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Diagnostic Imaging Journeyman

Volume 3. Osteology and Positioning

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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

This third of five volumes consists of nine units presenting topics related to osteology and positioning in the 4R051 Diagnostic Imaging Journeyman course. The information discussed within this volume is not intended to serve as a comprehensive positioning guide yet, it is designed to reinforce the fundamental knowledge that all Airmen should possess when striving for upgrade to 5 skill level (Journeyman). For a more comprehensive look into the topics discussed in this volume, there are many excellent civilian publications that discuss radiographic positioning in great detail. Most departments have at least one set of these publications available to aid you when an uncommon view is requested.

Unit 1 kicks things off with a discussion about the organization of the human body, basic anatomical terminology, and how to reference the various body planes and positions. In unit 1 section two, the discussion continues about basic osteology and arthrology topics to include skeletal structure, bone classification and formation, joint classification, and then finishes up with common fractures you can expect to image as an X-ray technologist.

Unit 2 dives into osteology of the extremities. Section one discusses the lower extremity and pelvic girdle while section two discusses the upper extremity and shoulder girdle.

Unit 3 continues the osteology discussion on the vertebral column and thorax regions. Section one focuses on the osteology of the vertebral column, section two speaks about the ribs and sternum, and section three talks about the respiratory system.

Unit 4, section one, discusses the osteology of the cranium while section two closes out the osteology discussion on facial bones and paranasal sinuses.

In units 5-9, the discussion switches gears and takes us away from the osteology side of the house to talk about many of the routine imaging positions and some of the typical additional radiographic positions commonly performed in Air Force Dianostic Imaging departments.

Unit 5 discusses positioning of the upper extremities. Positioning the upper extremity includes the fingers, hand, wrist, forearm, elbow, humerus, and shoulder.

Unit 6 discusses positioning of the Lower extremities. In this unit, we will cover many of the standard projections and a few additional projections that you will use when radiographing traumatic injuries to the lower extremities.

Unit 7 discusses positioning of the chest and abdomen. Radiography of the chest and abdomen represents probably the greatest percentage of the workload done in most radiology departments across the world.

Unit 8 discusses positioning of the vertebral column. In this unit, we will cover many of the routine and additional projections for the cervical, thoracic, and lumbar vertebral column regions as well as projections for the sacrum and coccyx.

Unit 9 discusses positioning of the skull and facial bones. Precise part positioning and central ray (CR) alignment are often critical in successful radiography of the skull and facial bones.

Foldout 1 is provided as a supplement to this volume for reference. The text will tell you when to use it.

A glossary is also included for your use.

Code numbers on figures are for preparing agency identification only.

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This volume is valued at 27 hours and 9 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Unit 1. Organization of the Body, Terminology, and Basic Osteology

WE BEGIN VOLUME THREE with a review of body organization, osteology, arthrology, and positioning as well as the terms associated with these topics. These topics are the foundation for our profession and the terms can easily be called the "jargon" we use to communicate with our colleagues on a technical level.

1–1. Organization of the Body and Anatomical Terminology

In order to have a clear discussion of osteology and positioning, we need to discuss how the human body is organized, the terminology used to describe a structure's relative location within the body, and its position in relationship to other adjacent structures.

401. Organization of the body

No matter whether building a house or understanding how the human body is constructed, there is always a foundation. Our foundation starts with a basic understanding of the anatomy and physiology of the human body as it correlates to the levels of organization and the systems of the body.

Anatomy and physiology

The study of human *anatomy* is the study of the individual structures of the body and their relationships among other structures. To break the word down a bit more, "ana" means up and "tomy" means process of cutting. In early days, human anatomy was studied only by dissecting or carefully cutting up the various body parts to study how they were put together and their relationship to adjacent structures. Today, much less barbaric means are needed. In fact, many diagnostic imaging methods are used to improve our knowledge of human anatomy. If anatomy is the study of body structures, then it is important for you to know that *physiology* is the study of how the body parts work. Never forget that the study of human anatomy and physiology are always connected because how a body part is put together directly effects how that said part is able to perform a specific function for the body.

Levels of organization in the human body

There are six levels of organization when trying to understand human body anatomy and physiology. The levels are chemical, cellular, tissue, organ, system, and organismal.

Chemical

The chemical level includes atoms and molecules. An atom is the smallest unit of matter and a molecule is two or more atoms joined together. Some atoms are essential for sustaining life: carbon, hydrogen, oxygen, nitrogen, phosphorus, calcium, and sulfur. Deoxyribonucleic acid (DNA) and glucose (commonly known as blood sugar) are two examples of molecules found in the human body.

