2

BACK

1. INTRODUCTION

The back forms the axis (central line) of the human body and consists of the vertebral column, spinal cord, supporting muscles, and associated tissues (skin, connective tissues, vasculature, and nerves). A hallmark of human anatomy is the concept of "segmentation," and the back is a prime example. **Segmentation** and **bilat eral symmetry** of the back will be obvious as you study the vertebral column, the distribution of the spinal nerves, the muscles of th back, and its vascular supply.

Functionally, the back is involved in three primary tasks:

- Support: the vertebral column forms the axis of the body and is critical for our upright posture (standing or si ting), as a support for our head, as an attachment point and brace for movements of our upper limb, and as a support for transferring the weight of our trunk to the lower limbs
- Protection: the vertebral column protects the spinal cord and proximal portions of our spinal nerves before they distribute throughout the body
- Movements: muscles of the back function in movements of the head and upper limb and in support and movements of the vertebral column

2. SURFACE ANATOMY

Key Landmarks

Key surface landmarks are shown in Figure 2-1 and include the following bony landmarks:

- **Vertebrae prominens**: the spinous process of the C7 vertebra, usually the most prominent process in the midline at the posterior base of the neck
- **Scapula**: part of the pectoral girdle that supports the upper limb; note its spine, inferior angle, and medial border
- **Iliac crests**: felt best when you place your hands "on your hips"; an imaginary horizontal line connecting the crests passes through the spinous process of the L4 vertebra and the intervertebral disc of L4-L5, a useful landmark for a lumbar puncture or epidural block
- **Posterior superior iliac spines**: an imaginary horizontal line connecting these two points passes through the spinous process of S2 (second sacral segment)

3. VERTEBRAL COLUMN

The vertebral column (spine) forms the central axis of the human body, highlighting the segmental nature of all vertebrates, and is composed of 33 vertebrae distributed as follows (Fig. 2-2):

- **Cervical:** seven total; first two called the atlas (C1) and axis (C2)
- **Thoracic:** twelve total; each articulates with a pair of ribs
- **Lumbar:** five total; large vertebrae for support of the body's weight
- **Sacrum:** five fused vertebrae for stability in the transfer of weight from the trunk to the lower limbs
- **Coccyx:** four total; Co1 often is not fused, but Co2-Co4 are fused (a remnant of our embryonic tail)

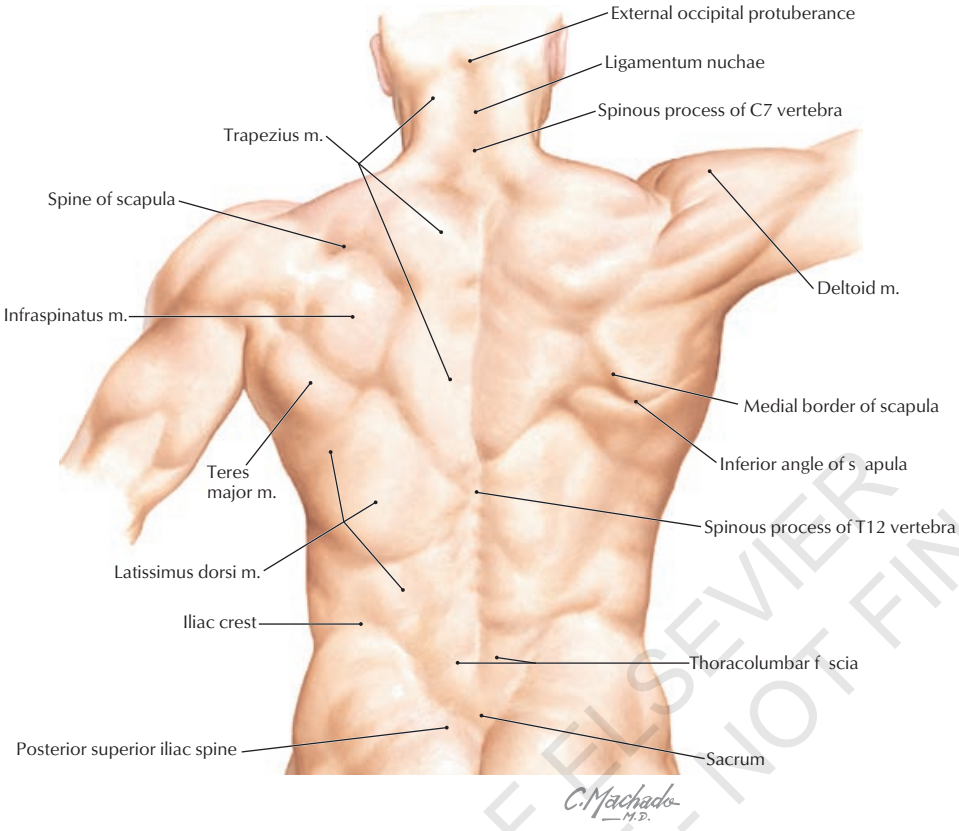
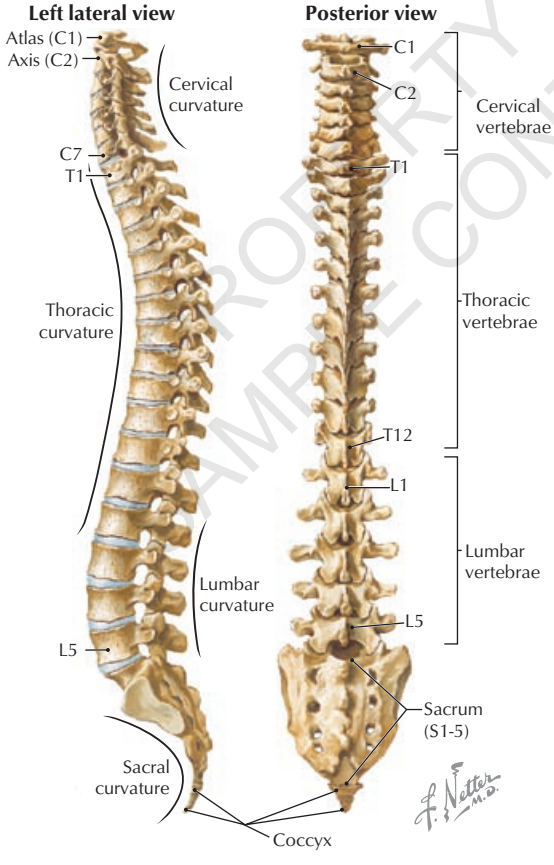


