Spine

Learning Objectives

At the conclusion of this chapter, you will be able to:

- Name the regions that make up the spine and identify each on an anatomic diagram and on a radiograph
- Identify on a diagram the parts of a typical vertebra
- Identify significant positioning landmarks for the spine by palpation
- Demonstrate correct body and part positioning for routine projections and common special projections of the spine
- Correctly evaluate radiographs of the spine for positioning accuracy
- Describe and recognize on radiographs abnormalities and pathology common to the spine

Key Terms

atlas
axis
cervical spine
coccyx
dens
facets
intervertebral disks
kyphosis
kyphotic curve
lamina (pl. laminae)
lordosis
lordotic curve
lumbar spine
pedicles
sacrum
scoliosis
stenosis
thoracic spine
vertebra (pl. vertebrae)

Most radiography of the spine may be accomplished successfully in either the upright or the recumbent position. In medical practices and hospitals, radiography of the spine is done in both the recumbent and upright positions. In chiropractic practices, spine radiography is almost always done in the upright position. This chapter provides instruction and illustration for both methods.

ANATOMY

The spine (Fig. 15.1) is the central portion of the skeletal system. It provides the supporting framework for the body. It also surrounds and protects the spinal cord. The spine is called the *vertebral column* because it is made up of many irregularly shaped bones known as **vertebrae**. The spine is divided into five regions: cervical spine, thoracic spine, lumbar spine, sacrum, and coccyx. The vertebrae are named according to spinal region and are numbered from the top down. For example, the third vertebra from the top of the thoracic region is simply called the *third thoracic vertebra*, abbreviated T3.

When viewed from the front, the normal spinal column is relatively straight. When seen from the side, however, the spine has four curves (Fig. 15.2). It arches anteriorly and posteriorly to provide a springlike flexibility that absorbs shock as we walk and run. A curvature that is convex (bowing outward) anteriorly is called a **lordotic curve**, or **lordosis**. One that is convex posteriorly is called a **kyphotic curve**, or **kyphosis**. An abnormal lateral curvature is called **scoliosis** and results from rotation of a lordotic and/or kyphotic curve (Fig. 15.3).

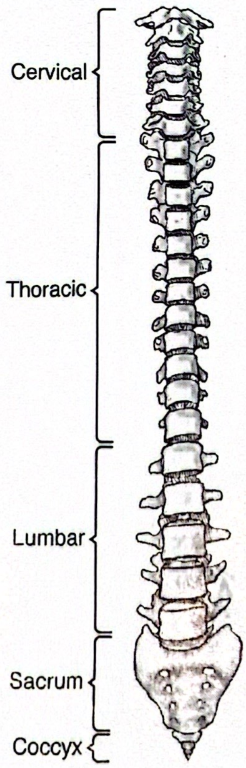

Fig. 15.1 Anterior aspect of spine.

A typical vertebra is illustrated in Fig. 15.4. The block-like anterior portion is called the *body*. It consists of cancellous bone with a thin cortex. Posterior to the body is a ring of bone called the *vertebral arch*. It is formed by the pedicles, which attach to the body on either side, and by the **laminae** posteriorly. The hole in the ring is called the *vertebral foramen*. It is the passage for the spinal cord. The concave superior and inferior surfaces of the pedicles are

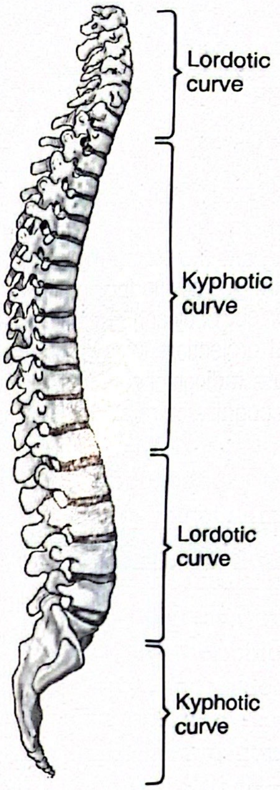

Fig. 15.2 Lateral aspect of spine.

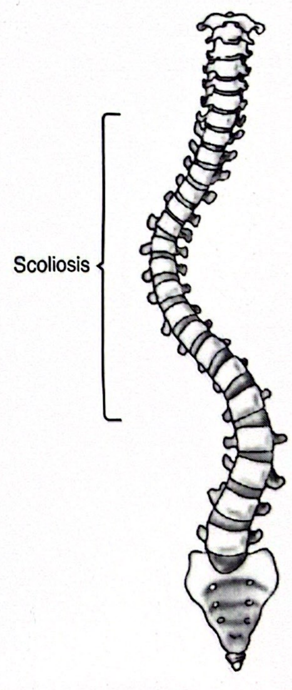

Fig. 15.3 Scoliosis: abnormal lateral spine curvature.

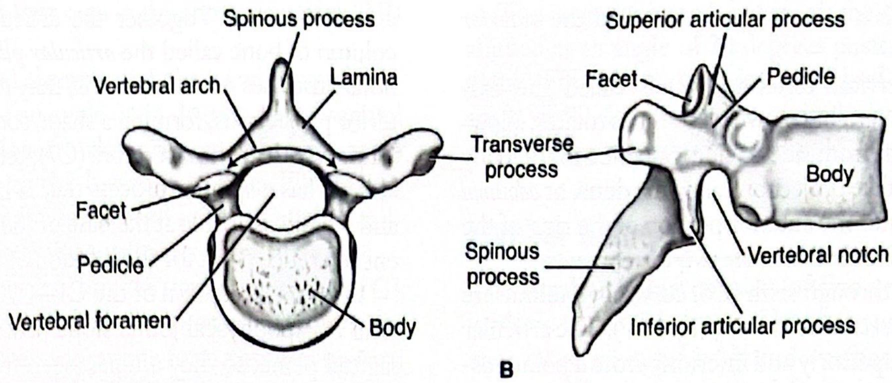

Fig. 15.4 Typical vertebra. (A) Superior aspect. (B) Lateral aspect.

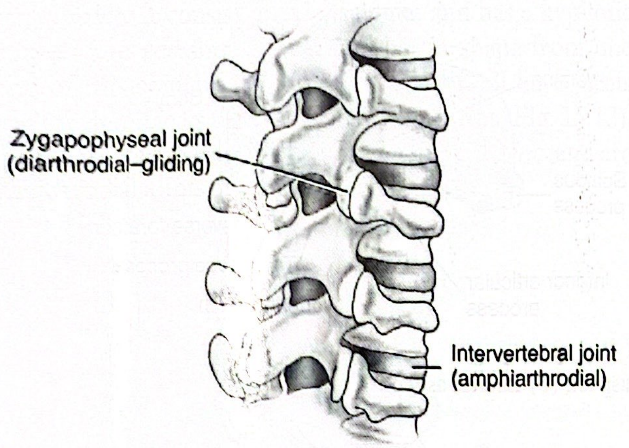

Fig. 15.5 Spinal joints. Intervertebral joints are between the bodies anteriorly, and zygapophyseal joints are between the articular processes posteriorly.

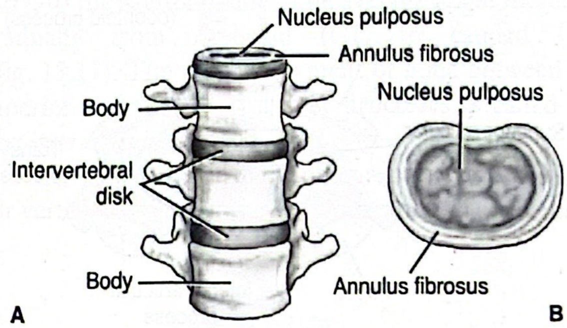

Fig. 15.6 Intervertebral disk. (A) Anterior aspect. (B) Superior aspect.

called *vertebral notches*. The spaces formed by joining with the vertebral notches above and below are the *intervertebral foramina*, which allow passage of spinal nerves and blood vessels. Two projections, extending laterally from the junction of the pedicles and lamina, are called the *transverse processes*. The spinous process projects posteriorly and inferiorly from the junction of the lamina. Four articular processes extend superiorly and inferiorly from the junction of the pedicles and lamina. The articular surfaces of these processes are called **facets**. They articulate with facets on the articular processes of the vertebrae above and below, forming the zygapophyseal joints. The zygapophyseal joints are diarthrodial joints of the gliding type. Fig. 15.5 illustrates typical joints of the spine.

The vertebrae are cushioned anteriorly, between the bodies, by pads of fibrocartilage called **intervertebral disks** (Fig. 15.6). These disks have a tough outer covering, the annulus fibrosus, and a soft, pulpy center called the *nucleus pulposus*.

Cervical Spine

The **cervical** spine is the most superior region of the vertebral column. It supports the head and the structures of the neck. The cervical spine consists of seven vertebrae and has a lordotic curve.

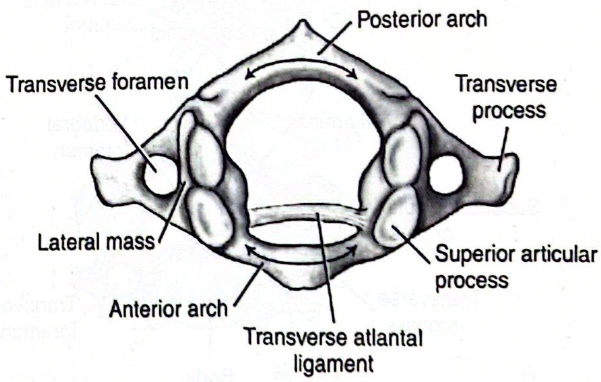

Fig. 15.7 Superior aspect of atlas (C1).

The first two cervical vertebrae differ in form from the others to accommodate the support and rotation of the skull. The first cervical vertebra (C1) is called the **atlas** (Fig. 15.7). It is a ringlike structure with no vertebral body and a very short spinous process called the *posterior tubercle*. The atlas consists of two lateral masses connected by an anterior arch and a posterior arch. Each lateral mass has superior and inferior articular processes. The superior articular processes articulate with the base of the skull, and the inferior ones form joints with similar processes on the superior aspect of the second cervical vertebra (C2). The transverse processes project laterally and slightly downward from the lateral masses. On the anterior surface of the anterior arch is a rounded process called the *anterior tubercle*.

The second cervical vertebra (C2) is called the **axis** (Fig. 15.8). It is the vertebra on which the atlas rotates, allowing the head to turn from side to side. Superior to the body of the axis is a toothlike projection called the **dens**, or *odontoid process*. It projects into the anterior portion of the ring of the atlas and acts as a pivot between the two vertebrae.

The third (C3) through sixth (C6) cervical vertebrae are termed the *typical cervical vertebrae* (Fig. 15.9). The articular processes extend superiorly and inferiorly from a point posterior to the transverse process at the junction of the pedicle and the lamina. Together the articular processes form a column of bone called the *articular pillar*. The cervical spinous processes are bifid; that is, they are split into two posterior projections, forming a shape somewhat like a fishtail. The seventh cervical vertebra (C7), termed the *vertebra prominens*, has a spinous process that is larger than the others and is easily palpable at the base of the neck. It is a convenient reference point for the location of other vertebrae.

With the exception of the C1–C2 articulation, the cervical zygapophyseal joints slope posteriorly and lie in the sagittal plane, so they are best seen from the lateral aspect (Fig. 15.10). The C1–C2 articulations differ in position

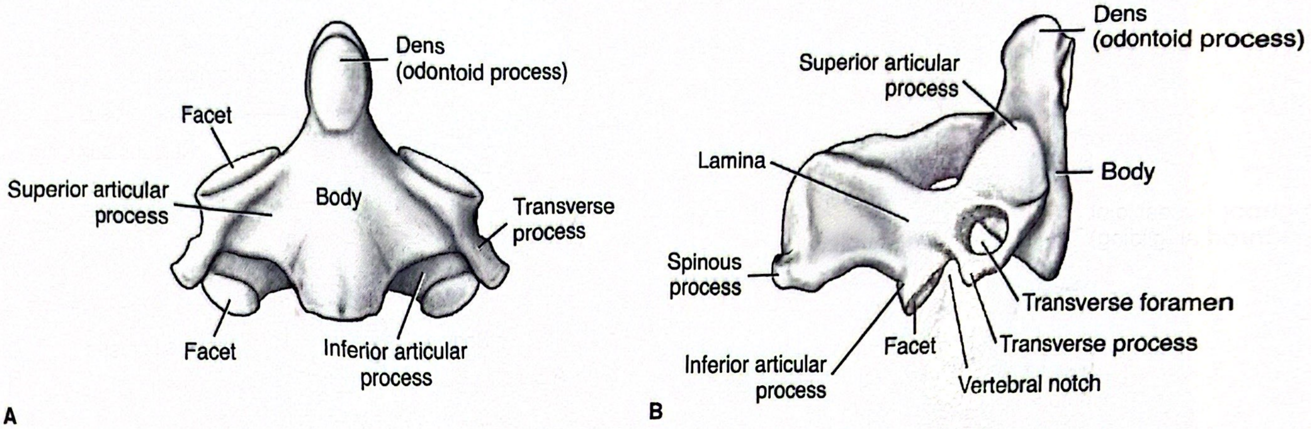

Fig. 15.8 Axis (C2). (A) Anterior aspect. (B) Lateral aspect.

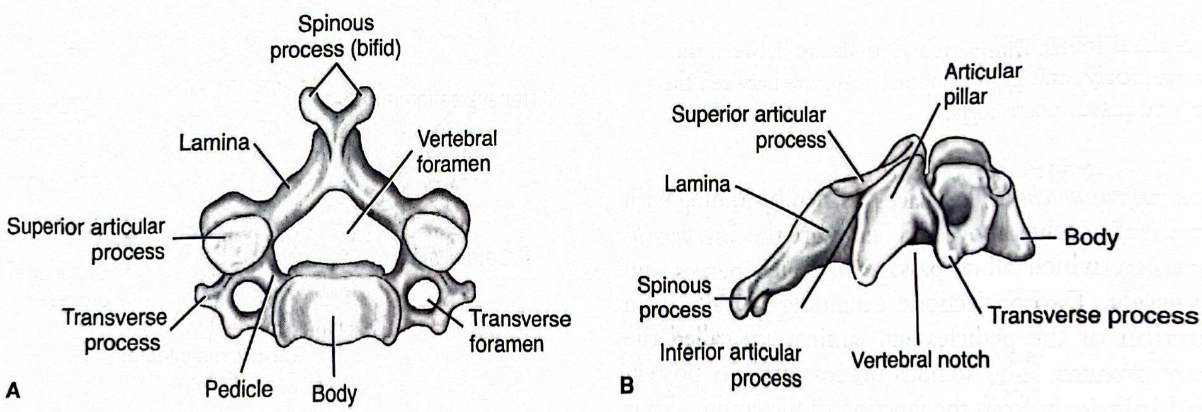

Fig. 15.9 Typical cervical vertebra. (A) Superior aspect. (B) Lateral aspect.

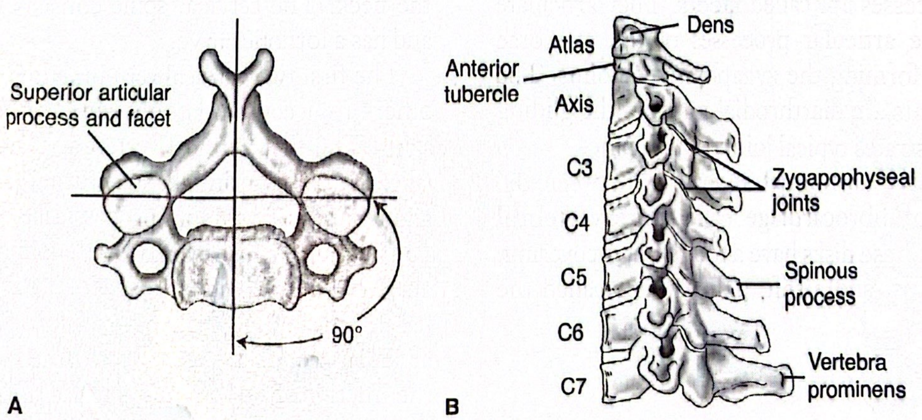

Fig. 15.10 Direction of cervical zygapophyseal joints. (A) Aligned at 90 degrees to sagittal plane. (B) Seen in lateral projection.

and direction and are best seen in the anteroposterior (AP) projection.

The intervertebral foramina of the cervical spine are oriented anteriorly at an angle of 45 degrees to the sagittal plane. These foramina are also oriented inferiorly at an angle of 15 degrees to the horizontal plane (Fig. 15.11). Nerves branching off the spinal cord exit the vertebral column through these foramina to all parts of the body.

Each cervical transverse process (including those of C1 and C2) features a hole called the *transverse foramen* (see Fig. 15.9). The transverse foramina form passages on each side for the vertebral artery and vein.

Thoracic Spine

The **thoracic spine** is sometimes also referred to as the *dorsal spine*. It consists of 12 vertebrae and has a kyphotic curve. The vertebrae vary somewhat in shape from one end of this spinal region to the other, but all have facets and/or demifacets that articulate with the ribs (Fig. 15.12). These joints are called *costal* or *costovertebral joints* and are diarthrodial joints of the gliding type.

The zygapophyseal joints of the thoracic spine are aligned at an angle of 20 degrees posterior to the coronal plane (Fig. 15.13). The intervertebral foramina lie at an angle of 90 degrees to the sagittal plane and so are seen from the lateral perspective (Fig. 15.14).

Lumbar Spine

The **lumbar spine** consists of five vertebrae and has a lordotic curve. The typical lumbar vertebra (Fig. 15.15) has a large, rounded body and a rather large, flat spinous process. The intervertebral foramina form an angle of 90 degrees to the sagittal plane and are seen from the lateral perspective (Fig. 15.16). The zygapophyseal joints lie at an angle of 30 to 60 degrees, open posteriorly, to the sagittal plane. The average angle increases gradually from cephalad (C1) to caudad (L5) (Fig. 15.17). The narrow segment of bone between the superior and inferior articular processes is called the *pars interarticularis*.