Cellular

At this level, molecules combine to form cells. A cell is the basic structural and functional unit of an organism. They are the smallest living units in the body. Three types of common cells in the body are smooth muscle cells, nerve cells, and epithelial cells.

Tissue

This organizational level consists of grouping cells and the materials surrounding them that work together to perform a particular function. There are four basic tissue types in the body: epithelial, connective, muscle, and nervous tissue.

Organs

This level might very well be the most commonly recognized because most people can name the major organs of the body. An organ is a collection of two or more tissues joined together into a structural unit to serve a common function. Most organs like the stomach, heart, liver, lungs, brain, and eyes are easily recognizable because they have common and distinctive shapes.

System

The fifth level of structural organization in the body is system. A body system is two or more related organs that work together in the execution of a specific body function. An example is the respiratory system. The function of the respiratory system is breathing; the organs that make up the respiratory system are the pharynx, larynx, trachea, bronchi, lungs, and the diaphragm. It is possible for an organ to be associated with more than one body system. For example, the pancreas is part of the digestive system and the endocrine system.

Organismal

This is the final level of organization and the largest. An organism is any contiguous living system such as one living person, an insect, or a plant. An organism may be unicellular (single cell) or comprised of trillions of cells grouped into specialized tissues and organs like in the case of the human body. As in the human body, all parts function together to constitute one total organism.

Body systems

There are eleven systems of the human body: integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic and immune, respiratory, digestive, urinary, and reproductive systems. In this lesson, we will outline the anatomy (components) and physiology (functions) of each of the eleven body systems. Something to keep in mind, all body systems influence other systems and as a simple example, the cooperation between the integumentary and skeleton systems supports this ideal. The skin serves as a barrier between the outside world and the internal structures of the body. In turn, the skeletal system provides support for the integumentary system.

Body Systems		
System Name	**Anatomy (Components)**	**Physiology (Functions)**
Integumentary	Skin, hair, nails, sweat glands and oil glands.	Protects the body, regulates body temperature, eliminates some wastes, helps make vitamin D, and detects sensations such as touch, pain, warmth, and coldness.
Skeletal	Bones, joints, and their associated cartilages.	Supports and protects the body, aids body movements, houses cells that produce blood cells, stores minerals, and lipids (fat)
Muscular	Skeletal muscles, smooth muscles, and cardiac muscles.	Provide strength, balance, posture, movement, and heat for the body to keep warm.

Body Systems		
System Name	**Anatomy (Components)**	**Physiology (Functions)**
Nervous	Brain, spinal cord, nerves, and sensory organs. (eyes and ears)	To send signals (impulses) from one cell to another to regulate body activities, detect changes in the body's environment (both internal and external), interpret the changes, and respond by causing muscular or glandular secretions.
Endocrine	Hormone producing glands (pineal gland, hypothalamus gland, pituitary gland, thymus gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries, and testes) and hormone producing cells in several other organs.	Regulate body activities by releasing hormones, which are chemical messengers transported in blood from and endocrine gland to a particular organ.
Cardiovascular	Blood, heart, and blood vessels.	Pump blood through the vessels, carry oxygen and other nutrients to cells, carry carbon dioxide and other wastes away from cells, help regulate body temperature, and water content of body fluids. Blood components help defend against disease and mend damaged blood vessels.
Lymphatic and Immune	Lymphatic fluid and vessels, spleen, thymus, lymph nodes, and tonsils.	Returns proteins and fluids into blood and carries lipids (fat) from gastrointestinal tract to blood. Protect against disease-causing organisms such as bacteria and viruses.
Respiratory	Lungs and air passageways such as the pharynx (throat), larynx (voice box), trachea (windpipe), and bronchial tubes.	Transfers oxygen from inhaled air to blood and carbon dioxide from blood to exhaled air. Using air flowing out of lungs, it produces sounds via the vocal cord vibrations.
Digestive	Mouth, esophagus, stomach, small and large intestines, and anus. Also includes accessory organs such as the salivary glands, liver, gallbladder, and pancreas.	Breaks down food physically and chemically, absorbs nutrients, eliminates solid waste.
Urinary	Kidneys, ureters, urinary bladder, and urethra.	Produces, stores, and eliminates urine, waste, and regulates volume and chemical composition of blood.
Reproductive	Gonads (testes and ovaries) and associated organs--Females: uterine tubes, uterus, and vagina. Males: epididymis, ductus deferens, and penis.	Produce sperm and oocytes (gametes) that unite to form a new organism. Gonads also release hormones that regulate reproduction. Associated organs transport and store gametes.