FIGURE 2-1 Key Bony and Muscular Landmarks of the Back



Level	Corresponding structure
C2-3	Mandible
C3	Hyoid bone
C4-5	Thyroid cartilage
C6	Cricoid cartilage
C7	Vertebra prominens
T3	Spine of scapula
T8	Point of inferior vena cava pierces diaphragm
T10	Xiphisternal junction
T10	Point of esophagus entering stomach
T12	Point of aorta entering abdomen
L1	End of spinal cord
L3	Subcostal plane
L3-4	Umbilicus
L4	Bifurcation of aorta
L4	Iliac crests
S2	End of dural sac

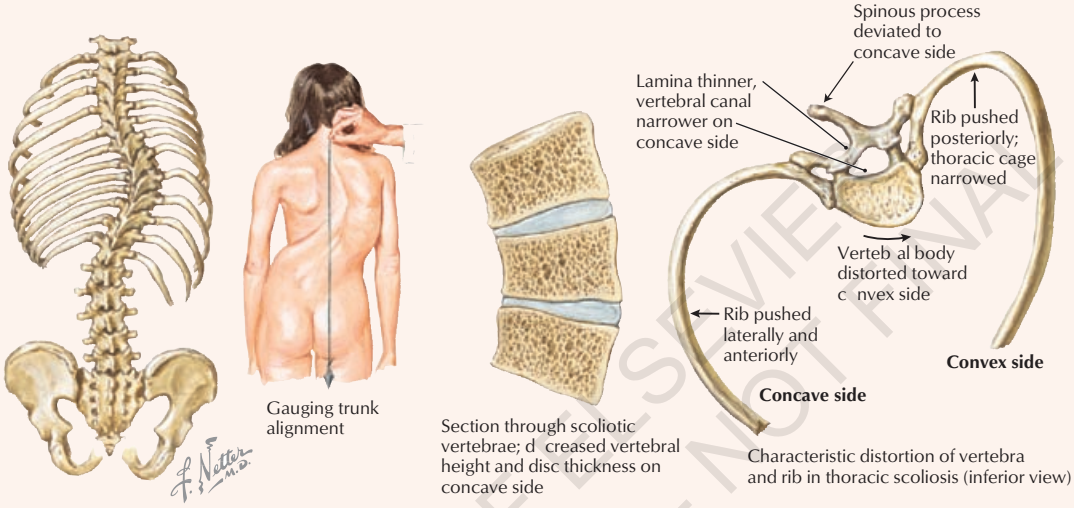
FIGURE 2-2 Vertebral Column

CLINICAL FOCUS

Scoliosis

Scoliosis is abnormal lateral curvature of the spine, which also includes an abnormal rotation of one vertebra upon the other. In addition to scoliosis, other accentuated curvatures of the spine include **kyphosis** (hunchback) and **lordosis** (swayback).