When radiographed in the oblique projection, the lumbar vertebrae demonstrate a configuration that resembles

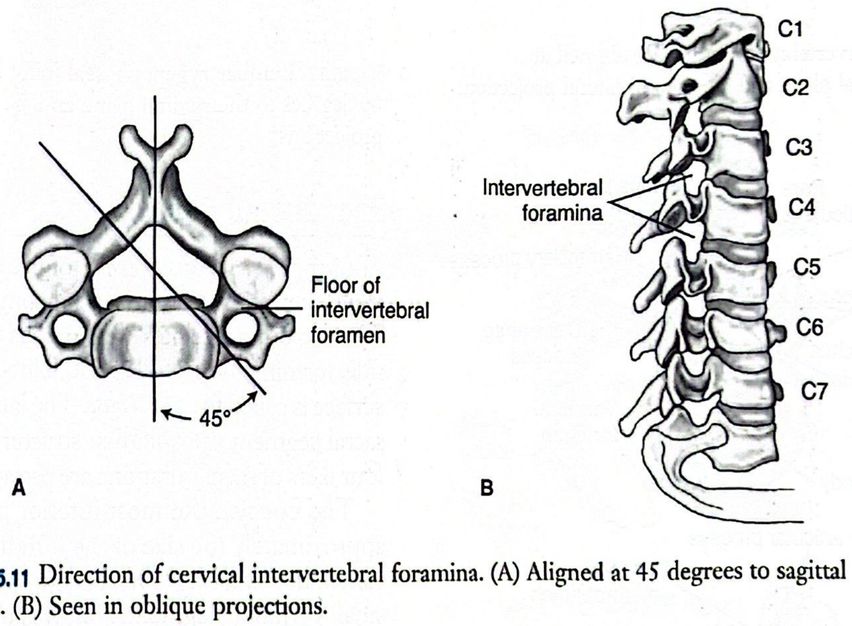

Fig. 15.11 Direction of cervical intervertebral foramina. (A) Aligned at 45 degrees to sagittal plane. (B) Seen in oblique projections.

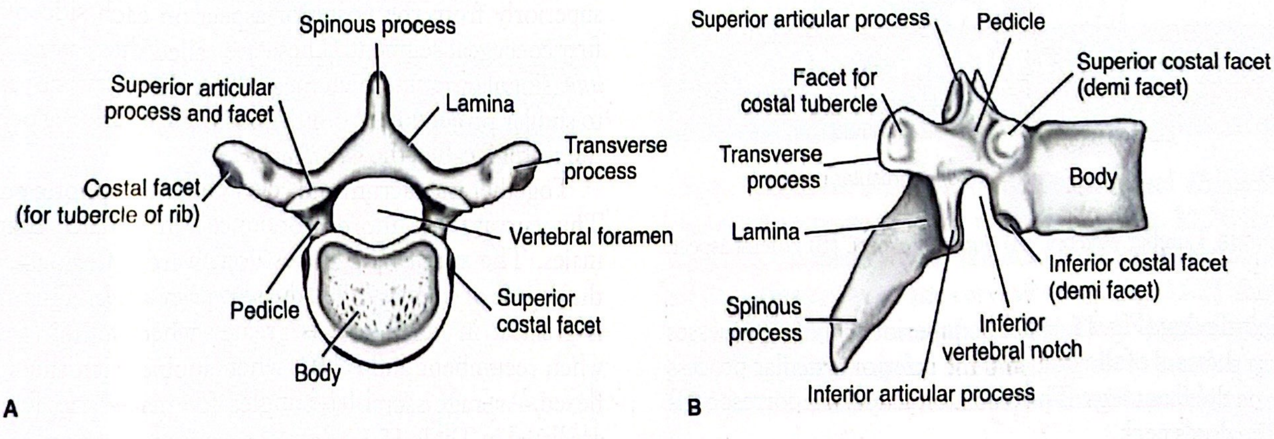

Fig. 15.12 Thoracic vertebra. (A) Superior aspect. (B) Lateral aspect.

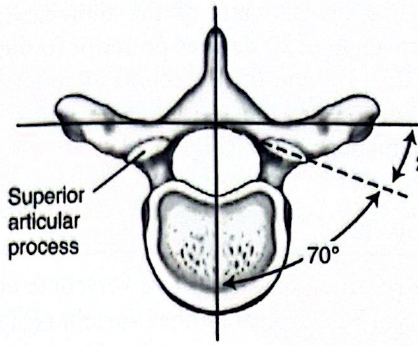

Fig. 15.13 Thoracic zygapophyseal joints are aligned at 70 degrees to the sagittal plane and are seen in oblique projections.

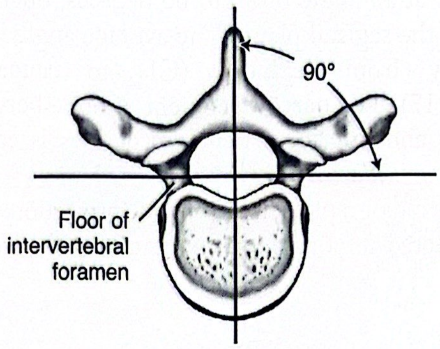

Fig. 15.14 Thoracic intervertebral foramina are aligned at 90 degrees to the sagittal plane and are seen in lateral projection.

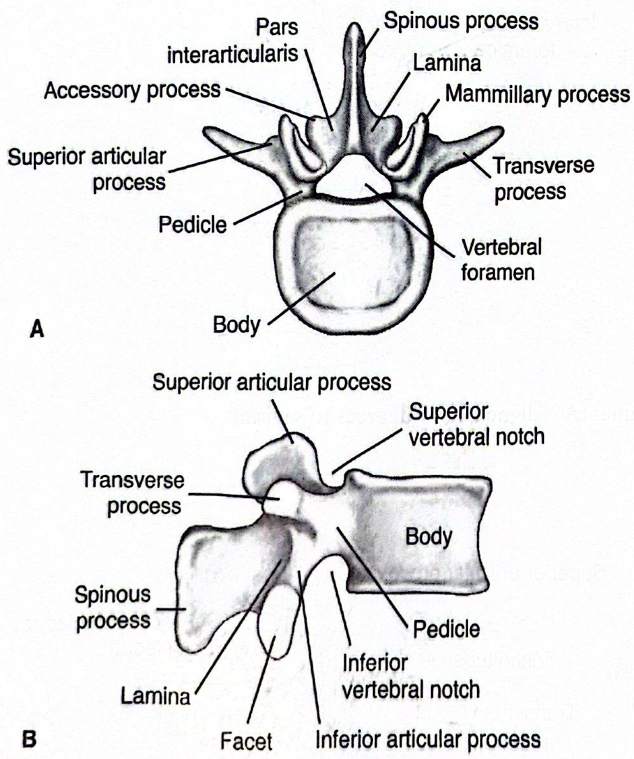

Fig. 15.15 Lumbar vertebra. (A) Superior aspect. (B) Lateral aspect.

a Scottie dog (Fig. 15.18). The superior articular processes form the ears of the dog, and the inferior articular process forms the front legs. The pars interarticularis corresponds to the dog's neck.

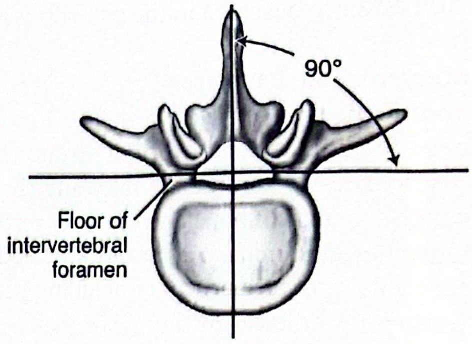

Fig. 15.16 Lumbar intervertebral foramina are aligned at 90 degrees to the sagittal plane and are seen in lateral projection.

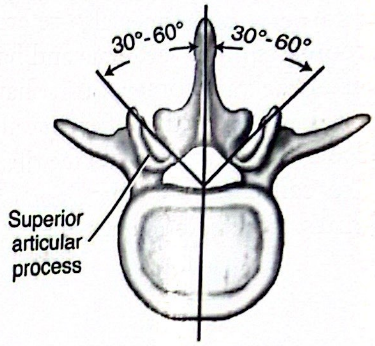

Fig. 15.17 Lumbar zygapophyseal joints are oriented 30 to 60 degrees to the sagittal plane and are seen in oblique projections.

Sacrum and Coccyx

At birth, the sacrum consists of five sacral vertebrae. In the adult, they are fused into a solid bony structure (Fig. 15.19). The sacrum articulates with the ilia of the pelvis on either side, forming the sacroiliac (SI) joints. Its broad, flat superior surface is called the *sacral base*. The lateral portions of the first sacral segment are winglike structures called the *alae*. The four pairs of sacral foramina are passages for nerves.

The coccyx, the most inferior portion of the spine, is approximately the size of the fifth finger. In lay terms, it is called the *tailbone*. The coccyx usually consists of four small vertebral segments, but it is not unusual for there to be three or five segments. The coccygeal segments tend to fuse in the adult. Two small bony projections extend superiorly from the posterior aspect on each side of the first coccygeal segment. These are called the *coccygeal cornua* (singular *cornu*, which means "horn"). They are joined to similar projections from the posterior inferior aspect of the sacrum, called the *sacral cornua*.

Together the sacrum and coccyx form a kyphotic curve. This curvature is more pronounced in females than in males. The sacral base slopes downward anteriorly, and the degree of slope is called the *sacral base angle*. This angle is greatest in females. It is greater when standing than when recumbent and is least when supine with the knees flexed. Average sacral base angles for males and females are listed in Table 15.1.

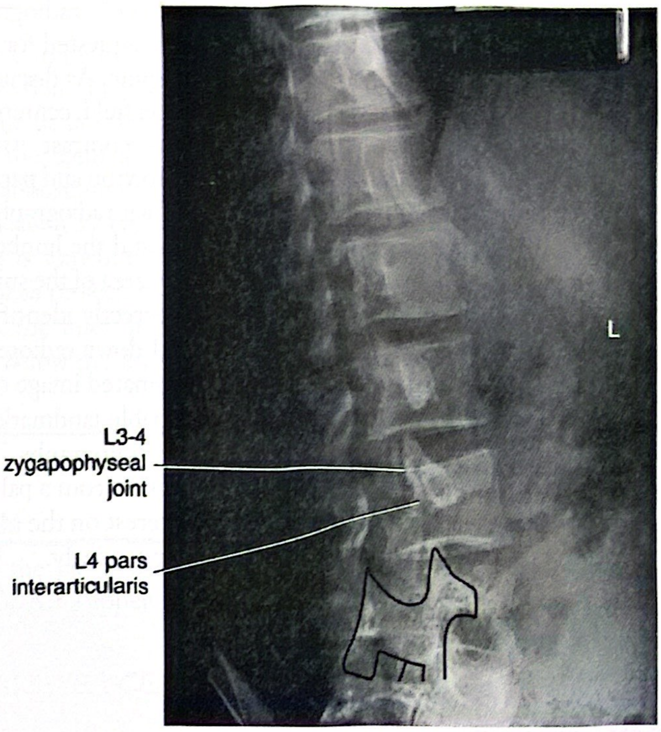

Fig. 15.18 Oblique lumbar spine radiograph showing Scottie dog configuration.

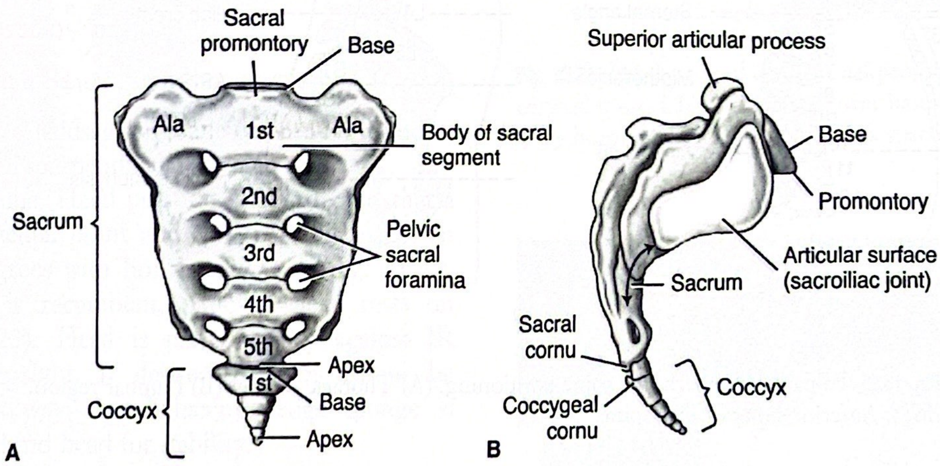

Fig. 15.19 Sacrum and coccyx. (A) Anterior aspect. (B) Lateral aspect.

TABLE 15.1
Average Sacral Base Angulation

Body Position	Sacral Base Angle in Males	Sacral Base Angle in Females
Standing	35 degrees	40 degrees
Supine with legs extended	30 degrees	35 degrees
Supine with knees fixed	25 degrees	30 degrees

POSITIONING AND RADIOGRAPHIC EXAMINATIONS

Many landmarks are used in positioning and alignment for various aspects of spine radiography. Fig. 15.20 illustrates the landmarks of the cranium and face that are helpful for radiography of the cervical spine. Fig. 15.21 shows the topographic anatomy that corresponds to specific vertebral levels of the spine. Memorizing these locations will enhance your ability to position patients accurately.

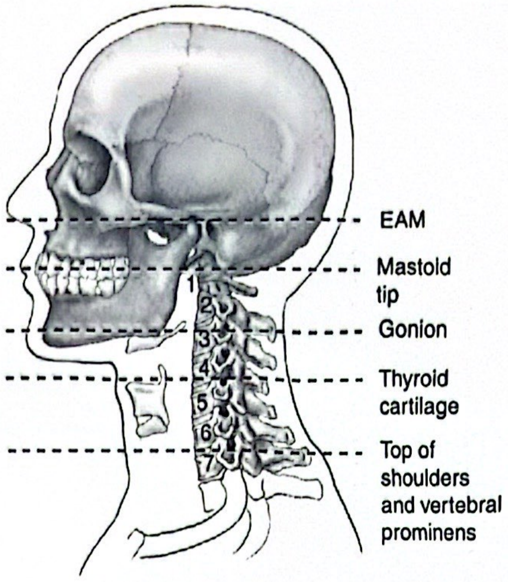

Fig. 15.20 Palpable landmarks for cervical spine positioning. *EAM*, External auditory meatus.

"Coned-down" radiographs, historically called *spot films*, may be requested for better visualization of specific areas of the spine. As discussed in Chapter 9, the use of a small radiation field, centered on the area of clinical interest, improves contrast while minimizing the negative effects of distortion and parallax. The most common areas for coned-down radiography are the upper cervical spine (C1 and C2) and the lumbosacral junction, but it may be helpful in any area of the spine. The limited operator must be able to correctly identify the location of any vertebra when a coned-down radiograph is necessary. When taking a closely collimated image of a vertebra that does not have a precise palpable landmark, it is helpful to have reference from routine radiographs. The limited operator can measure the distance from a palpable landmark to the vertebra of clinical interest on the radiograph and use this information to center properly.

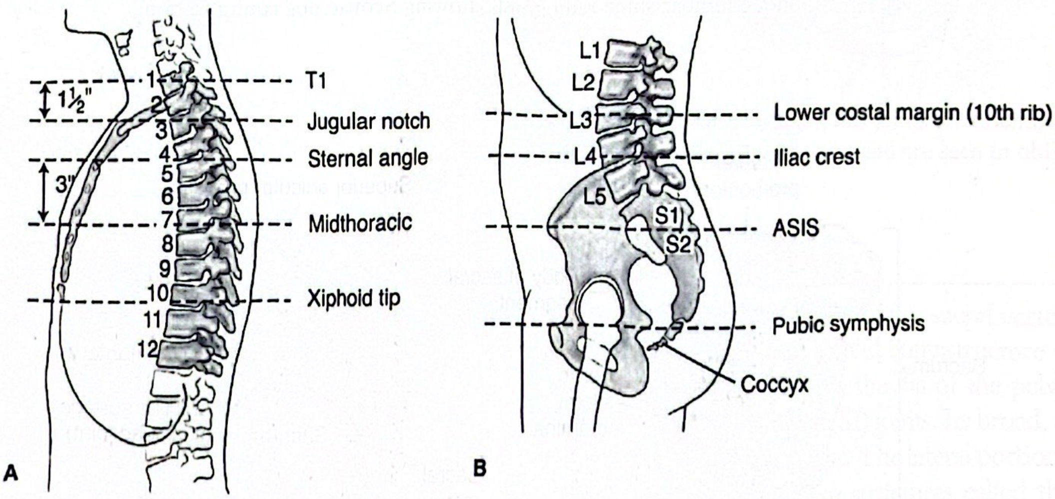

Fig. 15.21 Palpable landmarks for spine positioning. (A) Thoracic region. (B) Lumbar region. *ASIS*, Anterior superior iliac spine.

Cervical Spine

Two radiographs are necessary to demonstrate the entire cervical spine in the AP projection. The AP axial projection of the lower cervical spine demonstrates C3 through C7, but the lower jaw and the teeth are superimposed over the atlas and axis. To demonstrate the upper cervical vertebrae, a second AP projection is taken through the open mouth. This projection is sometimes referred to as the *AP open-mouth* or the *odontoid* projection.

For the lateral projection, the inferior margin of the image receptor (IR) must be below the level of the upper surface of the shoulder to demonstrate all of C7. This results in a large object–image receptor distance (OID) between the neck and the IR. To minimize magnification and improve detail on this projection, a 72-inch source–image receptor distance (SID) is used. Detail is also enhanced by the use of the small focal spot.

Before undergoing cervical spine radiography, the patient must remove eyeglasses, earrings, hairpins, necklaces, and any clothing that has fasteners that might fall within the radiation field. Dentures and hearing aids should also be removed.

ROUTINE EXAMINATION

The routine examination of the cervical spine includes the AP axial (lower cervical), AP (upper cervical), and lateral projections.

AP AXIAL PROJECTION (LOWER CERVICAL SPINE)

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; central ray (CR) plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Seated, standing, or supine.

Part position: Midsagittal plane of both body and head are aligned perpendicular to center of IR, with patient facing tube. Head position is adjusted so that a line between mental point and base of skull makes an angle of 15 degrees with horizontal plane (Fig. 15.22). When patient is recumbent, patient's head rests on table (Fig. 15.23). Head is placed firmly against IR holder when upright. If desired position cannot be attained in this way, a radiolucent wedge sponge is placed under/behind head for stability.

> **TIP:** The upper margin of the collimator light field will fall across the patient's face at an angle of 15 degrees, which simplifies the adjustment of the head position.

Central ray: Centered with regard to IR at an angle of 15 degrees cephalad through thyroid cartilage.

Collimation: Adjust light field to 10 inches (25 cm) lengthwise and 1 inch (2.5 cm) beyond skin shadows on the sides. Place side marker in the collimated light field.

Patient instruction: Stop breathing. Do not move.