402. Basic anatomical terminology

To avoid any misunderstanding and confusion in describing the location of anatomical structures, we use the standard body position as a point of reference.

Normal anatomical position

The generally accepted standard position is called the *normal anatomical position* or *anatomical position.* This position is assumed when the body is standing erect, the arms are hanging at the sides, and the palms of the hands are turned forward (fig. 1–1). When using anatomical reference terms, you must visualize the body in this position.

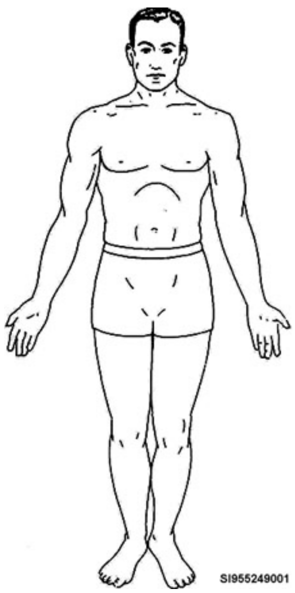


Figure 1–1. Normal anatomical position.

Anatomical reference terms

"Anterior" and "ventral" refer to the front of the body; "posterior" and "dorsal" to the back. These terms may also be used to indicate relative positions within the body (e.g., the anterior and posterior clinoid processes of the sphenoid). However, for the hands "palmar" is used instead of anterior. In describing the feet, "plantar" refers to the sole and "dorsal" to the upper surface. "Volar" may be used when describing the anterior surface of the forearm and hand.

"Medial" refers to structures located nearer the midline of the body; "lateral" to those nearer the side (e.g., the tibia is medial to the fibula, and the fibula is lateral to the tibia). These terms may also be used to identify surfaces of various structures. For example, the thumb and little finger are located on the lateral and medial aspects of the hand, respectively.

"Superior" refers to a position towards the head or above a particular reference point; "inferior" to a position towards the feet or below a reference point. The thoracic vertebrae are superior to the lumbar vertebrae, and the lumbar vertebrae are inferior to the thoracic vertebrae.

"Proximal" means nearer to the point where a limb attaches to the body or point of origin. "Distal" refers to farther from the point where a limb attaches to the body or point of origin. For example, the shoulder joint is in the proximal arm, and the wrist joint is in the distal arm. Or, we could say, the shoulder is proximal to the wrist.

"Cephalic or cephalad" means to angle towards the head whereas "caudal or caudad" means to angle towards the feet. For example, angle the central ray (CR) 15 degrees cephalic.

Terms of movement

Several terms are used to describe movement of a part or parts of the body. The term "abduct" means to move away from. For instance, if you raise your arm from your side until it is at a 90 degree angle with your body, you have abducted your arm. The opposite term is "adduct"; to move toward. Bringing your arm back down to your side is adducting your arm.

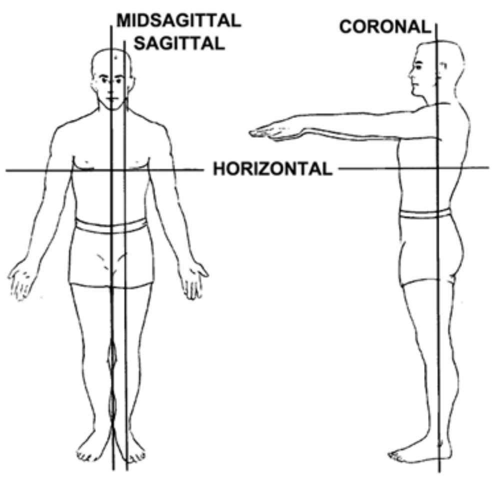


Figure 1–2. Planes of the body.

The term "pronate" means to make more prone. If you place your hand, palm down, on a table, you have pronated your hand. The opposite is, of course, to "supinate", or to make more supine. Rolling your hand over until the palm faces up is supinating the hand. Finally, "invert" means to rotate or flex the foot inward, raising the medial surface, whereas "evert" means to rotate or flex the foot outward, raising the lateral surface.

403. Body planes and positions

Figure 1–2 illustrates the various planes of the body. These imaginary planes divide the body into sections.

Planes of the body

Plane of the body are useful as reference points for locating anatomical structures. The *midsagittal* (median) *plane* divides the body into equal right and left halves. Any of the vertical planes that parallel the midsagittal plane are called *sagittal* planes. A *coronal* (frontal) plane is any vertical plane that divides the body into anterior and posterior portions. A *horizontal* (or transverse) plane is any plane that divides the body into superior and inferior portions.