Pathologic anatomy of scoliosis



Several Common Abnormal Curvatures of the Spine

Disorder	Definition	Etiology
Scoliosis (illustrated)	Accentuated lateral and rotation curve of thoracic or lumbar spine	Genetic, trauma, idiopathic; occurs in adolescent girls more than boys
Kyphosis	Hunchback, accentuated flexion of thoracic spin	Poor posture, osteoporosis
Lordosis	Swayback, accentuated extension of lumbar spine	Weakened trunk muscles, late pregnancy, obesity

Viewed from the lateral aspect (see Fig. 2-2), one can identify the following:

- **Cervical curvature** (cervical lordosis): this curvature is acquired secondarily when the infant can support the weight of its own head
- **Thoracic curvature** (thoracic kyphosis): a primary curvature present in the fetus (imagine the spine in the "fetal position")
- **Lumbar curvature** (lumbar lordosis): this curvature is acquired secondarily when the infant assumes an upright posture and supports its weight
- **Sacral curvature**: a primary curvature present in the fetus

Typical Vertebra

A "typical" vertebra has several consistent features (Fig. 2-3):

- **Body**: the weight-bearing portion of a vertebra that tends to increase in size as one descends the spine
- **Arch**: a projection formed by paired pedicles and laminae
- **Transverse processes**: the lateral extensions from the union of the pedicle and lamina
- **Articular processes** (facets): two superior and two inferior facets for articulation with adjacent vertebrae

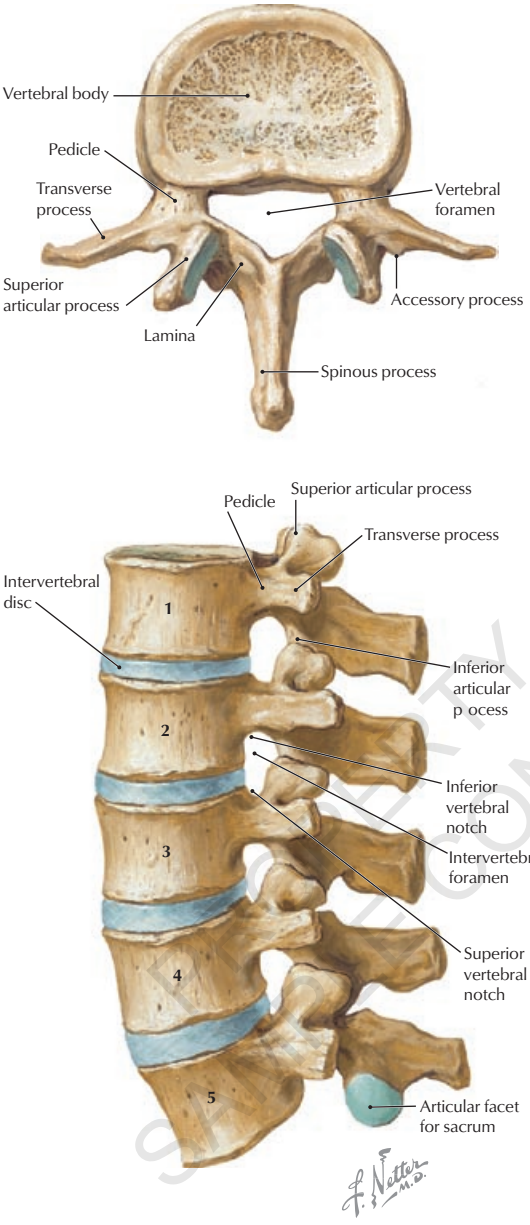


FIGURE 2-3 Features of a Typical Vertebra as Represented by the L2 Vertebra (Superior View) and by the Articulated Lumbar Vertebrae

TABLE 2-1 Key Features of the Cervical Vertebrae

Atlas (C1)
Ringlike bone; superior facet articulates with occipital bone
Two lateral masses with facets
No body or spinous process
C1 rotates on articular facets of C2
Vertebral artery runs in groove on posterior arch
Axis (C2)
Dens projects superiorly
Strongest cervical vertebra
Other Cervical Vertebrae (C3 to C7)
Large triangular vertebral foramen
Transverse foramen, through which vertebral artery passes
C3 to C5: short bifid spinous process
C6 to C7: long spinous process
C7 called vertebra prominens
Narrow intervertebral foramina
Nerve roots at risk of compression

- **Spinous process**: a projection that extends posteriorly from the union of two laminae
- **Vertebral notches**: superior and inferior semicircular features that in articulated vertebrae form an intervertebral foramen (two semicircular notches form a circle)
- **Intervertebral foramina**: the opening formed by the vertebral notches that is traversed by spinal nerve roots and associated vessels
- **Vertebral foramen** (canal): a foramen formed from the vertebral arch and body that contains the spinal cord and its meningeal coverings
- **Transverse foramina**: apertures that exist in transverse processes of cervical vertebrae only and transmit the vertebral vessels

Regional Vertebrae

The Cervical Vertebrae

The cervical spine is composed of seven cervical vertebrae. The first two cervical vertebrae are unique and are termed the *atlas* (C1) and *axis* (C2) (Fig. 2-4). The **atlas** (C1) holds the head on the neck and gets its name from Atlas, the god of mythology who held the world on his shoulders. The **axis** (C2) is the point of articulation where the head turns on the neck, providing an "axis of rotation." Key features of the cervical vertebrae are summarized in Table 2-1. The cervical region is a fairly mobile portion of the spine, allowing for flexion and extension as well as rotation and lateral bending.