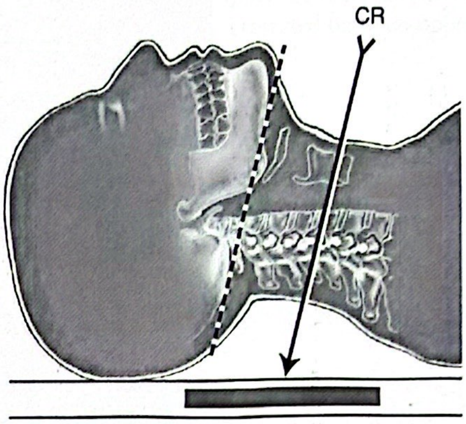

Fig. 15.22 Head position for AP axial projection of lower cervical spine. Chin is projected over base of skull. Angled x-ray beam is parallel to cervical disk spaces. *CR*, Central ray.

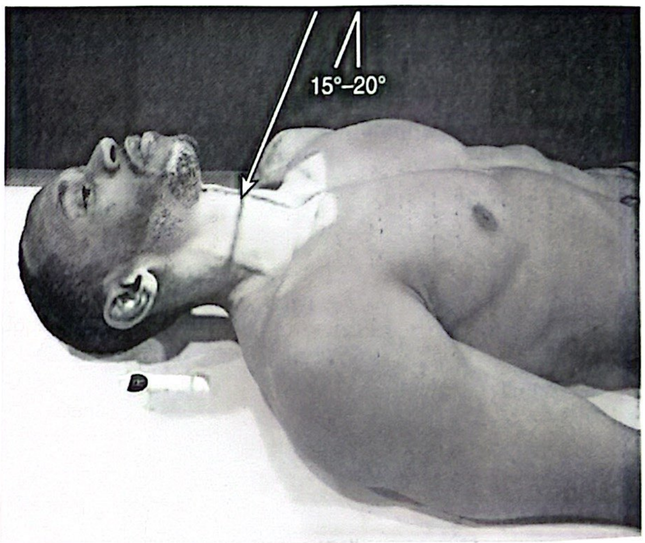

Fig. 15.23 Cervical spine (lower). Position for AP axial projection.

Structures seen: Vertebrae C3 through T2, including bodies, articular pillars, and intervertebral disk spaces (Fig. 15.24).

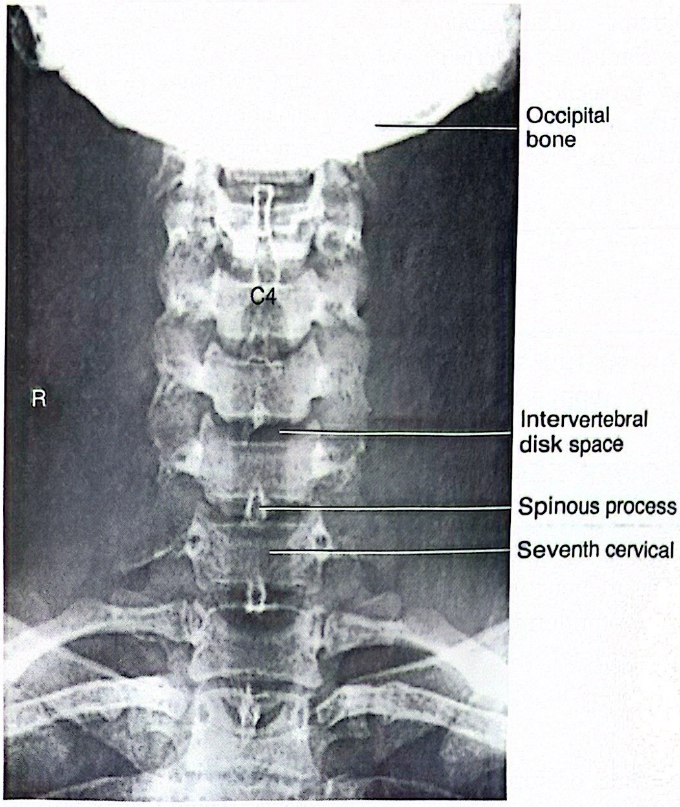

Fig. 15.24 Cervical spine (lower). AP axial projection.

AP PROJECTION/OPEN MOUTH TECHNIQUE (UPPER CERVICAL SPINE)

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum (30 inches may be used to increase the odontoid area field of view)

Body position: Seated, standing, or supine.

Part position: Patient faces tube with midsagittal plane of both body and head perpendicular to center of IR. Position of head is adjusted so that a line between lower surface of upper teeth (occlusal plane) and base of skull is parallel to horizontal plane (Figs. 15.25 and 15.26). When patient is upright, patient's head is placed firmly against IR holder or a radiolucent wedge sponge for stability.

Central ray: Perpendicular to center of IR, through midpoint of open mouth.

Collimation: Adjust light field to 5 × 5 inches (13 × 13 cm) on the collimator. Close collimation improves image quality and prevents unnecessary exposure to thyroid gland and eyes. Place side marker in the collimated light field.

Patient instruction: Open mouth as wide as possible. Stop breathing. Do not move.

> **TIP:** If the patient has closed the mouth following positioning and must reopen it before the exposure, it is wise to instruct the patient to "drop the lower jaw" as far as possible. When instructed to "open wide," patients may tend to extend the neck, which causes incorrect position of the head.

Structures seen: Lateral masses and transverse processes of atlas, dens, and upper half of body of axis, seen between upper and lower teeth (Fig. 15.27).

> **TIP:** If the base of the skull is superimposed on the atlas and the dens, then the patient's neck was extended too far. If the upper teeth are superimposed on the atlas and the dens, then the patient's neck was flexed too much. If the lower teeth are superimposed on the upper half of the axis and the base of the skull is in the proper position, the patient's mouth was not open far enough.

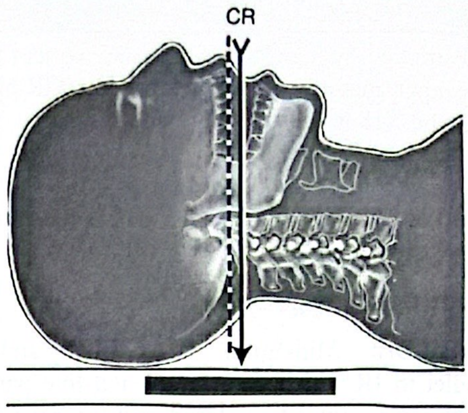

Fig. 15.25 Head position for AP projection of upper cervical spine. With mouth wide open, upper teeth are projected over base of skull, with atlas and axis projected between upper and lower teeth. *CR*, Central ray.

Fig. 15.26 Cervical spine *(upper)*. Position for AP projection—open mouth technique.

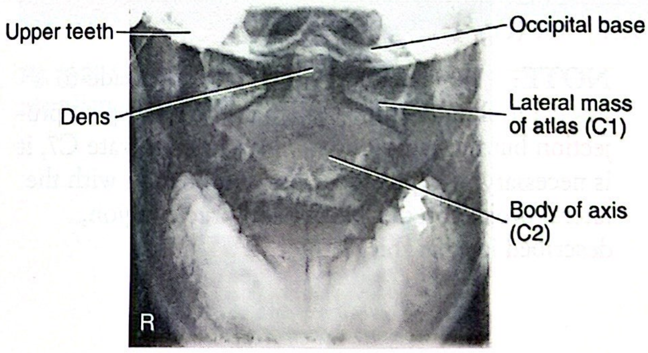

Fig. 15.27 Cervical spine *(upper)*. AP projection—open mouth technique.

LATERAL PROJECTION (GRANDY METHOD)

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 60 to 72 inches (152 to 183 cm) is recommended because of the increased OID

Body position: Seated or standing.

Part position: Midsagittal planes of body and head are parallel to IR with infraorbitomeatal line parallel to floor. Shoulders must be relaxed and depressed. IR is positioned so that upper margin is about 1 inch above the external auditory meatus (EAM) (Fig. 15.28).

> **TIP:** Patients with high, square shoulders may need to have sandbags of equal weight suspended from the wrists to place the shoulders below C7 (see Fig. 13.104). Alternatively, patient may stand on the center of a long strap, grasping the two ends to maintain downward tension on the shoulders.

Central ray: Perpendicular to center of IR through body of C4.

> **TIP:** Place your finger on the tip of the C7 spinous process and note the location of its shadow in the collimator light beam. It should be within the posterior margin of the IR and at least 2 inches above its inferior margin.

Collimation: Adjust light field to 8 × 10 inches (18 × 24 cm) on the collimator. Eyes should be excluded from field. Place side marker in the collimated light field.

Patient instruction: Stop breathing. Do not move.

> **TIP:** Do *not* instruct patient to "take a deep breath" because doing so tends to elevate the shoulders.

Structures seen: All seven cervical vertebrae and soft tissues of anterior neck, including spinal alignment, bodies, disk spaces, spinous processes, and zygapophyseal joints (Fig. 15.29).

> **NOTE:** When a good effort has been made to lower the shoulders for the lateral cervical spine projection but the radiograph fails to demonstrate C7, it is necessary to supplement the examination with the lateral projection of the cervicothoracic region, described later in this chapter.

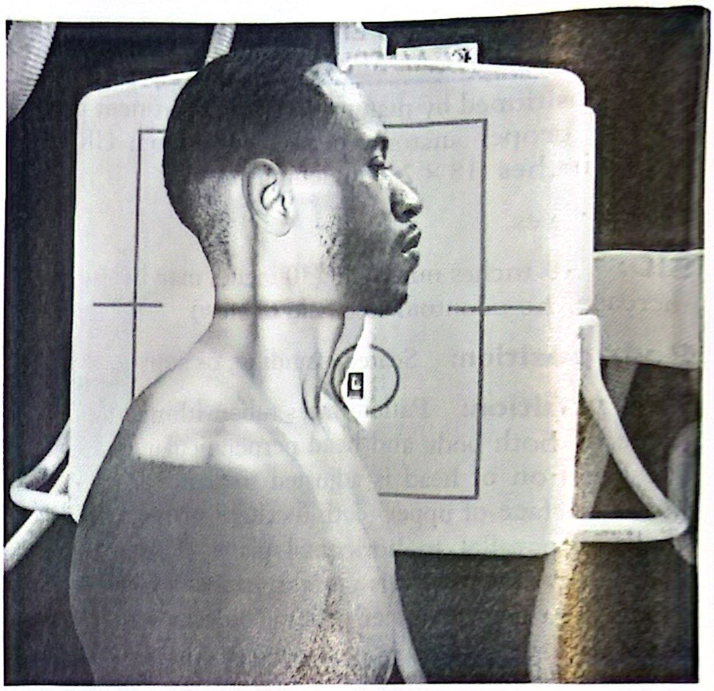

Fig. 15.28 Cervical spine. Position for lateral projection.

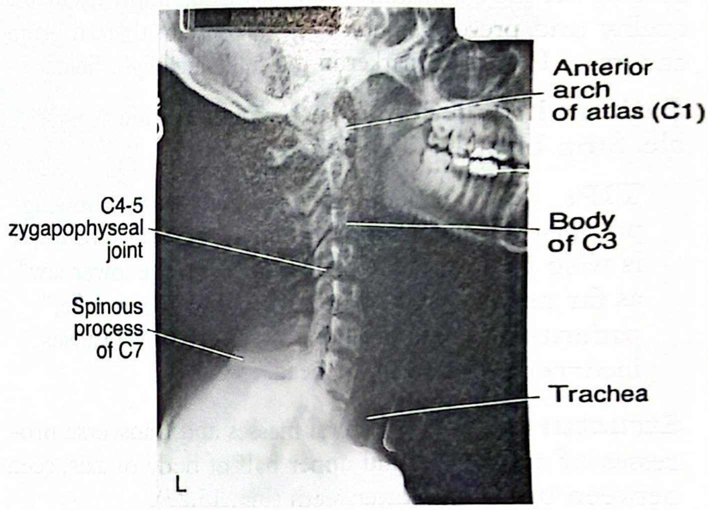

Fig. 15.29 Cervical spine. Lateral projection, Grandy method.

SUPPLEMENTAL PROJECTIONS

LATERAL PROJECTION IN FLEXION AND EXTENSION

Lateral projections with the cervical spine in flexion and extension are performed to evaluate intersegmental stability.

> **NOTE:** When there has been recent trauma to the cervical spine, the lateral projection in the dorsal decubitus position should be evaluated by the physician before proceeding with flexion and extension lateral projections.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 10 × 12 inches (24 × 30 cm) lengthwise

Grid: Yes

SID: 60 to 72 inches (152 to 183 cm) is recommended because of the increased OID

Position for flexion: Patient is positioned as for routine lateral projection. Patient is then instructed first to "tuck" chin close to neck and then to flex neck, attempting to look at a spot at midsternum (Fig. 15.30).

Position for extension: Patient is positioned as for routine lateral projection. Patient is then instructed to extend neck, looking at a spot on ceiling directly above head (Fig. 15.31).

> **NOTE:** *The radiographer must not force these positions.* The desired degree of flexion or extension is the fullest extent that is tolerable for the patient.

Central ray: Perpendicular to center of IR, through body of C4.

Collimation: Adjust light field to 10 × 12 inches (24 × 30 cm) on the collimator. Place side marker in the collimated light field.

Patient instruction: Stop breathing. Do not move.

Structures seen: All seven cervical vertebrae and soft tissues of anterior neck, including spinal alignment, bodies, disk spaces, spinous processes, and zygapophyseal joints. Head tilted face down in flexion (Fig. 15.32) and tilted face up in extension (Fig. 15.33).

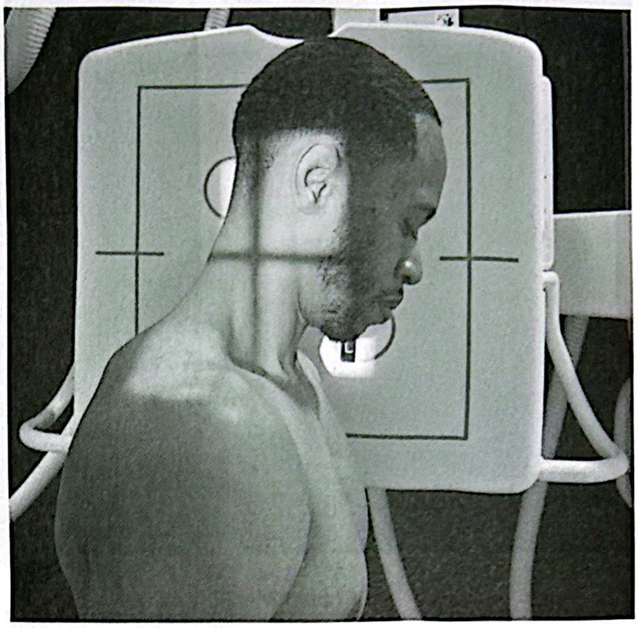

Fig. 15.30 Cervical spine. Position for lateral projection in flexion.

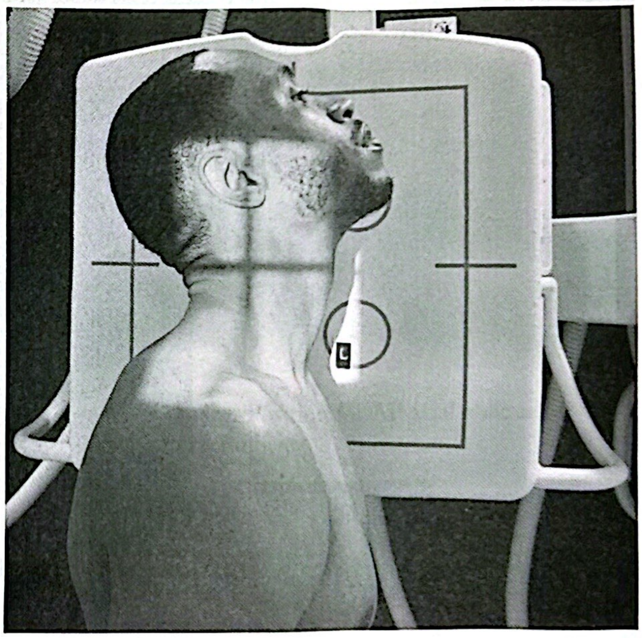

Fig. 15.31 Cervical spine. Position for lateral projection in extension.

Fig. 15.32 Cervical spine. Lateral projection in flexion.

Fig. 15.33 Cervical spine. Lateral projection in extension.

OBLIQUE PROJECTIONS

Oblique projections are taken in left/right pairs. They may be done in a posteroanterior (PA) projection (right anterior oblique [RAO] and left anterior oblique [LAO] positions) or AP projection (right posterior oblique [RPO] and left posterior oblique [LPO] positions). They may be done recumbent, with a 40-inch SID, or upright, with either a 40-inch or a 72-inch SID. The available equipment and the preferences of the physician may dictate both the method and the positions used.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 60 to 72 inches (152 to 183 cm) is recommended because of the increased OID

Body position: Seated, standing, or recumbent.

Part position: Coronal plane of body forms angle of 45 degrees with plane of IR. Sagittal plane of skull is perpendicular to coronal plane of body. Have patient elevate and, if necessary, protrude the chin so that mandible does not overlap spine.

Central ray:

AP obliques: Angled 15 degrees cephalad to center of IR through body of C4 (Figs. 15.34 and 15.35).

PA obliques: Angled 15 degrees caudad to center of IR through body of C4 (Figs. 15.37 and 15.38).

Collimation: Adjust light field to 8 × 10 inches (18 × 24 cm) on the collimator. Eyes should be excluded from field. Place side marker in the collimated light field.

Patient instruction: Stop breathing. Do not move.

Structures seen: AP obliques demonstrate intervertebral foramina on side farthest from IR (Fig. 15.36). PA obliques demonstrate intervertebral foramina on side nearest IR (Fig. 15.39).

Fig. 15.34 Cervical spine. Position for AP axial oblique projection, patient upright.

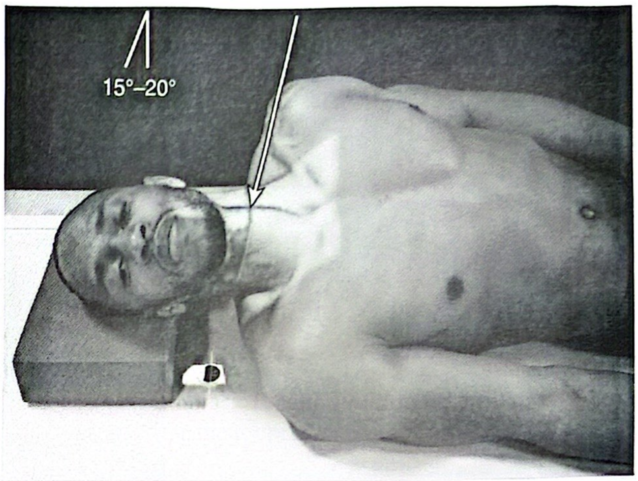

Fig. 15.35 Cervical spine. Position for AP axial oblique projection, patient recumbent.

