor car accidents)

2. Thoracic vertebrae (12) - bodies increase in size in rostral-caudal sequence; body is heart shaped; have costal facets on bodies and transverse processes for attachments of heads and tubercles of ribs; spinous processes are long and inclined posteriorly and inferiorly; articular processes are in a coronal plane.

3. Lumbar vertebrae (5) - large bodies, pedicles, laminae and transverse processes; articular facets are oriented in a sagittal plane.

4. Sacral vertebrae (5) - vertebrae are fused; Lateral Mass = fused transverse processes; Medial Crest = fused spinous processes; Anterior and Posterior Sacral Foramina = correspond to intervertebral foramina for sacral spinal nerves; sacro-iliac joint transmits weight from vertebrae to pelvis.

5. Coccygeal vertebrae (3-5) - fused; rudimentary equivalent of tail bones.

C. Ligaments - vertebrae held tightly together by ligaments.

1. Anterior Longitudinal Ligament - strong band which joins bodies of vertebrae on anterior side.

2. Posterior Longitudinal Ligament - weaker and narrower band joining bodies of vertebrae on posterior side of bodies (**inside vertebral canal**).

3. Ligamenta Flava - yellow elastic bands which connect laminae of adjacent vertebrae (flava = yellow, L. due to protein elastin)

4. Interspinous and Supraspinous Ligaments - connect spines of vertebrae; greatly thickened in cervical region to form Ligamentum Nuchae (extends from external occipital protuberance of skull to spine of the seventh cervical vertebra; supports head and neck and provides for muscle attachments).

D. Joints

1. Joints between articular processes (facets) are synovial plane joints which permit sliding movements; joints are immobilized in Facet Fusion surgery.
(Note: Synovial joints have a connective tissue capsule and synovial fluid inside capsule; synovial fluid minimizes friction and lubricates the joint).

Note: **Spinal Fusion** - vertebrae are surgically linked to eliminate movement; **Facet Fusion surgery** - adjacent facets are joined together with screws.

2. Intervertebral discs - interposed between bodies of adjacent vertebrae; each disc consists of an inner gelatinous part (Nucleus Pulposus) surrounded by collagenous fibers and fibrocartilage (Anulus Fibrosus).

Note: **Herniation of Nucleus Pulposus = 'Slipped Disc'** - In the young the intervertebral discs are quite strong. Traumatic injury to the column usually results in vertebral fractures rather than damage to discs. In older people, degenerative changes can occur resulting in weakening of the anulus fibrosus. Strains applied to the back can result in disc displacement in which the nucleus pulposus bulges out, usually in a **posterolateral direction (lateral to the narrow Posterior Longitudinal Ligament) typically at levels L4-L5 or L5-S1**. This is commonly referred to as a 'slipped disc' and can produce extremely painful nerve compression.

Note **Definition: Herniation = displacement of a structure from its normal position.**

Note: **Osteoarthritis of spine** – Osteoarthritis is a degenerative joint disease. In the spine, osteoarthritis can involve degeneration of intervertebral discs and the cartilages at joints between articular processes (facets); Ankylosing osteoarthritis – extreme form that can produce fusion (ankylosis) of vertebrae.

E. Movements

1. General classes of movements

- a. Flexion - bending anteriorly
- b. Extension - bending posteriorly
- c. Lateral flexion - bending laterally
- d. Rotation - rotatory movements about the long axis of the spinal column.

2. Movements in Different Regions - determined by the orientations of the articular facets

- a. Cervical - articular facets angled; permits considerable flexion-extension, lateral flexion and rotation.
- b. Thoracic - relatively fixed; articular facets oriented in a coronal plane; permits some small rotation, no flexion-extension.
- c. Lumbar - articular facets oriented in a sagittal plane; permits

flexion-extension, no rotation.

F. Spinal Curvatures

1. Primary curvature - whole spine is concave anteriorly at birth, remains so in adult thorax, sacrum.

2. Secondary curvatures - develop in early childhood.

a. Cervical curvature - concave posteriorly, develops in infants to help support head.

b. Lumbar curvature - concave posteriorly, develops with walking to help support trunk.

c. Lateral curvature - concave away from side of handedness = concave to left in right-handed people, concave to right in left-handed people.

3. Abnormal curvatures

a. **Kyphosis** - abnormal curvature that is concave **anteriorly**, usually found in thoracic region in elderly; 'hump' back.

b. **Scoliosis** - abnormal **lateral** curvature; can be due to presence of a **hemivertebra** (developmental anomaly in which half a vertebra fails to develop)

c. **Lordosis** - exaggerated lumbar curvature that is concave **posteriorly**; often assumed by pregnant women.

II. SUMMARY CHARTS OF SPINAL CURVATURES, FEATURES OF VERTEBRAE, LIGAMENTS

1. SUMMARY OF SPINAL CURVATURES: Clinically Important

	Curvature	Location (Most common)	Cause/Function
Normal			
Primary	Concave Anterior	All of vertebral column; retained in Thoracic, Sacral Regions	
Secondary	Concave Posterior	Cervical, Lumbar Regions	Cervical (hold up head), Lumbar (support body)
Lateral	Concave away from side of handedness	Cervical, Lumbar mainly	Aid in lifting heavy objects (shift center of gravity)
Abnormal			
Kyphosis	Exaggerated Concave Anterior	Often in Thoracic Region	Osteoporosis, etc.
Scoliosis	Exaggerated Lateral	Thoracic, Lumbar most common	Hemivertebra (half of vertebral body does not form)
Lordosis	Exaggerate Concave Posterior	Lumbar (normal in pregnancy)	Obesity

2. SUMMARY OF FEATURES OF VERTEBRAE

Vertebra	#	Features	Articular Process Oriented	Movements
Cervical	7	Bodies small, Foramina transversaria (small in C7) C1 = Atlas - no body C2 = Axis - dens C7 = Vertebra prominens	Slanted (Superiorly and Medially)	Considerable freedom of movement: Flex-Extend, Lateral Flex, Rotate
Thoracic	12	Facets for ribs on bodies (heads of ribs), transverse processes (articular tubercles of ribs)	Coronal plane	Little movement: No Flex-Extend, Small Rotate
Lumbar	5	Large bodies	Sagittal plane	Flex-Extend, No Rotate
Sacral	5	Fused		Normally no movement
Coccygeal	3-5	Fused, rudimentary		No movement

3. SUMMARY OF LIGAMENTS OF VERTEBRAE

Ligament	Location/connects	Clinical
Anterior Longitudinal Ligament	anterior side of bodies of vertebrae	broad band, prevents disc herniation anteriorly
Posterior Longitudinal Ligament	posterior side of bodies of vertebrae (inside canal)	narrow band (discs herniate lateral to ligament)
Ligamenta Flava	laminae of vertebrae	last layer penetrated by needle in epidural anesthesia
Interspinous and Supraspinous ligaments	spines of vertebrae	thickened in neck to form Ligamentum nuchae (extends from Ext. Occipital Protuberance to C7)