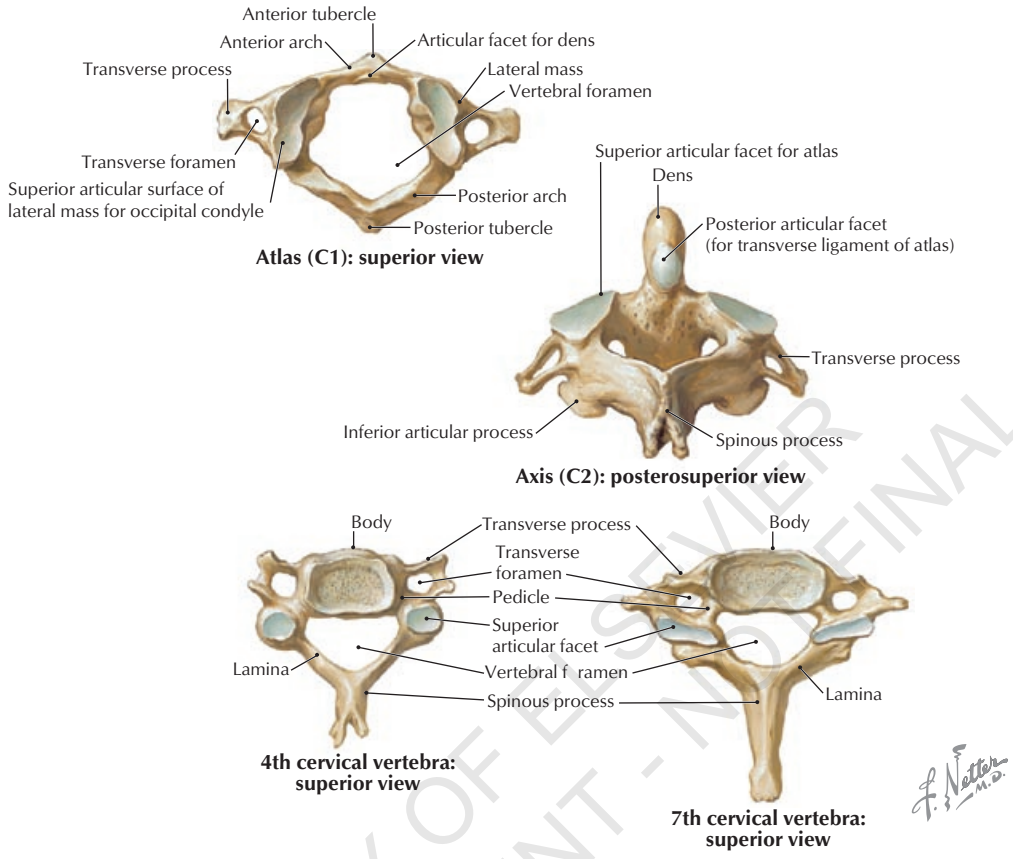
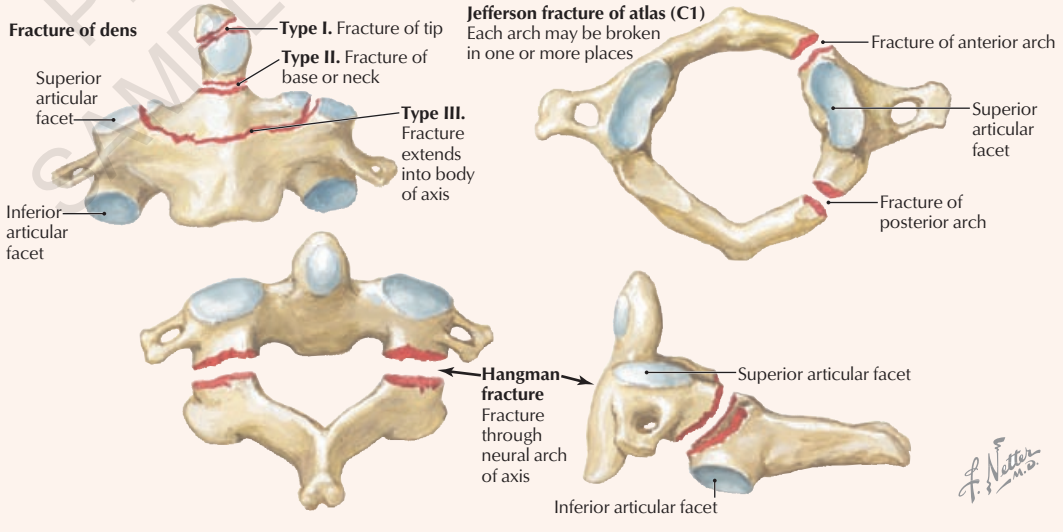


FIGURE 2-4 Representativ Cervical Vertebrae

C L I N I C A L F O C U S

Cervical Fractures

Fractures of the axis (C2) often involve the dens and are classified as types I, II, and III. Type I fractures are usually stable, type II fractures are unstable, and type III fractures, which extend into the body, usually reunite well when immobilized. The **"hangman" fracture** a pedicle fracture of the axis, can be stabilized, if survived, with or without spinal cord damage. A **Jefferson fracture** is a burst fracture of the atlas, often caused by a blow to the top of the head.