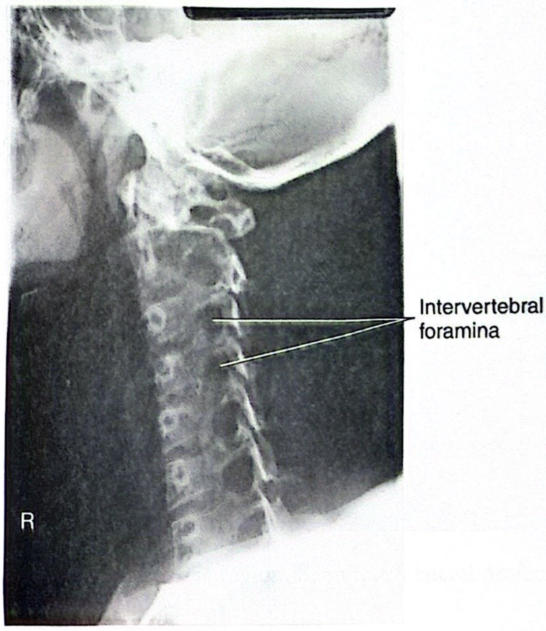

Fig. 15.36 Cervical spine. AP axial oblique projection (40-inch SID).

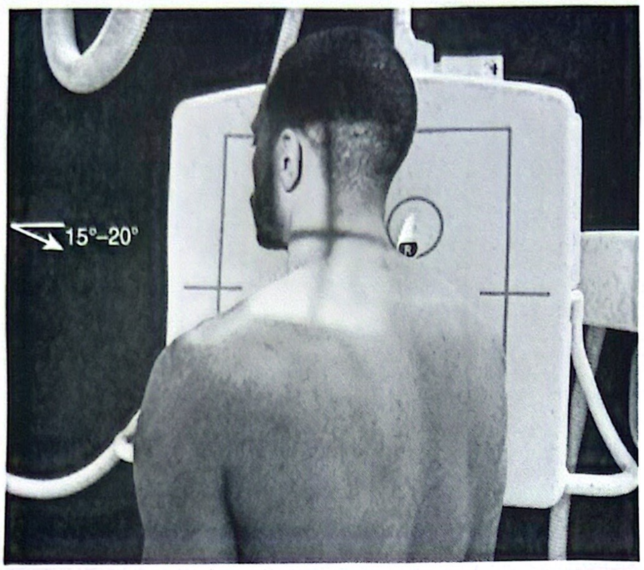

Fig. 15.37 Cervical spine. Position for PA axial oblique projection, patient upright.

Fig. 15.38 Cervical spine. Position for PA axial oblique projection, patient recumbent.

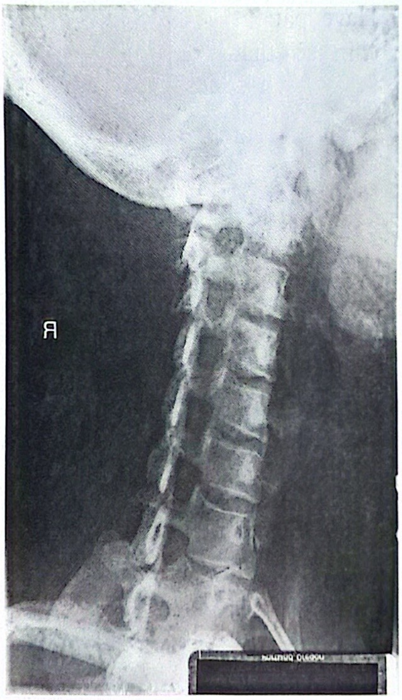

Fig. 15.39 Cervical spine. PA axial oblique projection (72-inch SID).

LATERAL PROJECTION OF CERVICOTHORACIC REGION

The lateral projection of the cervicothoracic region is commonly called the *swimmer's technique*. It is used when routine lateral projections of either the cervical or the thoracic spine fail to demonstrate this area adequately. The shoulder positions create a small "window" between the shoulders, and the cervicothoracic spine is projected into this relatively open area.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 10 × 12 inches (24 × 30 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Seated, standing, or recumbent.

Part position: Sagittal planes of body and head are parallel to IR. Arm nearest IR is raised above head and shoulder is rounded anteriorly. Opposite shoulder is depressed and slightly posterior (Figs. 15.40 and 15.41).

Central ray: Perpendicular to IR at C7–T1 interspace. Central ray enters at base of neck in midcoronal plane at level of C7 spinous process.

Collimation: Adjust light field to 10 × 12 inches (24 × 30 cm) on the collimator. Place side marker in the collimated light field.

Patient instruction: Stop breathing. Do not move.

Structures seen: Vertebrae C6 through T3 (C5 through T5 with larger IR) in lateral projection without significant rotation. Bodies, disk spaces, spinous processes, and zygapophyseal joints are demonstrated between shoulders (Fig. 15.42).

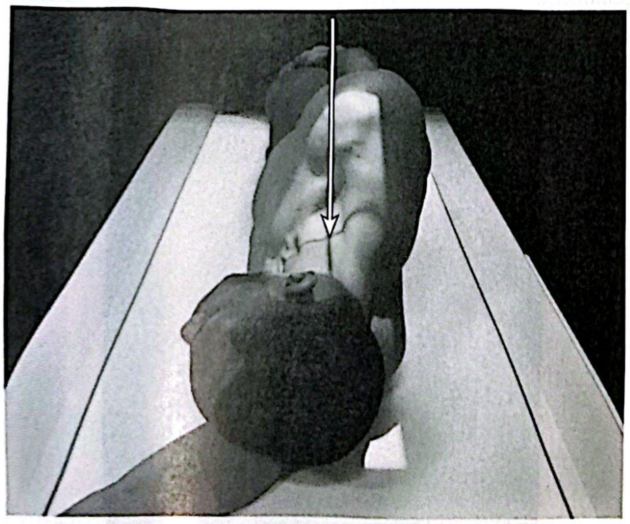

Fig. 15.40 Cervicothoracic region. Position for swimmer's lateral projection, patient recumbent.

TIP: Take care when positioning the arms so that the midsagittal plane of the body remains parallel to the IR. The most common error associated with this position is rotation of the body so that the spine is oblique rather than lateral.

Compensating filter: This projection will be improved with the use of a compensating filter because of the extreme difference between the thin lower neck and the very thick upper thoracic region. With the use of a specially designed filter, the C7–T1 area can be more clearly seen.

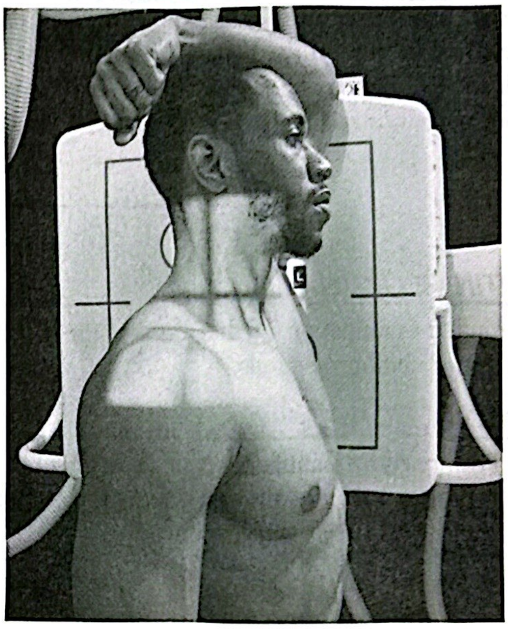

Fig. 15.41 Cervicothoracic region. Position for swimmer's lateral projection, patient upright.

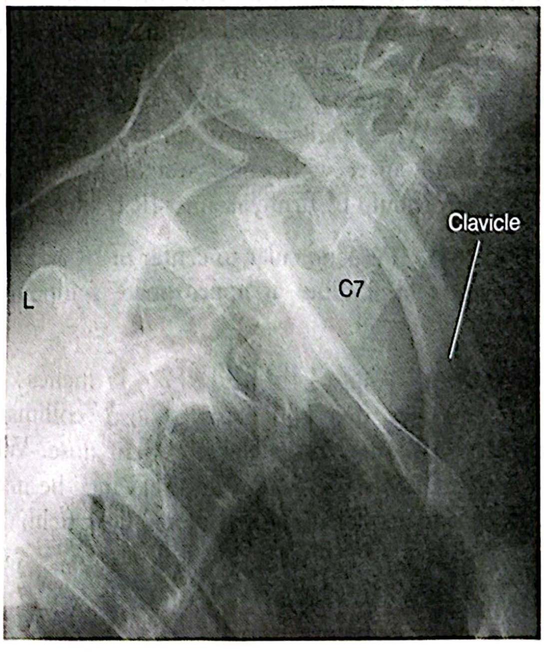

Fig. 15.42 Cervicothoracic region. Swimmer's lateral projection.

Thoracic Spine

There is significant tissue density variation between the extreme ends of the thoracic spine. Near the neck there is much less tissue to penetrate than at the level of T12 in the upper abdominal region. For this reason, it is desirable to use the anode heel effect (see Chapter 5). For recumbent studies, the patient should be instructed to lie on the table with the head toward the anode end of the x-ray tube. If use of the anode heel effect is insufficient to compensate for the extremes in tissue density, a wedge-type compensating filter may be placed in the x-ray beam so that its thick edge is over the upper thoracic spine.

In the lateral projection, the density variation is reversed. The proximal thoracic spine is more difficult to penetrate because of the bone and muscle mass of the shoulders, and there is little lung tissue in this area. The inferior portion is relatively easily penetrated because its mass is largely air-containing lung. For this reason, it may be desirable to reverse the position of the compensating filter for the lateral projection. In any case, the first three thoracic vertebrae are seldom visualized well on the lateral projection. When the area of clinical interest includes the upper thoracic vertebrae, it is usual for the examination to include a swimmer's lateral projection of the cervicothoracic region. This projection was explained and illustrated in the previous section. In some facilities, the swimmer's lateral projection is a routine part of the basic thoracic spine examination.

For this examination, the patient should undress down to the waist and don a gown that opens in the back. This will facilitate visualization and palpation of the spine. Any jewelry that would be in the radiation field should be removed. For standing examinations, the shoes should also be removed.

ROUTINE EXAMINATION

The routine examination of the thoracic spine includes the AP and lateral projections.

AP PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14 × 17 inches (35 × 43 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Seated, standing, or recumbent.

Part position: Midsagittal plane of body is perpendicular to IR and centered on it, with patient facing tube. Superior border of IR is aligned 1.5 to 2 inches (3.8 to 5 cm) above the shoulders (Figs. 15.43 and 15.44). When patient is supine, it is helpful to place a bolster under knees. When patient is standing, feet should be shoulder-width apart with equal weight bearing, and patient's back should be firmly against IR holder.

Central ray: Perpendicular to center of IR at T7. This point is in midline at approximate midpoint of sternum.

Collimation: Adjust light field to 7 × 17 inches (18 × 43 cm) on the collimator. Close collimation improves visualization and reduces patient dose. When there is significant scoliosis, a wider field may be necessary. Place side marker in the collimated light field.

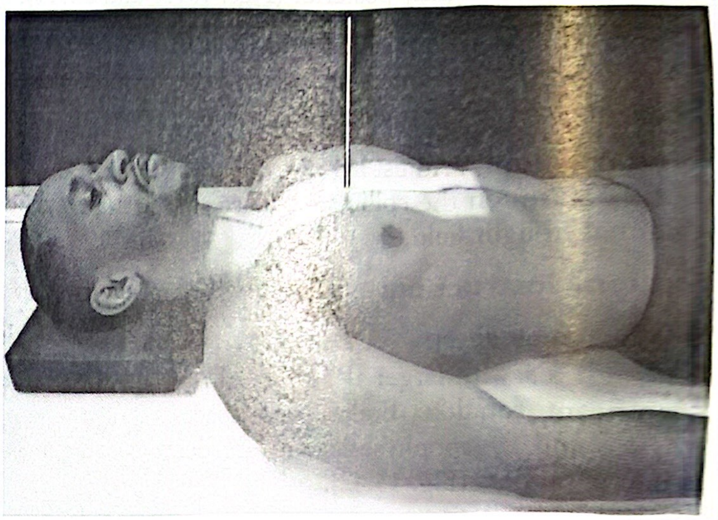

Fig. 15.43 Thoracic spine. Position for AP projection, patient recumbent.

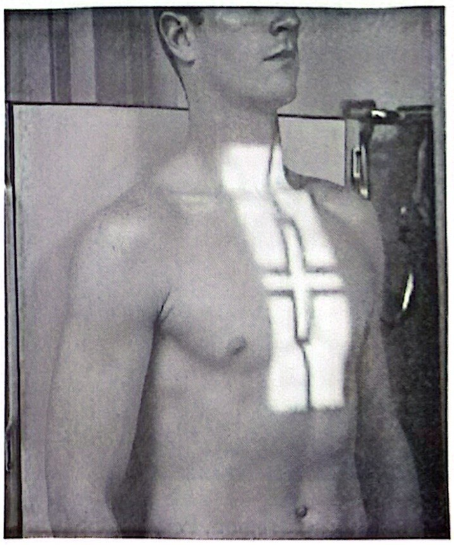

Fig. 15.44 Thoracic spine. Position for AP projection, patient upright.

Shielding: Lead half-apron.

Patient instruction: Do not move. Suspend breathing on expiration.

Structures seen: All 12 thoracic vertebrae, particularly the bodies, disk spaces, and transverse processes. C7 and at least a portion of L1 are usually also seen (Fig. 15.45).

Compensating filter: The image quality of this projection can be improved significantly with use of a compensating filter. Various wedge filters are available to assist in providing a uniform density of the entire thoracic spine.

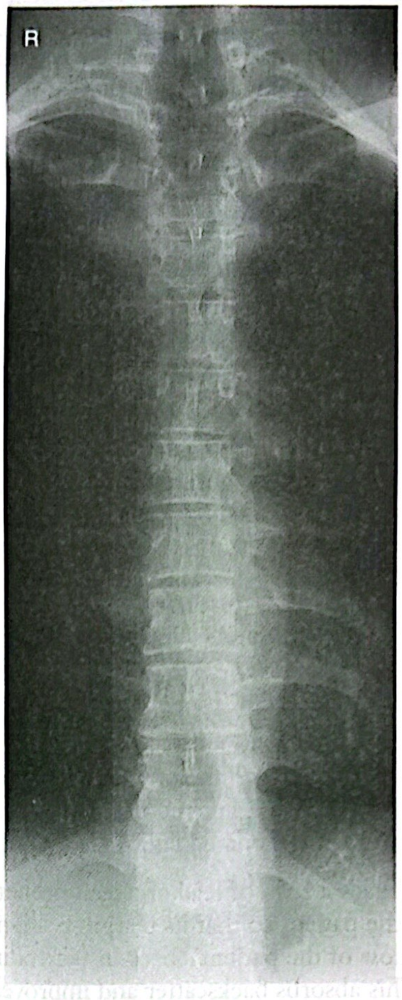

Fig. 15.45 Thoracic spine. AP projection.

LATERAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14 × 17 inches (35 × 43 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Seated, standing, or recumbent.

Part position: Sagittal plane of body is parallel to IR. Center the posterior half of the thorax to the midline of the IR. Arms may be raised overhead (Fig. 15.46) or anterior to body with shoulders rounded anteriorly (Fig. 15.47). The superior border of the IR is adjusted to 1.5 to 2 inches (3.8 to 5 cm) above the shoulders. Take care that entire length of thoracic spine is parallel to IR. When patient is recumbent, this may require support of a radiolucent sponge under waist and/or hips.

Central ray: Perpendicular to center of IR at level of T7. Central ray enters at inferior angle of scapula through middle of posterior half of thorax.

Collimation: Adjust light field to 7 × 17 inches (18 × 43 cm) on the collimator. A wider field may be necessary if there is exaggerated thoracic kyphosis. Place side marker in the collimated light field.

> **TIP:** Place a strip of lead or a lead rubber mask behind the patient so that its margin is aligned with the shadow of the patient's back in the collimator light. This absorbs backscatter and improves visualization of the spinous processes.

Patient instruction: Do not move. Perform shallow breathing during exposure.

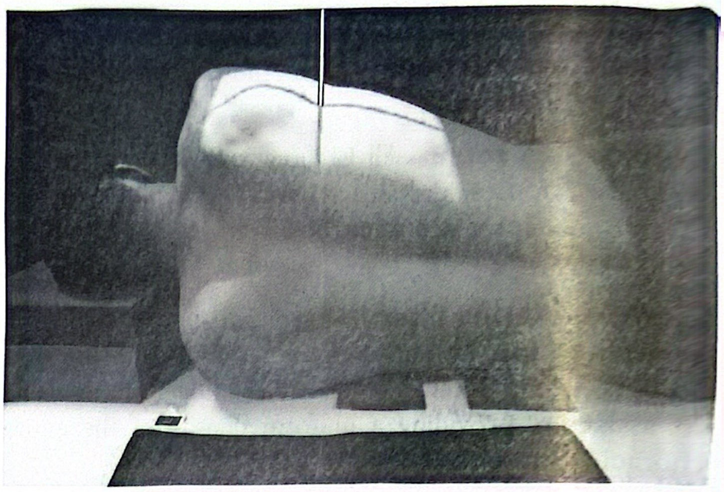

Fig. 15.46 Thoracic spine. Position for lateral projection, patient recumbent. Note the lead strip placed on table for absorption of scatter radiation.