The Thoracic and Lumbar Vertebrae

The thoracic spine is composed of 12 thoracic vertebrae (Fig. 2-5 and Table 2-2). The 12 pairs of ribs articulate with the thoracic vertebrae. This region of the spine is more rigid and inflexible than the cervical region.

The lumbar spine is composed of five lumbar vertebrae (see Figs. 2-3 and 2-5, and Table 2-2). They are comparatively large for bearing the weight of the trunk and are fairly mobile, but not nearly as mobile as the cervical spine.

The Sacrum and Coccyx

The sacrum is composed of five fused vertebrae that form a single wedge-shaped bone (see Fig. 2-5 and Table 2-2). The sacrum provides support for the pelvis. The coccyx is a remnant of our embryonic tail and usually consists of four vertebrae, with the last three being fused into a single bone. The coccyx lacks vertebral arches and has no vertebral canal (see Fig. 2-5 and Table 2-2).

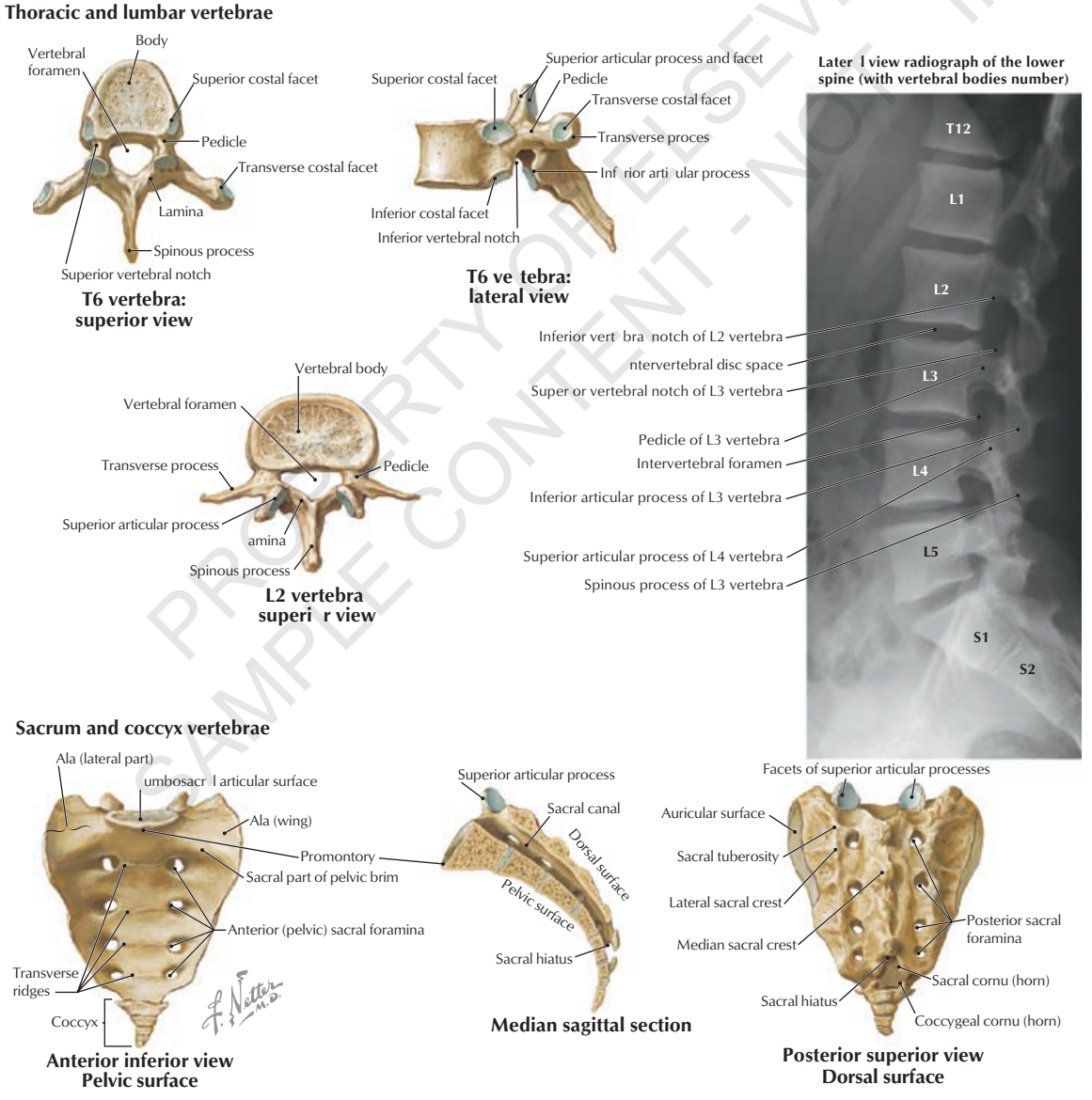


FIGURE 2-5 Representative Vertebrae

TABLE 2-2 Key Features of Vertebrae

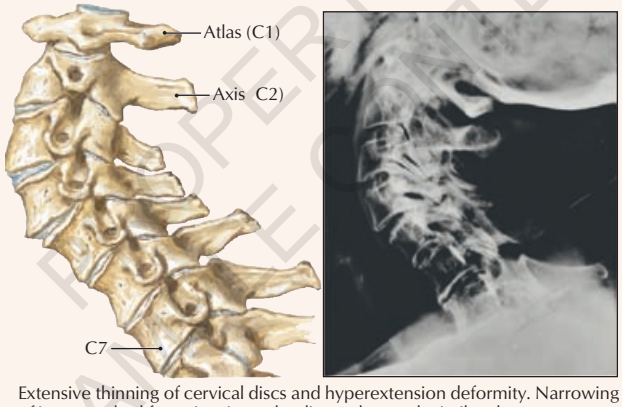
T1-T12	Heart-shaped body, with facets for rib articulation
	Small circular vertebral foramen
	Long transverse processes, which have facets for rib articulation in T1-T10
	Long spinous processes, which slope posteriorly and overlap next vertebra
L1-L5	Kidney-shaped body, massive for support
	Mid-sized triangular vertebral foramen
	Facets face medial or lateral direction, which permits good flexion and extension
	Spinous process is short
	L5: largest vertebra
Sacrum	Large, wedge-shaped bone, which transmits body weight to pelvis
	Five fused vertebrae, with fusion complete by puberty
	Four pairs of sacral foramina on dorsal and ventral (pelvic) side
	Sacral hiatus, the opening of sacral vertebral foramen
Coccyx	Co1 often not fused
	Co2-Co4 are fused
	No pedicles, laminae, spines
	Remnant of our embryonic tail

C L I N I C A L F O C U S

Osteoarthritis

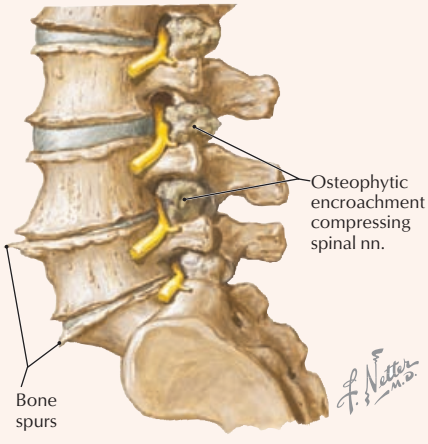
Osteoarthritis is the most common form of arthritis and often involves erosion of the articular cartilage of weight-bearing joints, such as those of the vertebral column.

Cervical spine involvement



Extensive thinning of cervical discs and hyperextension deformity. Narrowing of intervertebral foramina. Lateral radiograph reveals similar changes.

Lumbar spine involvement



Degeneration of lumbar intervertebral discs and hypertrophic changes at vertebral margins with spur formation. Osteophytic encroachment on intervertebral foramina compresses spinal nerves.

Characteristics of Osteoarthritis	
Characteristic	**Description**
Etiology	Progressive erosion of cartilage in joints of spine, fingers, knee, and hip most commonly
Prevalence	20 million Americans, significant after age 65 years
Risk factors	Age, female sex, joint trauma, repetitive stress, obesity, genetic, race, previous inflammatory joint disease
Complications	In spine, involves IV disc and facet joints, leading to hyperextension deformity and spinal nerve impingement

Joints and Ligaments of the Craniovertebral Spine

The craniovertebral joints include the **atlanto-occipital** (atlas and occipital bone of the skull) and **atlantoaxial** (atlas and axis) joints. Both are synovial joints that provide a relatively wide range of motion compared with other joints of the vertebral column. The atlanto-occipital joint permits one to nod the head up and down (flexion and extension), whereas the atlantoaxial joint is a pivot joint that permits one to rotate the head from side to side, as if to indicate "no." The features of these joints and their ligaments are summarized in Figure 2-6 and Table 2-3.

Joints and Ligaments of the Vertebral Arches and Bodies

The joints of the vertebral arches (zygapophyseal joints) occur between the superior and inferior articular processes (facets) of adjacent vertebrae and allow for some gliding or sliding movement (Fig. 2-7 and Table 2-4). The corresponding ligaments connect the spinous processes, laminae, and bodies of adjacent vertebrae.

The joints of the vertebral bodies (intervertebral joints) occur between the adjacent vertebral bodies (see Fig. 2-7 and Table 2-4). These stable, weight-bearing joints also serve as shock absorbers owing to

C L I N I C A L F O C U S

Osteoporosis

Osteoporosis (porous bone) is the most common bone disease and results from an imbalance in bone resorption and formation, which places bones at a great risk for fracture.