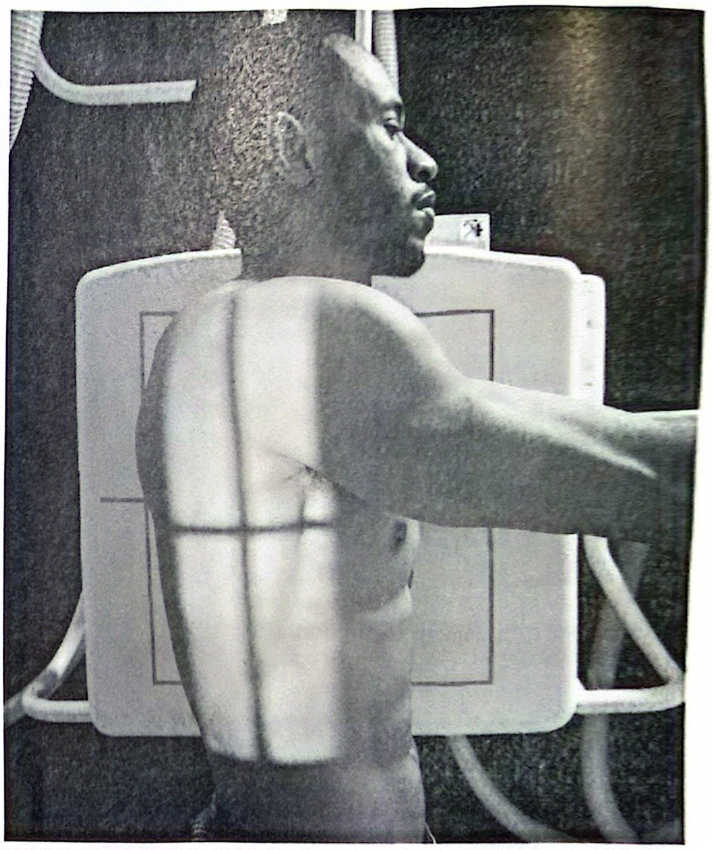

Fig. 15.47 Thoracic spine. Position for lateral projection, patient upright.

TIP: A low milliamperage (mA) setting that provides the desired milliampere-seconds (mAs) with an exposure time of 1 to 3 seconds is necessary for best results with breathing technique.

Structures seen: T3 through T12 with blurring of ribs and lung markings when breathing technique is used (Fig. 15.48).

Fig. 15.48 Thoracic spine. Lateral projection. Note blurring of ribs and lung structures resulting from use of breathing technique.

Lumbar Spine

For lumbar spine radiography, patients should remove outer clothing from the torso and don a gown opening in the back. Female patients must remove bras. For upright studies, shoes are also removed.

ROUTINE EXAMINATION

The routine examination of the lumbar spine includes the AP or PA and lateral projections.

AP OR PA PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14 × 17 inches (35 × 43 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Standing or recumbent.

Part position:

AP: Patient faces tube with midsagittal plane perpendicular to IR and centered on it (Fig. 15.49). When patient is supine, knees are flexed and may be supported with a bolster. When patient is standing, feet are shoulder-width apart with equal weight bearing, and torso is stabilized against upright IR holder (Fig. 15.50).

PA: Patient stands facing IR or lies prone, with midsagittal plane perpendicular to IR and centered on it.

Central ray: Perpendicular to center of IR through L4, in midline at level of iliac crest.

Collimation: Adjust light field to 8 × 17 inches (20 × 43 cm) on the collimator or to 14 × 17 inches (35 × 43 cm) when a full abdomen image is requested. Ensure SI joints are included. Place side marker in the collimated light field.

Shielding: Use gonad shielding for males. Shield females only if shield will not interfere with purpose of examination. Consider PA projection for reduced ovarian dose.

Patient instruction: Do not move. Suspend breathing on expiration.

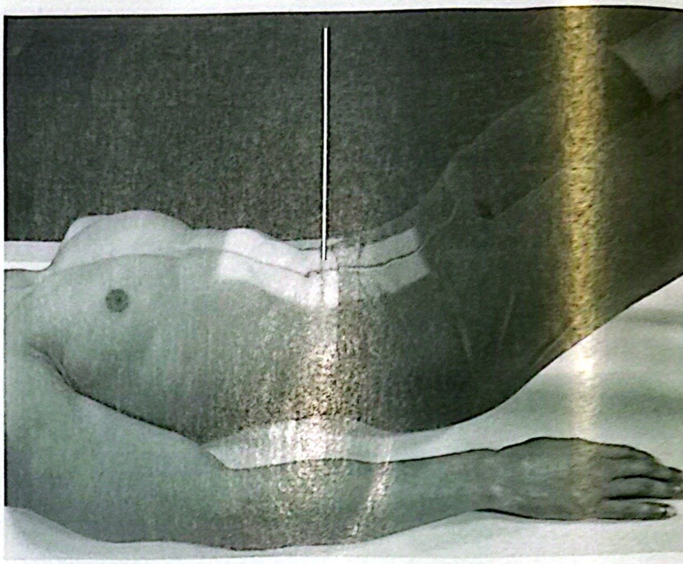

Fig. 15.49 Lumbar spine. Position for AP projection, patient recumbent. Note close collimation, which improves image quality and reduces patient exposure.

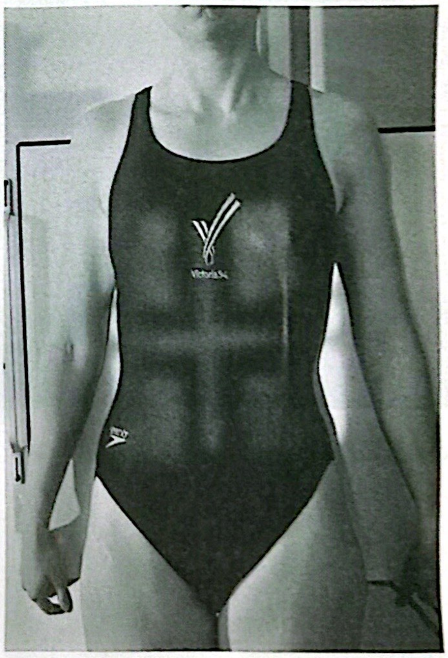

Fig. 15.50 Lumbar spine. Position for AP projection, patient upright. Note wide collimation to include entire abdomen.

Structures seen: All five lumbar vertebrae, intervertebral disk spaces, proximal portion of sacrum, and SI joints. This projection demonstrates the bodies, disk spaces, and transverse processes. The pedicles are seen on end. When a 35- × 43-cm IR is used, central pelvis and hip joints may be visualized if collimation is not too close (Figs. 15.51 and 15.52). Visualization of hip joints is particularly important to demonstrate pelvic tilt when an upright AP projection is taken.

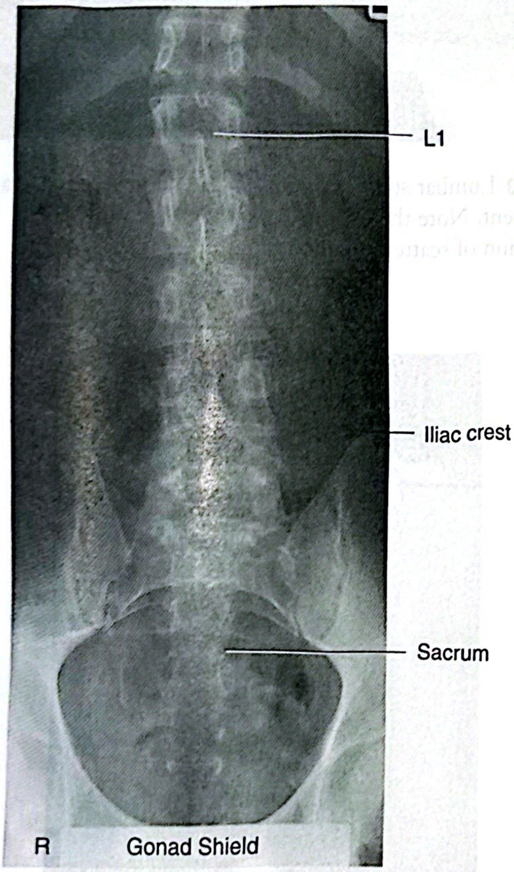

Fig. 15.51 Lumbar spine. AP projection, patient recumbent with knees flexed.

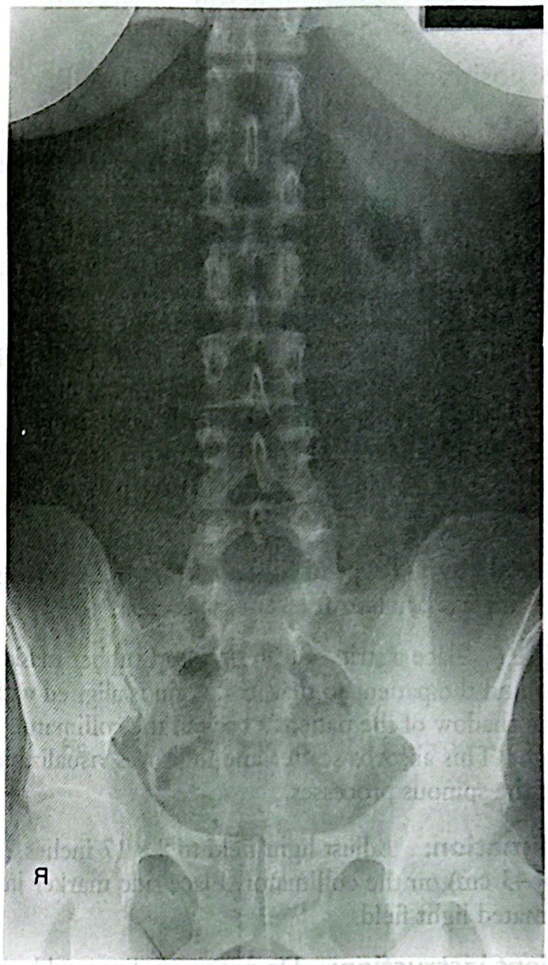

Fig. 15.52 Lumbar spine. PA projection, patient recumbent (same patient as Fig. 15.51). Note widening of intervertebral disk spaces and magnification of sacrum.

LATERAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14 × 17 inches (35 × 43 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Standing or recumbent.

Part position: Sagittal plane is parallel to IR.

Recumbent: In lateral recumbent position, spine is aligned parallel to center of Bucky with arms anterior to body. Radiolucent sponges may be used to elevate waist and/or hip to keep spine level (Fig. 15.53). Knees are flexed. A pad between knees helps keep pelvis lateral and maintain lateral position of spine.

Upright: Feet are shoulder-width apart with equal weight bearing, and torso is stabilized against upright IR holder. Arms are crossed over chest with hands supported on shoulders. Alternatively, arms may be supported out of radiation field by having patient grasp a pole (Fig. 15.54).

Central ray: Perpendicular to center of IR through L4, in midaxillary line at level of iliac crest.

> **TIP:** Place a strip of lead or a lead rubber mask behind the patient so that its margin is aligned with the shadow of the patient's back in the collimator light. This absorbs scatter and improves visualization of the spinous processes.

Collimation: Adjust light field to 8 × 17 inches (20 × 43 cm) on the collimator. Place side marker in the collimated light field.

Patient instruction: Do not move. Suspend breathing on expiration. (Respiratory phase is particularly important on the lateral projection. If exposed on inspiration, the posterior lung fields will superimpose the body of L1.)

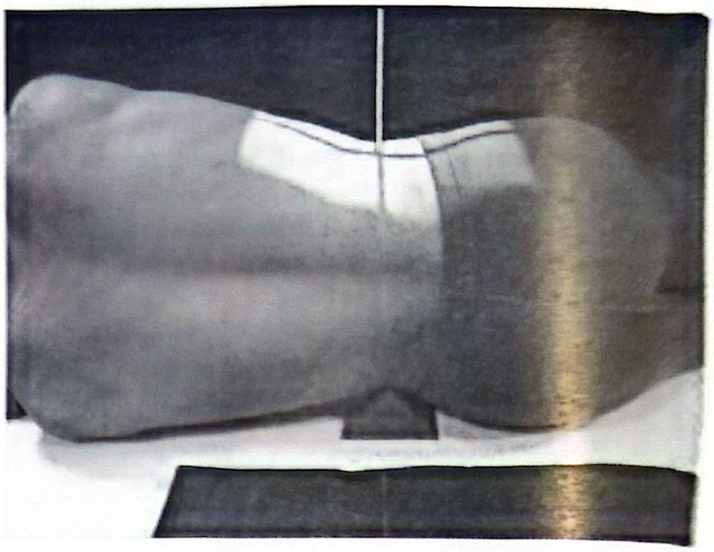

Fig. 15.53 Lumbar spine. Position for lateral projection, patient recumbent. Note the lead strip placed on the table for absorption of scatter radiation.

Fig. 15.54 Lumbar spine. Position for lateral projection, patient upright.

Structures seen: All five lumbar vertebrae and superior half of sacrum, including intervertebral foramina, spinous processes and profile of the bodies, and intervertebral disk spaces (Fig. 15.55).

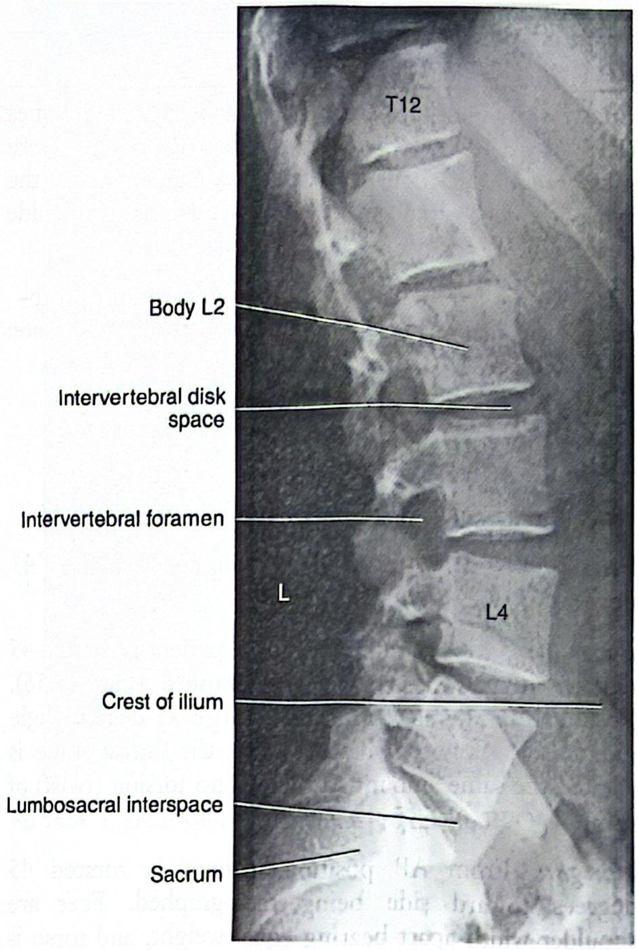

Fig. 15.55 Lumbar spine. Lateral projection.

SUPPLEMENTAL PROJECTIONS

AP OBLIQUE PROJECTION

Bilateral oblique projections are taken. AP obliques (RPO and LPO positions), rather than PA obliques, are most commonly done because they demonstrate the zygapophyseal joints and pars interarticularis of the side nearest the IR, providing better detail.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14 × 17 inches (35 × 43 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Standing or recumbent.

Part position: Sagittal plane is aligned at angle of 45 degrees to IR.

Recumbent: From supine position, patient is rotated 45 degrees toward side being radiographed (Fig. 15.56). Position may be supported by a large 45-degree-angle radiolucent sponge. Take care that the entire spine is rotated the same amount so there is no torsion (twist) of spine.

Upright: From AP position, patient is rotated 45 degrees toward side being radiographed. Feet are shoulder-width apart bearing equal weight, and torso is stabilized against upright IR holder (Fig. 15.57).

Central ray: Perpendicular to center of IR through L3. Central ray enters at point 2 inches medial to anterior superior iliac spine (ASIS) farthest from IR and 1.5 inches superior to iliac crest.

Collimation: Adjust light field to 9 × 14 inches (23 × 35 cm) on the collimator. Place side marker in the collimated light field.

Shielding: Although gonad shielding is shown in Fig. 15.56, it is not recommended if the lower lumbar spine is of clinical interest.

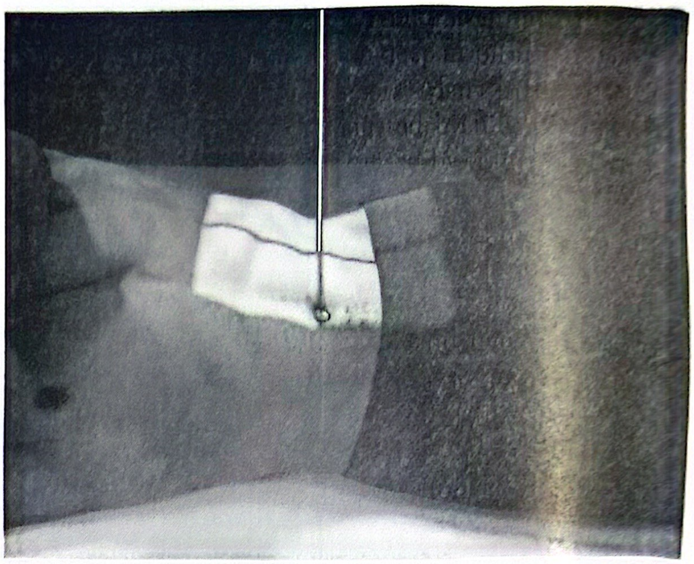

Fig. 15.56 Lumbar spine. Position for AP oblique projection, RPO position, patient recumbent.

Fig. 15.57 Lumbar spine. Position for AP oblique projection, RPO position, patient upright.

Patient instruction: Do not move. Suspend breathing on expiration.

Structures seen: All five lumbar vertebrae and upper portion of sacrum, including zygapophyseal joints and pars interarticularis on the side nearest the IR (Fig. 15.58).

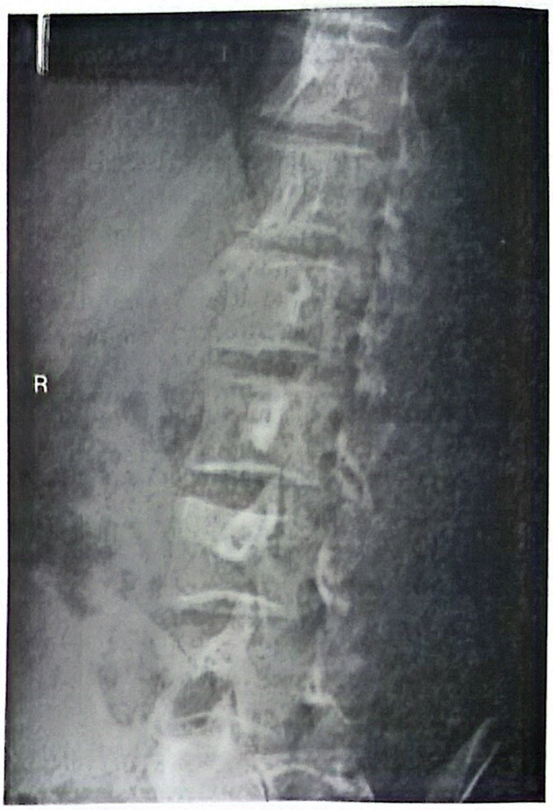

Fig. 15.58 Lumbar spine. AP oblique projection, RPO position.

LATERAL PROJECTION OF L5–S1 LUMBOSACRAL JUNCTION

A coned-down radiograph of the lumbosacral junction in the lateral projection is helpful when there is poor visualization of this area on the routine lateral projection. This may occur as a result of insufficient penetration of this dense area. This projection is important because this junction is a common site of chronic low back pain. Although this projection may be taken with the patient upright, the result is usually superior when the patient is recumbent.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: As for routine lateral lumbar projection, with care taken that spine is parallel to IR (Fig. 15.59).

Central ray: Directed perpendicular to center of IR through lumbosacral joint. This centering point is 2 inches posterior to ASIS and 1.5 inches inferior to iliac crest on coronal line midway between ASIS and posterior prominence of sacrum. When spine cannot be supported, angle 5 degrees caudad for males and 8 degrees caudad for females.

Collimation: Adjust light field to 5 × 5 inches in the center of the IR. Place side marker in the collimated light field.

Patient instruction: Do not move. Suspend breathing on expiration.

Structures seen: The lower one or two lumbar vertebrae, the upper sacrum, and an open lumbosacral junction (Fig. 15.60).

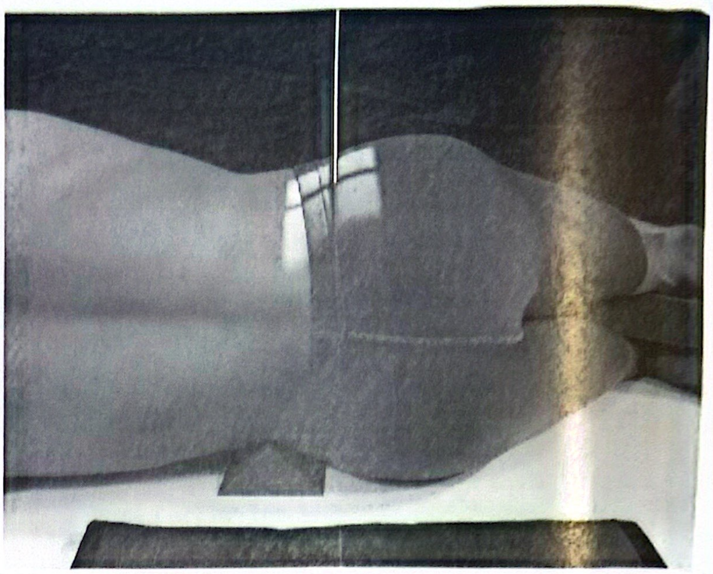

Fig. 15.59 L5–S1 Lumbosacral junction. Position for lateral projection.

Fig. 15.60 L5–S1 Lumbosacral junction. Lateral projection.

Lumbar Spine and Sacroiliac Joints

AP AXIAL PROJECTION OF LUMBOSACRAL JUNCTION AND SACROILIAC JOINTS

Because of the sacral base angle, the lumbosacral junction is not well seen on the routine AP projection of the lumbar spine. The AP axial projection directs the central ray parallel to the sacral base. See Table 15.1 for variations in sacral base angle. This projection is also useful for demonstration of the SI joints.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Supine, as for AP recumbent lumbar spine, with knees flexed and supported.

Central ray: Angled 30 degrees cephalad for males and 35 degrees cephalad for females. It is directed to center of IR through lumbosacral junction (Fig. 15.61). Central ray enters in midline, 1 inch inferior to the ASIS (Fig. 15.62).

Collimation: Adjust light field to 8 × 10 inches (18 × 24 cm) on the collimator. Place side marker in the collimated light field.

Shielding: Gonad shielding for males. Ovarian shielding would interfere with purpose of examination.

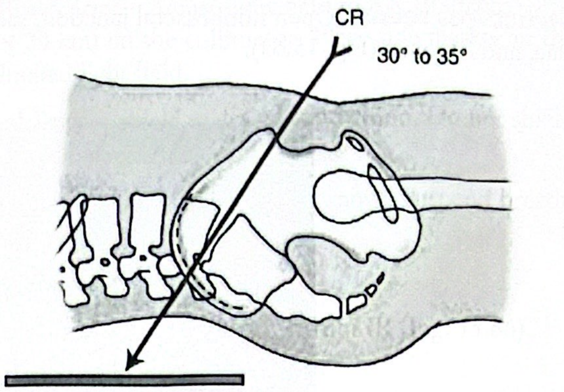

Fig. 15.61 Alignment of central ray *(CR)* for AP axial projection of lumbosacral junction and sacroiliac joints.

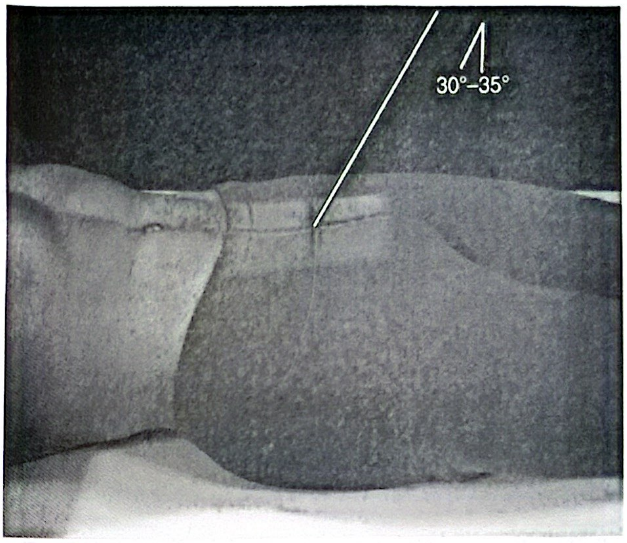

Fig. 15.62 Lumbosacral junction and sacroiliac joints. Position for AP axial projection.

Structures seen: Open lumbosacral junction, sacral alae, and SI joints (Fig. 15.63).

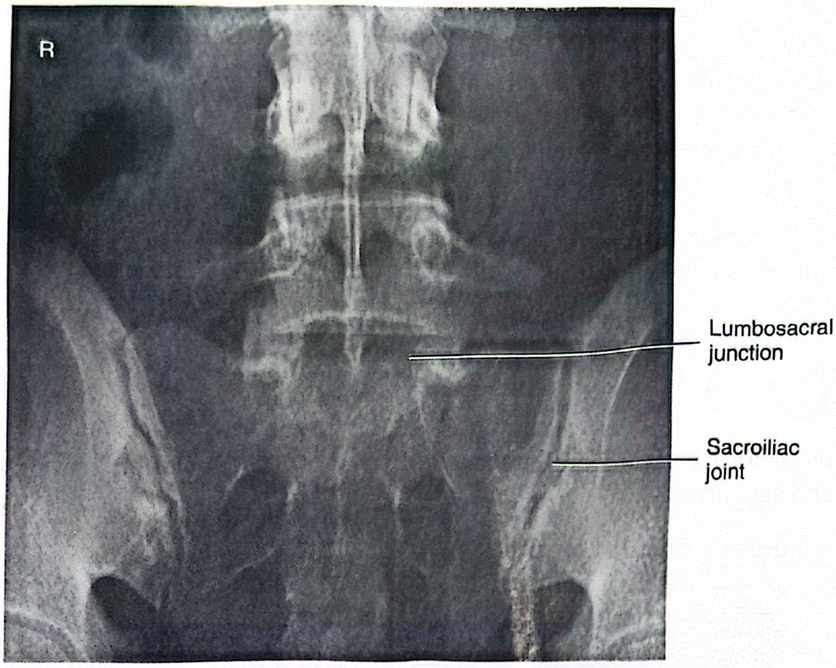

Fig. 15.63 L5–S1 Lumbosacral junction and sacroiliac joints. AP axial projection.

Sacroiliac Joints

ROUTINE EXAMINATION

The routine examination of the SI joints includes the AP oblique projections. The AP axial projection of the lumbosacral junction and the SI joints may also be included.

AP OBLIQUE PROJECTION

Bilateral AP oblique projections are usually taken for comparison.

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Recumbent.

Part position:

AP obliques (RPO, LPO positions): From supine position, body is rotated so that coronal plane is aligned at angle of 25 to 30 degrees to IR (Fig. 15.64). The side of interest is elevated, furthest from IR (Fig. 15.65). Position may be supported by radiolucent sponge under hip and lumbar area of elevated side. Take care the entire spine is rotated the same amount so that there is no torsion of spine.

PA obliques (RAO, LAO positions): From prone position, body is rotated so that coronal plane is aligned at angle of 25 to 30 degrees to IR. Side of interest is nearest the IR. This position may be supported by radiolucent sponge under hip and abdomen area on opposite side. Take care the entire spine is rotated the same amount so that there is no torsion of spine.

Central ray:

AP obliques: Perpendicular to center of IR through point 1 inch medial to ASIS farthest from IR.

PA obliques: Perpendicular to center of IR through point 1 inch medial to ASIS nearest the IR.

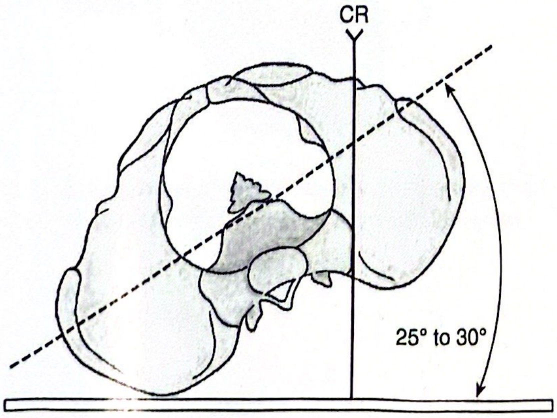

Fig. 15.64 When coronal plane is aligned to IR at a 25- to 30-degree angle, perpendicular central ray *(CR)* passes through sacroiliac joint on elevated side.

Collimation: Adjust light field to 8 × 10 inches (18 × 24 cm) on the collimator. Place side marker in the collimated light field.

Shielding: Shield males with precision. Do not shield females.

Patient instruction: Do not move. Suspend breathing on expiration.

Structures seen:

AP obliques: SI joint farthest from IR (Fig. 15.66).

PA obliques: SI joint nearest IR.

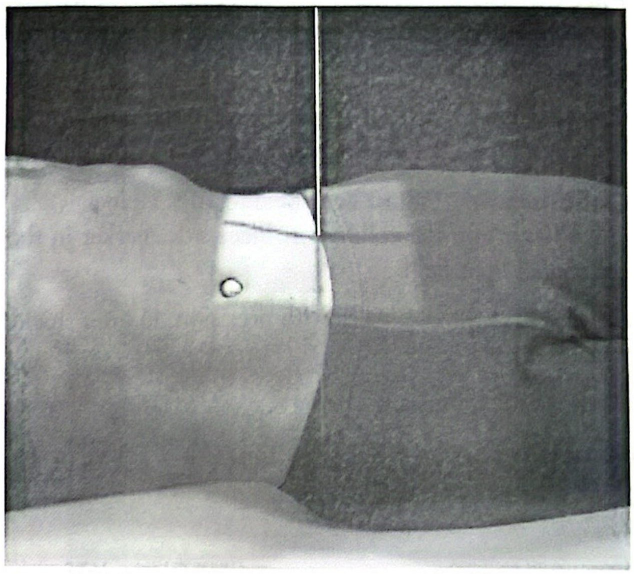

Fig. 15.65 Sacroiliac joint. Position for AP oblique projection, RPO position.

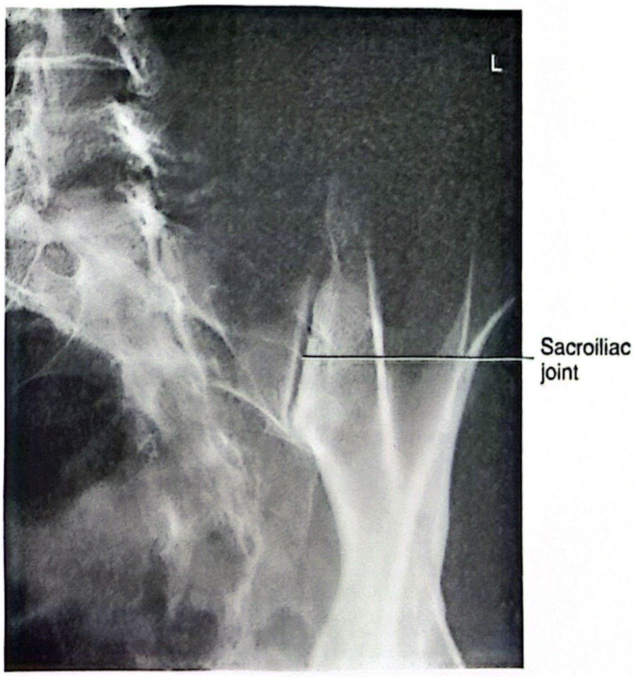

Fig. 15.66 Sacroiliac (SI) joint. AP oblique projection, RPO position, demonstrating left SI joint.

Sacrum

ROUTINE EXAMINATION

The routine examination of the sacrum includes the AP axial and lateral projections.

AP AXIAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 10 × 12 inches (24 × 30 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Recumbent or supine.

Part position: Midsagittal plane is perpendicular to IR and centered to it. Knees are flexed and supported with a bolster, if needed.

Central ray: Angled 15 degrees cephalad to enter body at midline, 1 inch inferior to the ASIS (Fig. 15.67).

Collimation: Adjust light field to 10 × 12 inches (24 × 30 cm) on the collimator. Place side marker in the collimated light field.

Shielding: Shield males with precision. Do not shield females.

Patient instruction: Stop breathing. Do not move.

Structures seen: Entire sacrum and SI articulations (Fig. 15.68).

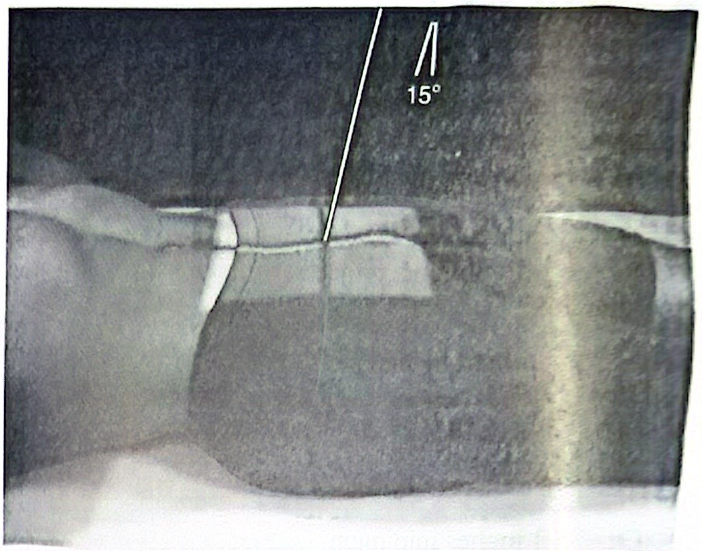

Fig. 15.67 Sacrum. Position for AP axial projection.

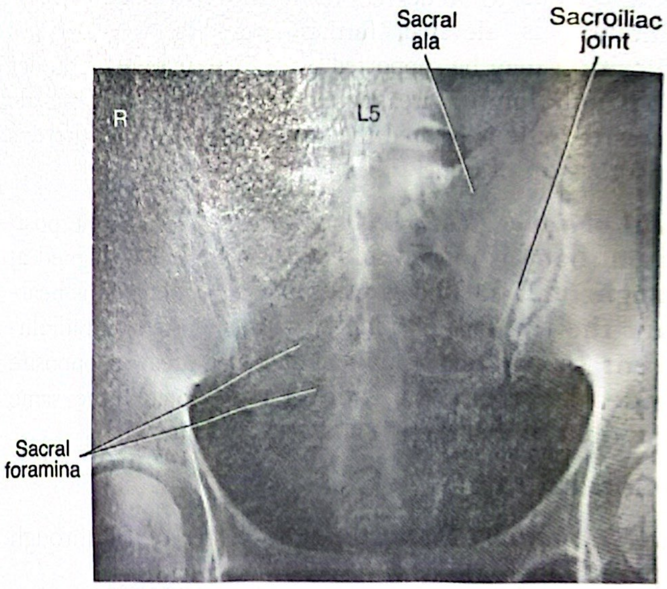

Fig. 15.68 Sacrum. AP axial projection.

LATERAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 10 × 12 inches (24 × 30 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Recumbent.

Part position: Sagittal plane is parallel to IR.

Recumbent: Spine is aligned parallel to center of Bucky with arms anterior to body. Radiolucent sponges may be used to elevate waist and/or hips to keep spine level (Fig. 15.69). Knees are flexed. A pad between knees helps maintain lateral position of pelvis and spine.

Central ray: Perpendicular to center of IR through center of sacrum. Central ray enters at point 3.5 inches posterior to ASIS (Fig. 15.70).

> **TIP:** Place a strip of lead or a lead rubber mask behind the patient so that its margin is aligned with the shadow of the patient's back in the collimator light. This absorbs backscatter and improves contrast resolution of the sacrum image.

Collimation: Adjust light field to 10 × 12 inches (24 × 30 cm) on the collimator. Place side marker in the collimated light field.

Patient instruction: Do not move. Suspend breathing on expiration.

Structures seen: Entire sacrum and lumbosacral junction (Fig. 15.71). Coccyx is sometimes seen.

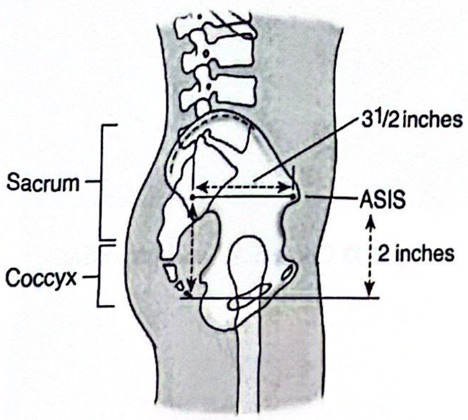

Fig. 15.69 Localization of sacrum and coccyx in relation to palpable landmarks. *ASIS,* Anterior superior iliac spine.