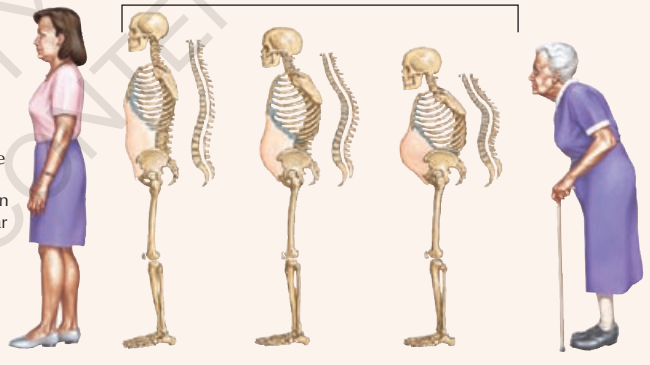
Axial

Vertebral compression fracture cause continuous (acute) or intermittent (chronic) back pain from midthoracic to midlumbar reg on, occasionally to lower lumbar region.

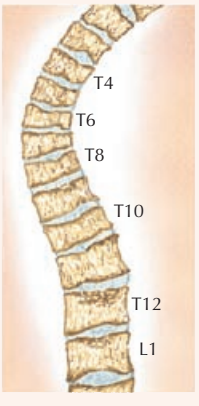
Characteristi s of Osteoporo i

Characteris c	Description
Etiology	Postmenop u al women, g net cs, vitamin D sy thesis defi ienc idiopathic
Prevalence	Approx mately 10 million Americans (8 million of them women), white
Risk factor	Family history, white female, increasing age, estrogen deficiency, vitamin D deficiency, low calcium intake, smoking, excessive alcohol use, inactive lifestyle
Complications	Vertebral compression fractures, fracture of proximal femur or humerus, ribs, and distal radius (Colles' fracture)

A hange in backbone strength over time



Osteoporosis is the thinning of the bones. Bones become fragile and loss of height is common as the back bones begin to collapse.



Multiple compression fractures of lower thoracic and upper lumbar vertebrae in patient with severe osteoporosis

F. Netter M.D.
C. Machado M.D.

Appendicular
Fractures caused by minimal trauma

Proximal femur | Proximal humerus | Distal radius

Most common types

TABLE 2-3 Features of the Atlanto-occipital and Atlantoaxial Joints

Ligament	Attachment	Comment
Atlanto-occipital (Biaxial Condyloid Synovial) Joint		
Articular capsule	Surrounds facets and occipital condyles	Allows flexion and extension
Anterior and posterior membranes	Anterior and posterior arches of C1 to foramen magnum	Limit movement of joint
Atlantoaxial (Uniaxial Synovial) Joint		
Tectorial membrane	Axis body to margin of foramen magnum	Is continuation of posterior longitudinal ligament
Apical	Dens to occipital bone	Is very small
Alar	Dens to occipital condyles	Limits rotation
Cruciate	Dens to lateral masses	Resembles a cross; allows rotation

the presence of the intervertebral disc between the bodies. Intervertebral discs consist of the following:

- Outer fibrocartilaginous **anulus fibrosus**
- Inner gelatinous **nucleus pulposus** (a remnant of the embryonic notochord)

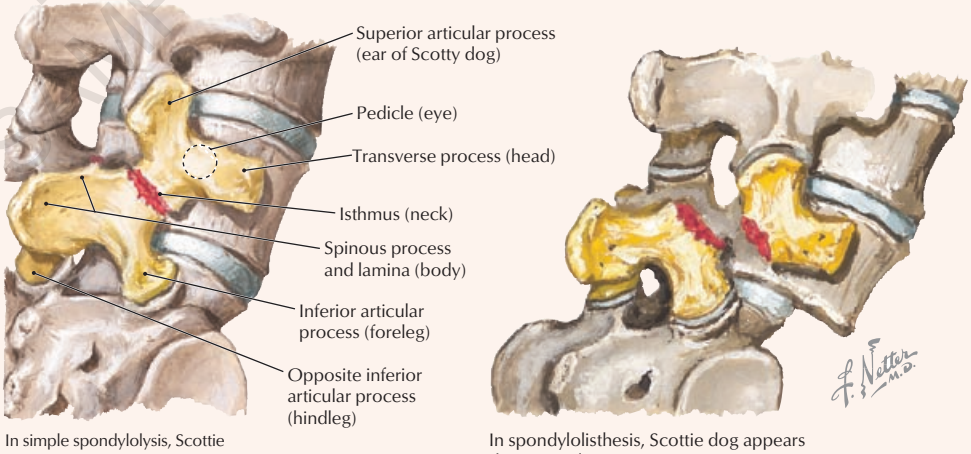
The lumbar intervertebral discs are the thickest, and the upper thoracic intervertebral discs are the thinnest. The anterior and posterior longitudinal ligaments help to stabilize these joints. Table 2-4 summarizes the features of these joints.