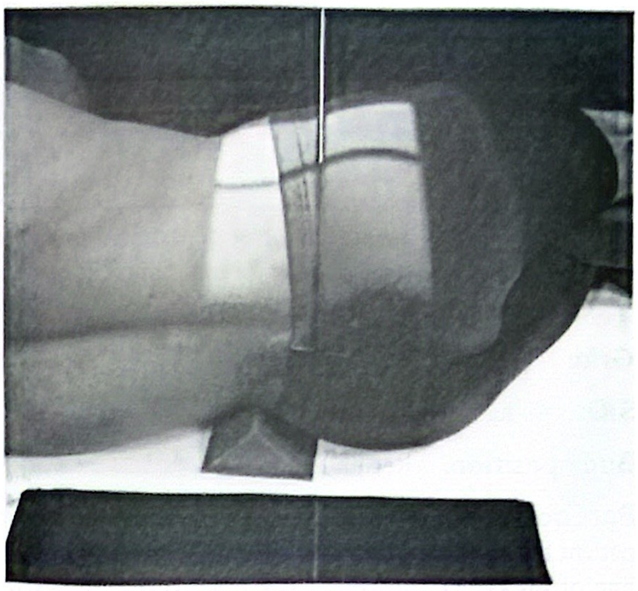

Fig. 15.70 Sacrum. Position for lateral projection.

Fig. 15.71 Sacrum. Lateral projection.

Coccyx

ROUTINE EXAMINATION

The routine examination of the coccyx includes the AP axial and lateral projections.

AP AXIAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Recumbent.

Part position: Coronal plane is parallel to IR with patient facing tube. Midsagittal plane is centered to midline of Bucky. When patient is supine, knees are flexed and supported with a bolster, if needed.

Central ray: Angled 10 degrees caudad to enter body in midline, 1 inch inferior to the ASIS (Fig. 15.72).

Collimation: Adjust light field to 6 × 8 inches (15 × 20 cm) on the collimator. Close collimation is required for adequate visualization. Place side marker in the collimated light field.

Shielding: Precise gonad shielding for males. Do not shield females.

Patient instruction: Do not move.

Structures seen: Entire coccyx and distal portion of sacrum (Fig. 15.73).

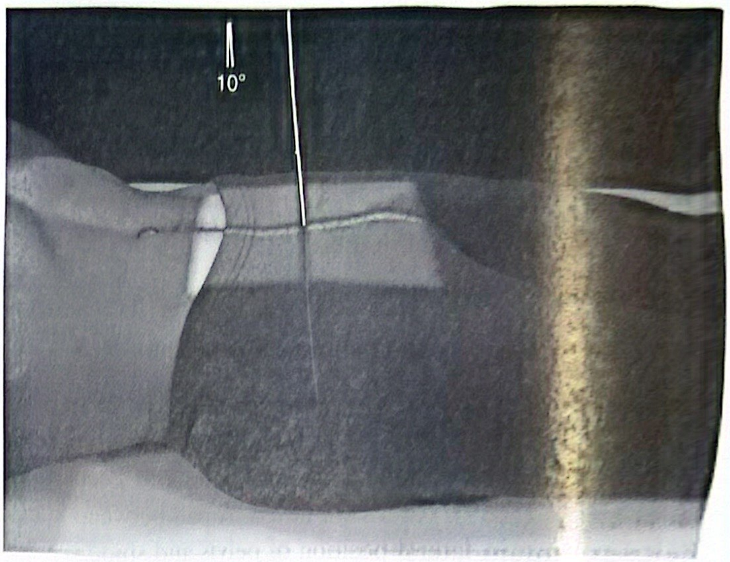

Fig. 15.72 Coccyx. Position for AP axial projection.

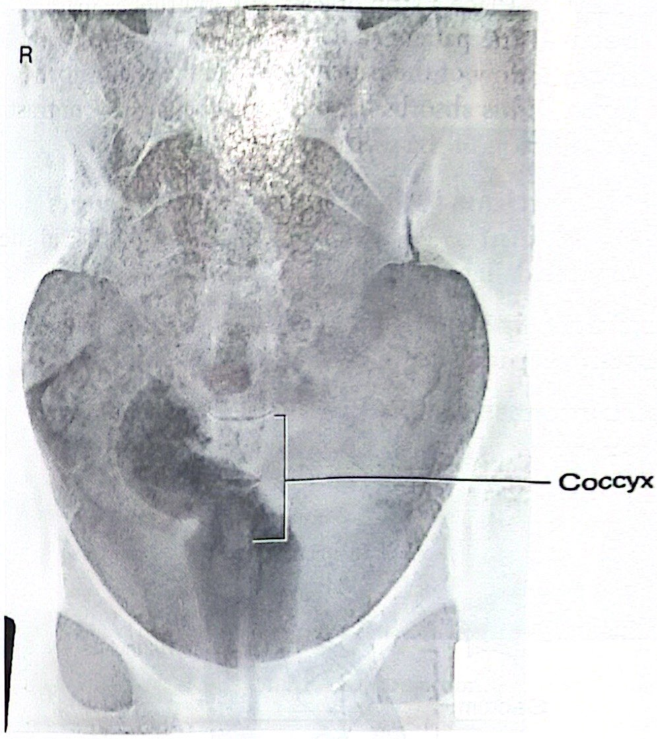

Fig. 15.73 Coccyx. AP axial projection.

LATERAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 8 × 10 inches (18 × 24 cm) lengthwise

Grid: Yes

SID: 40 inches minimum

Body position: Recumbent.

Part position: Sagittal plane is parallel to IR. When patient is recumbent, knees are flexed and may be separated by a sponge or cushion (Fig. 15.74).

Central ray: Perpendicular to center of IR through center of coccyx. Central ray enters at point 2 inches inferior to ASIS level and 3.5 inches posterior to ASIS.

> **TIP:** Place a strip of lead or a lead rubber mask behind the patient so that its margin is aligned to the shadow of the patient's back in the collimator light. This absorbs backscatter and improves contrast resolution of the coccyx image.

Collimation: Adjust light field to 6 × 8 inches (15 × 20 cm) on the collimator. Place side marker in the collimated light field.

Shielding: Precise gonad shielding for males. Do not shield females.

Patient instruction: Do not move.

Structures seen: Entire coccyx and distal portion of sacrum (Fig. 15.75).

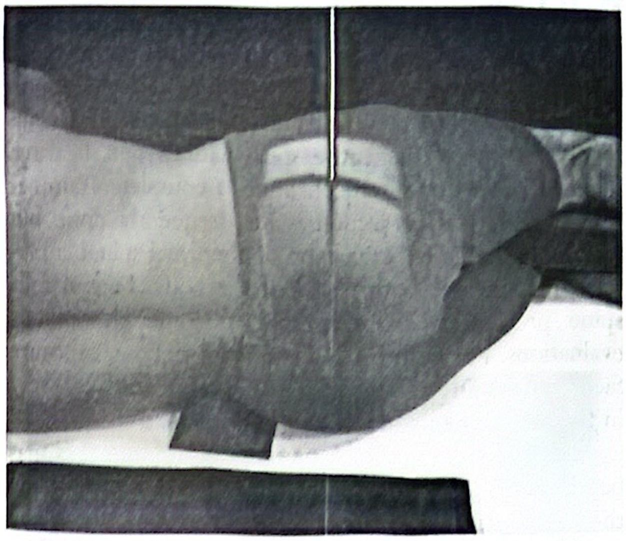

Fig. 15.74 Coccyx. Position for lateral projection.

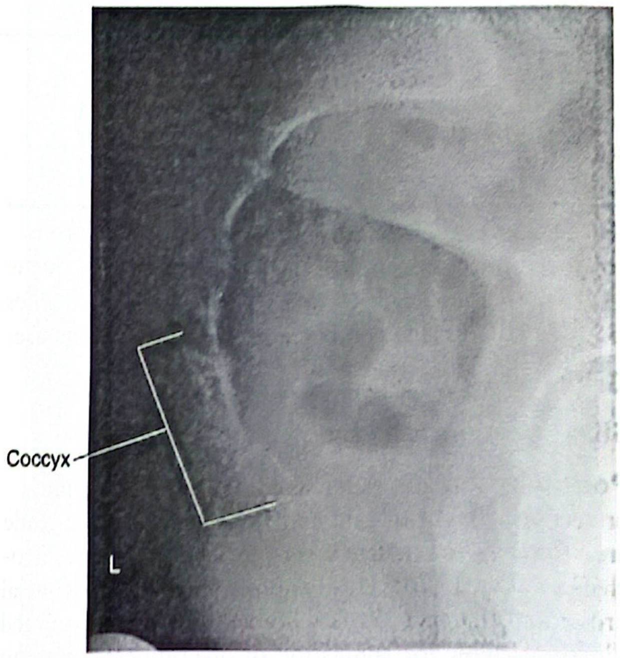

Fig. 15.75 Coccyx. Lateral projection.

Full Spine

It is sometimes desirable to demonstrate the entire spinal column on one image. This is useful for the evaluation of scoliosis. It is also used by some chiropractic physicians for evaluation of the entire spine with weight bearing. The PA projection often constitutes a complete examination. The lateral projection is less frequently done but may be desirable for evaluation of abnormal spinal curvatures that involve both planes of the body. Lateral full-spine projections are also used in some chiropractic evaluations. For both PA and lateral projections, exposure factors are adjusted for appropriate radiographic density in the lumbar region at the required distance.

The method described on the following pages has been endorsed by the American College of Radiology, the Academy of Orthopedic Physicians, and the Center for Development and Radiation Health of the US Department of Health and Human Services. Endorsements include use of the PA projection, compensating filters, and lateral breast protection.

Because of significant differences in thickness and tissue density between the cervical region and the lumbar region, some means is necessary to provide even radiographic density throughout the spine with a single exposure. This is best accomplished by using compensating filters to reduce the exposure to the cervical and upper thoracic areas.

Because patients who require this procedure must often be radiographed repeatedly, care is taken to shield sensitive tissue, such as the gonads, the breasts, the thyroid gland, and the eyes. *The PA projection is preferred for this reason.* Idiopathic scoliosis (scoliosis of unknown cause) most often affects females, beginning with the onset of puberty. The prognosis for successful treatment is determined in large part by the degree to which the girl is still growing. This is evaluated by assessment of the growth plate along the rim of the iliac crest. For this reason, collimation in the pelvic region must be wide enough to include the iliac crests bilaterally.

PA OR AP PROJECTION (FRANK ET AL. METHOD)

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14×36 inches (35×90 cm), or 14×34 inches (35×86 cm) if using computed radiography, lengthwise

Grid: Yes

SID: 60 inches minimum

Position: Upright as for standing PA lumbar spine projection. Height of grid and IR is adjusted to include area from top of patient's ears to level of greater trochanters (Fig. 15.76). Head is positioned as for AP axial projection of upper cervical spine, with neck extended slightly to allow for angulation of diverging x-ray beam at upper extreme of exposure field.

Central ray: Aligned perpendicular to center of IR, entering at midline approximately at level of xiphoid process.

Shielding: Lead aprons (see Fig. 15.76), upright shield stands, or shadow shield devices that attach to collimator.

Collimation: Adjust light field wide enough, usually 12 inches (30 cm), in pelvic region to include iliac crests bilaterally and full length of IR. Place side marker in the collimated light field.

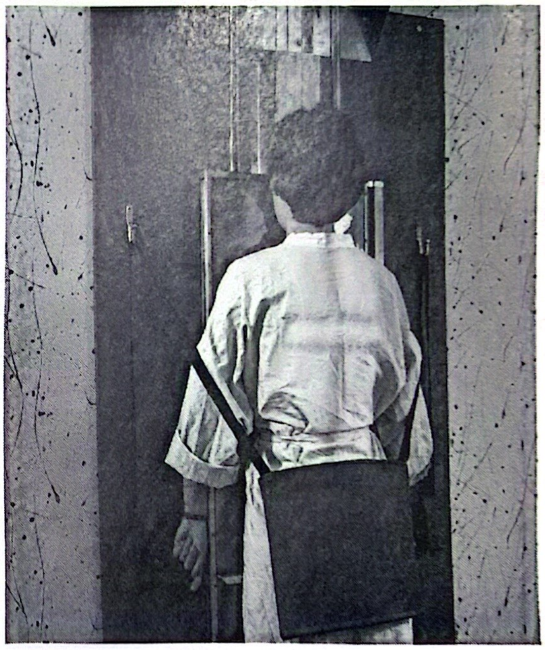

Fig. 15.76 Full spine. Position for PA projection.

Patient instruction: Stop breathing. Do not move.

Structures seen: Portion of mandible, entire spine, portion of pelvis (Figs. 15.77 and 15.78).

Compensating filter: The wide range of body part thicknesses and tissue densities in the thoracic and abdominal areas necessitates the use of specially designed compensating filters to create a more uniform radiographic brightness throughout the entire spine.

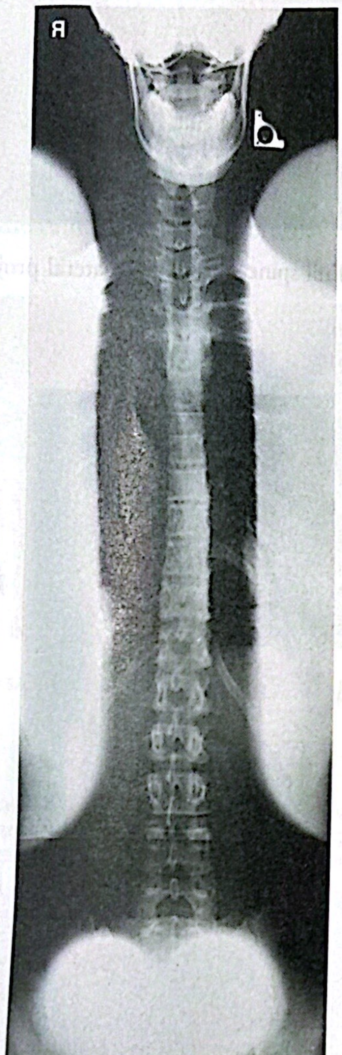

Fig. 15.77 Full spine. PA projection with breast and gonad shielding.

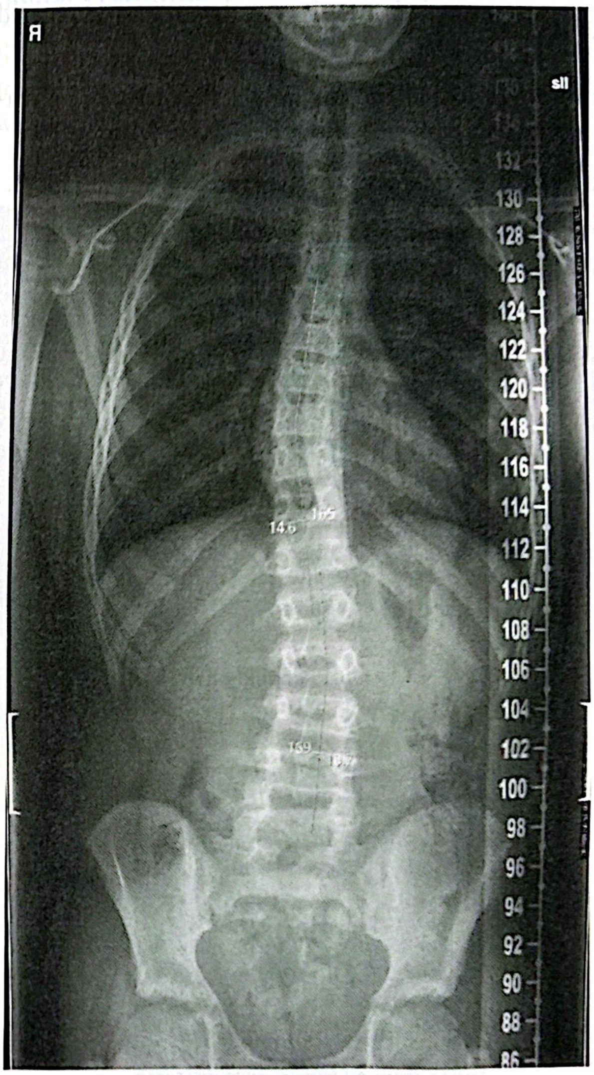

Fig. 15.78 Full spine. Image was made using two CR imaging plates and computer software to "stitch" the images together.

LATERAL PROJECTION

IR: Positioned by manufacturer or department protocol for proper anatomy display orientation; CR plate: 14 × 36 inches (35 × 90 cm), or 14 × 34 inches (35 × 86 cm) if using computed radiography, lengthwise

Grid: Yes

SID: 60 inches minimum

Position: Same as for upright lateral projection of thoracic spine. Shoulders are rounded anteriorly and arms are extended anterior to body and supported (Fig. 15.79).

Shielding: Lead aprons, upright shield stands, or shadow shield devices that attach to collimator.

Patient instruction: Stop breathing. Do not move.

Structures seen: Portion of mandible and skull, entire spine, portion of pelvis (Fig. 15.80).

Compensating filter: The wide range of body part thicknesses and tissue densities in the thoracic and abdominal areas necessitates the use of specially designed compensating filters to create a more uniform radiographic density (brightness) throughout the entire spine.

Fig. 15.79 Full spine. Position for lateral projection.

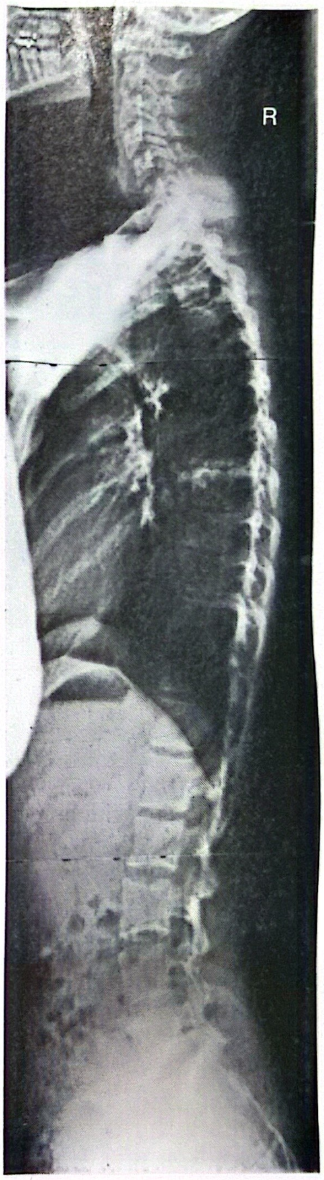

Fig. 15.80 Full spine. Lateral projection.

PATHOLOGY

Congenital Anomalies

The spine is a common site for congenital anomalies and deformities. A transitional vertebra occurs when a vertebra of one spinal region takes on characteristics of the adjacent region. For example, anomalous ribs sometimes occur on C7 (Fig. 15.81) or L1. Sometimes one or both spinous processes of L5 become fused to the sacrum (Fig. 15.82). This is called *sacralization of L5*. Occasionally there will be an extra vertebra in one region. This may or may not be accompanied by the lack of a vertebral segment in the adjacent region. For example, some individuals have six lumbar vertebrae. Often, this is the result of "lumbarization" of the first sacral segment resulting from its failure to fuse with the remainder of the sacrum.