CLINICAL FOCUS

Spondylolysis and Spondylolisthesis

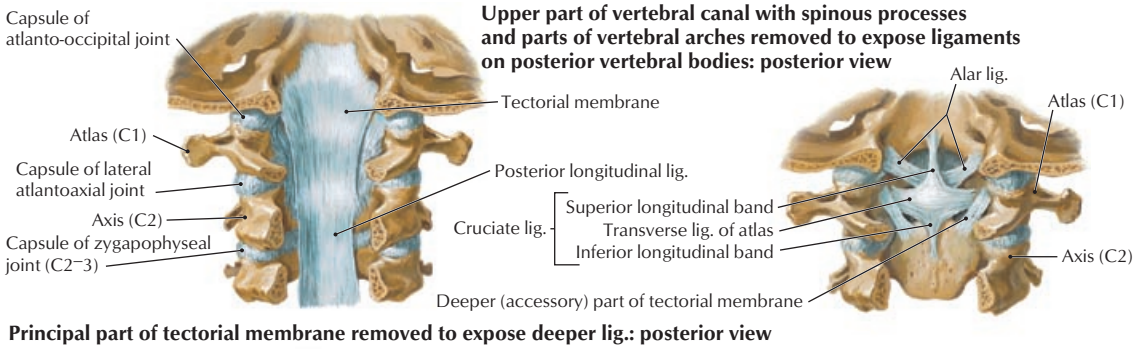
Various congenital and acquired conditions may affect the spine. ***Spondylolysis*** is a congenital defect or an acquired stress fracture of the lamina that presents with no slippage of adjacent articulating vertebrae (most common at the L5-S1 site). Its radiographic appearance is that of a "Scottie dog" with a collar (highlighted in yellow, with the fracture site indicated as the red collar). However, a bilateral defect (a complete dislocation, or luxation), called ***spondylolisthesis,*** results in an anterior displacement of the L5 body and transverse process while the posterior fragment (vertebral laminae and spinous process of L5) remains in proper alignment over the sacrum (S1). This defect has the radiographic appearance of a Scottie dog with a broken neck (highlighted in yellow, with the fracture in red). Pressure on spinal nerves often leads to low back and lower limb pain.

Post rior oblique views: Scottie dog profile in yellow and fracture site in red



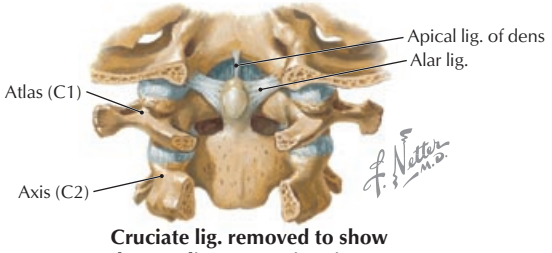
In simple spondylolysis, Scottie dog appears to be wearing a collar.

In spondylolisthesis, Scottie dog appears decapitated.

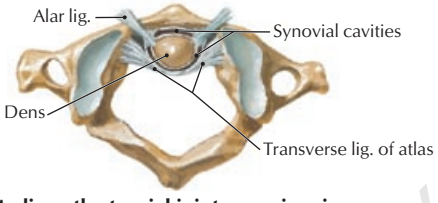


Upper part of vertebral canal with spinous processes and parts of vertebral arches removed to expose ligaments on posterior vertebral bodies: posterior view

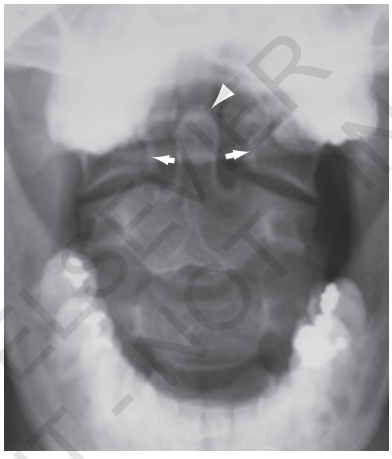
Principal part of tectorial membrane removed to expose deeper lig.: posterior view



Cruciate lig. removed to show deepest ligs.: posterior view



Median atlantoaxial joint: superior view



Normal open-mouth view of the dens of C2 (*arrowhead*) and the lateral masses of C1(*arrows*).

FIGURE 2-6 Craniovertebral Joints and Ligaments. *Radiograph reprinted with permission from Major N:* A Practical Approach to Radiology. *Philadelphia, Saunders 2006*

TABLE 2-4 Features of the Zygapophyseal and Intervertebral Joints

Ligament	Attachment	Comment
Zygapophyseal (Plane Synovial) Joints		
Articular capsule	Surrounds facets	Allows gliding motion C5-C6 is most mobile L4-L5 permits most flexion
Intervertebral (Secondary Cartilaginous [Symphyses]) Joints		
Anterior longitudinal (AL)	Anterior bodies and intervertebral discs	Is strong and prevents hyperextension
Posterior longitudinal (PL)	Posterior bodies and intervertebral discs	Is weaker than AL and prevents hyperflexion
Ligamenta flava	Connect adjacent laminae of vertebrae	Limit flexion and are more elastic
Interspinous	Connect spines	Are weak
Supraspinous	Connect spinous tips	Are stronger and limit flexion
Ligamentum nuchae	C7 to occipital bone	Is cervical extension of supraspinous ligament and is strong
Intertransverse	Connect transverse processes	Are weak ligaments
Intervertebral discs	Between adjacent bodies	Are secured by AL and PL ligaments