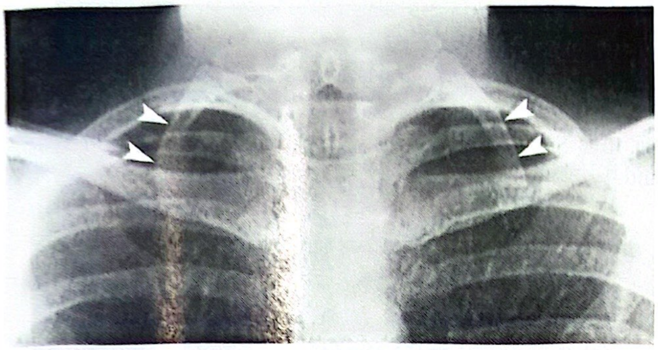

Fig. 15.81 Bilateral cervical ribs *(arrowheads)*.

Fig. 15.82 Unilateral sacralization of L5. There is a normal transverse process on the left, but on the right the transverse process is enlarged and fused with the sacrum.

Another congenital deformity of the spine is spina bifida, which results when the posterior portions of the neural arches fail to close during development of the embryo. Usually spina bifida is relatively insignificant and produces no symptoms, in which case it is called *spina bifida occulta*. It is most commonly seen at L5 (Fig. 15.83). Less commonly, the defect may be quite large, leaving the spinal cord unprotected; the condition is then termed *spina bifida vera* (Fig. 15.84).

Spinal Fractures

Spinal fractures may result from trauma. Fractures of vertebral bodies are often compression fractures with anterior wedging. Fig. 15.85 shows a lumbar fracture that involves

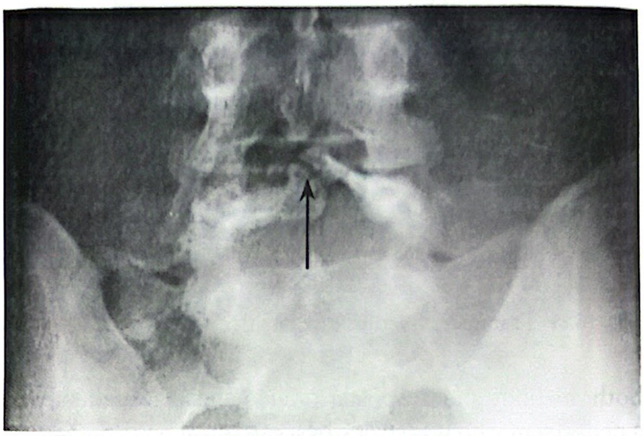

Fig. 15.83 Spina bifida occulta of L5 *(arrow)*.

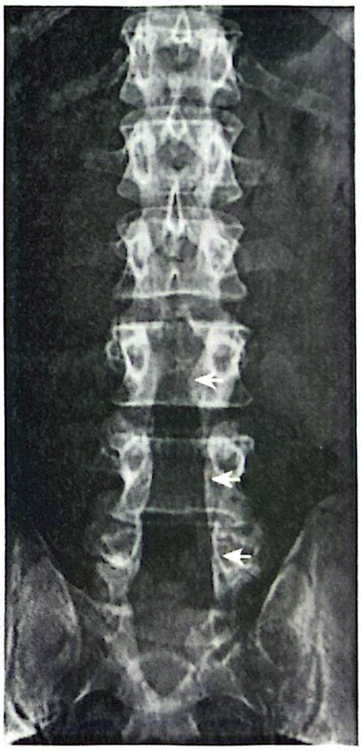

Fig. 15.84 Spina bifida vera *(arrows)*. The dark area involving L3 through L5 and the proximal sacrum is caused by congenital absence of portions of the posterior elements of the spine.

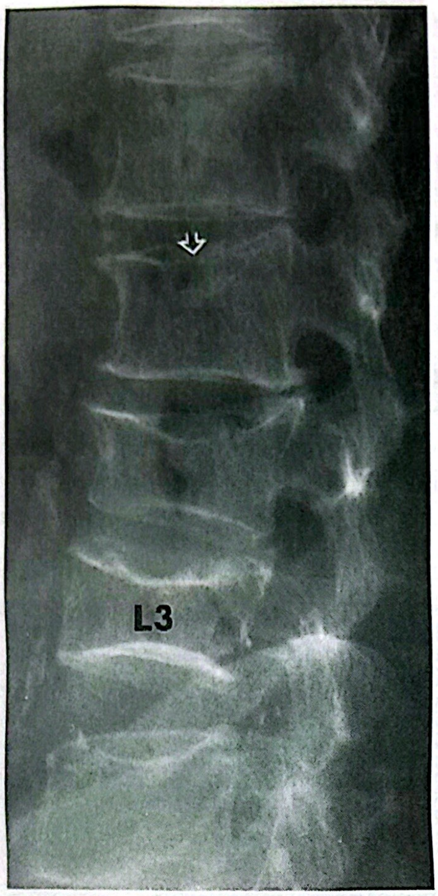

Fig. 15.85 Traumatic fracture of L1 with displacement *(arrow)*.

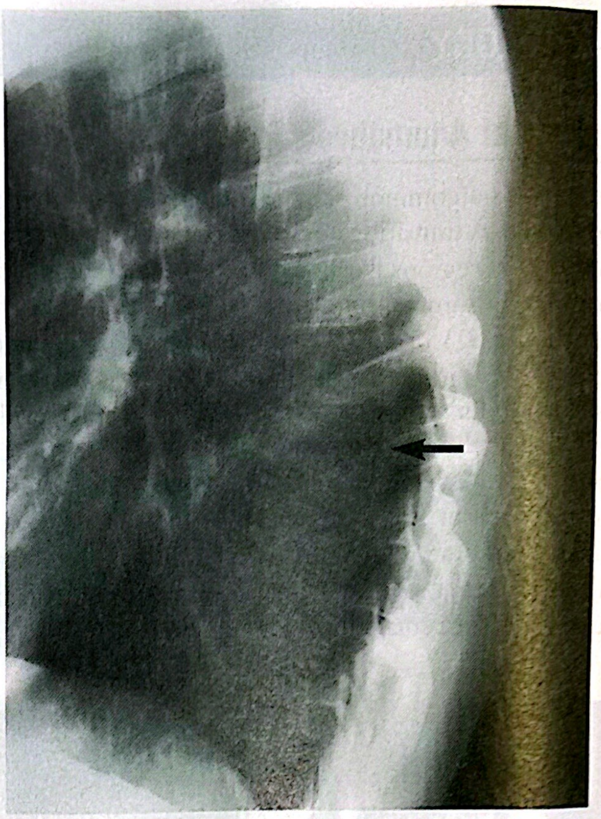

Fig. 15.86 Senile osteoporosis with partial collapse of T8 *(arrow)* and T10.

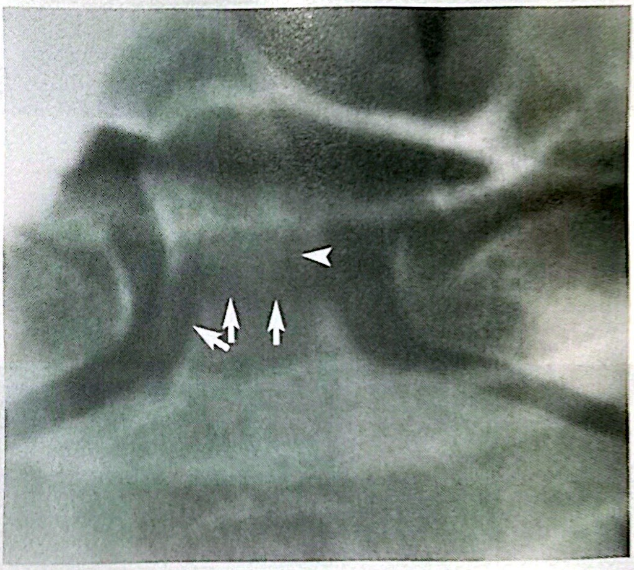

Fig. 15.87 Combined transverse *(arrows)* and oblique *(arrowhead)* fracture of the odontoid process.

both the body and the posterior elements. The patient was a pedestrian who was struck by a car.

In bones weakened by disease processes, fractures may occur with little or no trauma. These are called *pathologic fractures*. Pathologic compression fractures of the thoracic spine caused by osteoporosis are often seen in elderly women (Fig. 15.86).

Several fractures of the cervical spine are illustrated in Figs. 15.87, 15.88, and 15.89. These radiographs also illustrate the importance of demonstrating all of C7 on lateral projections and of obtaining a high-quality radiograph of the atlas and axis in the AP projection. Unstable or displaced fractures of the cervical spine may cause pressure on the spinal cord. Spinal cord pressure, particularly in the cervical region, may cause paralysis and may also be life threatening.

Spondylosis, Spondylitis, Spondylolysis, Spondylolisthesis, and Spondyloschisis

Spondylosis, *spondylitis*, *spondylolysis*, *spondylolisthesis*, and *spondyloschisis* refer to very different conditions, but the words look and sound very much alike. They all have the same root, *spondylo-*, which simply means "vertebra."

Spondylosis refers to fixation or fusion of vertebrae.

Spondylitis has the suffix *-itis*, which you may recall indicates inflammation. This term is often applied specifically to tuberculous disease of the vertebrae, which is also called *Pott disease*. Spondylitis is also seen with rheumatoid arthritis.

Spondylolysis refers to the breakdown of the structure of the bone. This occurs with osteoporosis, with some metastatic lesions, and with other conditions that cause atrophy and bony destruction.

Spondylolisthesis refers to the anterior displacement of one vertebra on another (Fig. 15.90). It occurs most commonly at the lumbosacral joint and is usually

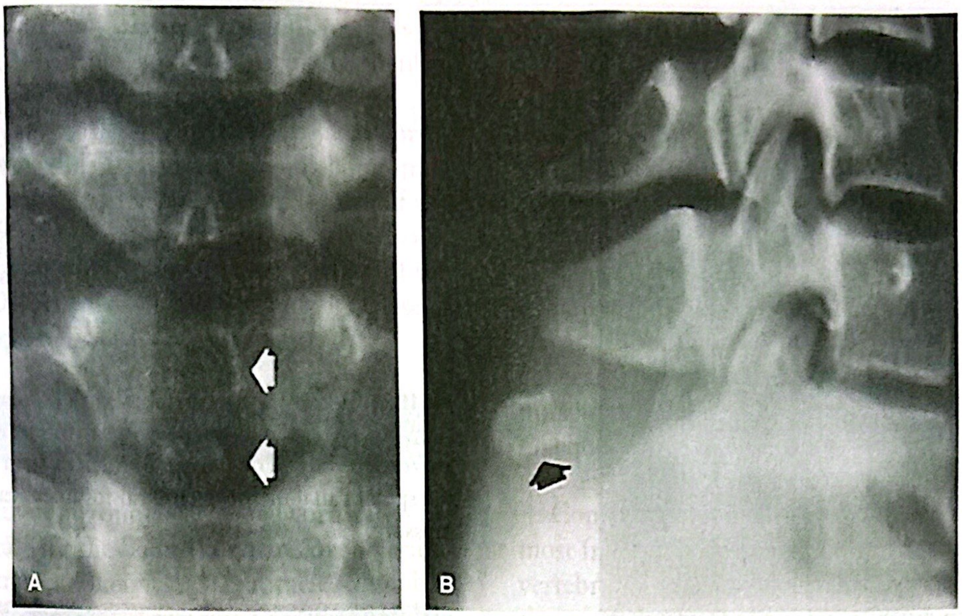

Fig. 15.88 Clay shoveler's fracture, an avulsion of the spinous process of C7. (A) AP projection shows the classic "double spinous process" sign *(arrows)*. (B) Avulsed fragment is clearly seen on the lateral projection *(arrow)*.

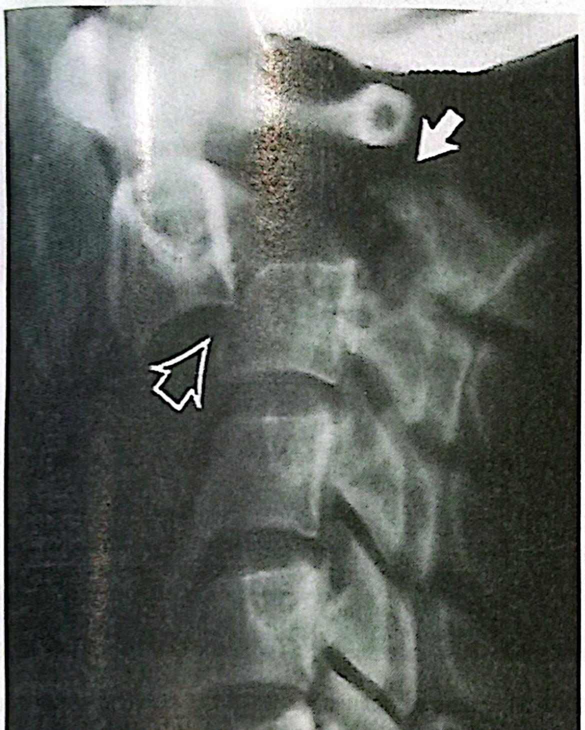

Fig. 15.89 Hangman's fracture is a fracture of the neural arch of C2 *(solid arrow)* with associated subluxation of C2–C3 *(open arrow)*.

caused by a defect or a fracture of the pars interarticularis or of the pedicle.

Spondyloschisis is the term for a congenital fissure (split or cleft) in the neural arch. Spina bifida occulta, discussed and illustrated earlier in this chapter, is an example of spondyloschisis.

Fig. 15.90 Spondylolisthesis of L5 and S1.

Disk Pathology

The pulpy center of intervertebral disks is normally gel-like, semiliquid, and very flexible. Its mass shifts to change the shape of the disk with the pressure of various spinal movements. With advancing age and repeated minor traumas to the spine, the disks tend to degenerate. The nucleus may dry out and become atrophied, which causes narrowing of the disk space. Without adequate cushioning, the joint becomes inflamed, and the surrounding bony structures show the characteristic signs of degeneration: sclerotic (hardened), irregular bone margins with hypertrophic lipping and spurring (Fig. 15.91). This condition is called *degenerative disk disease (DDD)* and is usually associated with osteoarthritis.

Fig. 15.91 Degenerative disk disease with associated arthritic changes. Note disk space narrowing and hypertrophic spurs on the anterior vertebral bodies. The dark linear shadows overlying two of the disks represent the "vacuum phenomenon" sometimes seen with severe disk degeneration.

Disk herniation or herniated nucleus pulposus (HNP) is the condition often called, in lay terms, a slipped disk.

The annulus fibrosus ruptures, and the nucleus is forced into the area posterior to the disk space (Fig. 15.92). The displaced nucleus causes pressure on the spinal cord and/or the nerve roots in this area.

Disk herniation is caused by trauma to the disk. In the lumbar area, it may be caused by pressure from lifting a heavy object. Herniated cervical disks are often the result of motor vehicle accidents. Disk herniation may cause acute pain, chronic discomfort, or recurrent painful episodes involving the site of the herniation. There may also be pain, numbness, or altered sensation in areas remote from the spine.

Although the radiographic examination may show a decrease in the height of the disk space, special imaging techniques are necessary to demonstrate disk herniation definitively. Myelography, discography, computed tomography, and magnetic resonance imaging studies (Fig. 15.93) may be used to identify disk pathology.

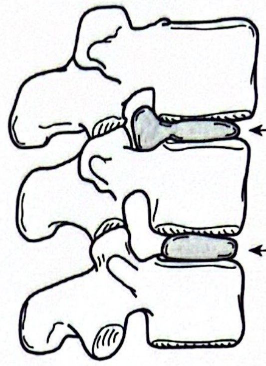

Fig. 15.92 When an intervertebral disk herniates, the annulus ruptures and the nucleus pulposus is forced out posteriorly and/or laterally. The herniated nucleus then occupies space in the spinal canal or intervertebral foramen, causing nerve pressure.

Fig. 15.93 Magnetic resonance image of the cervical spine in the sagittal plane shows herniation of the C4–C5 disk *(arrow)*. Note impression on the spinal cord.

Remote Symptoms of Spine Pathology

The nerves communicate messages of motion and sensation between the brain and all parts of the body by way of the spinal cord. The spinal cord is surrounded by the vertebral foramina, and nerves pass from the spinal cord to other parts of the body by way of the intervertebral foramina. This explains why changes in the vertebrae may cause symptoms in parts of the body remote from the spine. Such symptoms are indications of pressure on or irritation of the nerve roots.

Nerve root insult may cause pain, numbness, or altered sensation. Sciatica, for example, is pain along the path of the sciatic nerve in the buttock, posterior thigh, and leg. It is caused by nerve irritation in the lumbar region. Damage to nerve roots may cause weakness or paralysis. The function or control of organs may be affected as well. For example, nerves in the upper cervical region control vital functions such as breathing, and nerves in the lumbar region control bowel and urinary bladder function.

There are many possible causes of nerve root compression. Hypertrophic arthritic changes, such as bony spurs on the vertebrae, may cause **stenosis** (narrowing) of the intervertebral foramina. Misalignment of vertebrae, subluxation, or spondylolisthesis may cause crowding of the nerve pathways. Disk herniation is also a common cause of remote nerve symptoms.

SUMMARY

The vertebral column surrounds the spinal cord and is the supporting structure for the body. It consists of 33 vertebrae or spinal segments: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal. Most vertebrae consist of an anterior body, a posterior vertebral arch, two lateral projections called *transverse processes*, and a posterior projection called the *spinous process*. The joints between the vertebral bodies are cushioned by intervertebral disks. Zygapophyseal joints between the posterior elements facilitate motion. Each region of the spine has either a kyphotic or lordotic curvature.

Limited operators must be familiar with the landmarks used to locate center points and individual vertebrae in each region of the spine. The zygapophyseal joints and the intervertebral foramina of each spinal region vary in their relationships to body planes. The limited operator must be familiar with these relationships to demonstrate these structures accurately.

Most spine radiography may be done with the patient either upright or recumbent. All of the basic examinations of the spine consist of at least AP or PA and lateral projections. Oblique and axial projections and coned-down radiographs are frequently taken to supplement routine examinations.

Congenital anomalies are common in the spine. Those most frequently seen include extra vertebrae, transitional vertebrae, and anomalous ribs. Many pathologic conditions of the spine are diagnosed radiographically. Trauma may require radiographs to identify fractures or significant displacements. Degenerative, inflammatory, and neoplastic diseases also affect the spine and are evaluated with radiography. Some spinal conditions cause nerve symptoms in areas of the body remote from the spine.