NOTE: When referring to a transverse plane, the level of the plane must be given (e.g., the level of the umbilicus, or the level of the xiphoid).

Body positioning

Body position refers to the specific position the body is to be placed in when accomplishing a certain radiograph. Many terms are used to describe specific positions of the body. We will cover the most common ones used in radiography.

Common Radiography Terms	
Term	**Body Position**
Erect (upright)	Standing in any position.
Recumbent	Lying down in any position.
Supine	Lying on back.
Prone	Lying on stomach.
Lateral	Lying or standing with one side against the film or film holder (i.e., right lateral or left lateral).
Oblique	Any position in which the body is turned from 1 to 89° in relation to the plane of the film. Must include a qualifying term indicating which way the body is rotated. Such as medial or lateral rotation from an anterior posterior (AP) or posterior anterior (PA) position. Usually referred to by the surface of the body in contact with the film or image receptor, for example, right anterior oblique (RAO), left posterior oblique (LPO), etc.
Decubitus	Refers to any recumbent position in which the CR is directed horizontally to demonstrate fluid levels. Decubitus positions are identified by the side on which the patient is lying (the side down). See Figure 1–3.
Trendelenburg	A recumbent position with the table angled so that the head is lower than the feet.

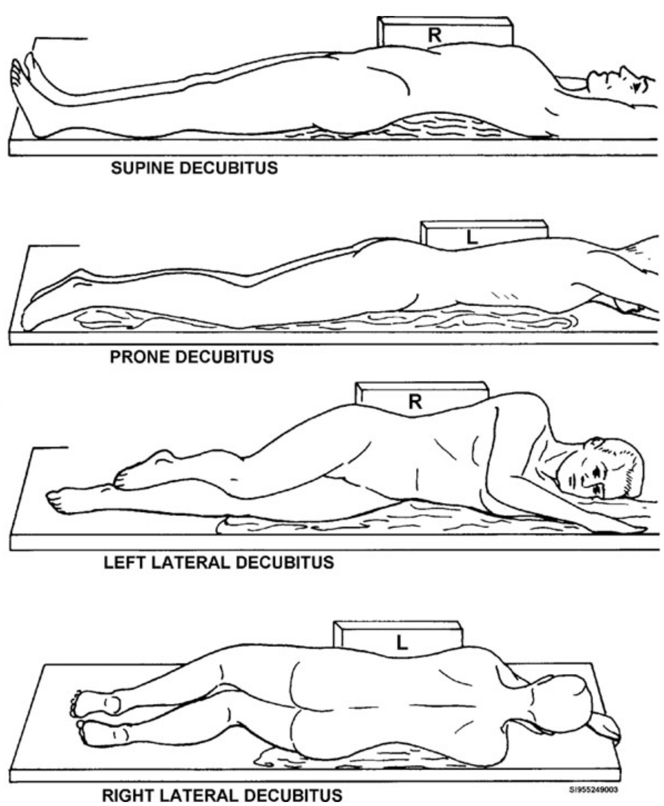


Figure 1–3. Decubitus positions.

Projection versus view

The terms *projection* and *view* are used extensively when discussing radiographs and radiographic positioning. Often they are used (incorrectly) interchangeably. The term *projection* refers strictly to the path of the CR. For instance, a PA projection of the chest, as you know, is one in which the patient's anterior surface is against the image receptor, film holder, cassette, etc. and the path of the CR is such that it enters the body posteriorly and exits anteriorly; hence the term posterior-anterior projection or PA.

View, on the other hand, describes the body part as seen by the image receptor (i.e., film, image intensifier, and so forth). In our previous example of the PA chest, the patient's anterior surface is against the film holder. It is, therefore, an anterior view of the chest. Likewise, a KUB (kidneys, ureters, and bladder) is normally a posterior view of the abdomen.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

401. Organization of the body

1. What does the term "anatomy" mean?

2. What does the term "physiology" mean?

3. Name the six levels of organization in the human body.

4. There are eleven systems of the human body. Match the appropriate anatomy or physiology in column B with the correct body system in column A. Each item may only be used once.

Column A

____ (1) Integumentary.
____ (2) Skeletal.
____ (3) Muscular.
____ (4) Nervous.
____ (5) Endocrine.
____ (6) Cardiovascular.
____ (7) Lymphatic and immune.
____ (8) Respiratory.
____ (9) Digestive.
____ (10) Urinary.
____ (11) Reproductive.

Column B

a. Produces, stores, and eliminates urine and waste.
b. Sends signals (impulses) from one cell to another to regulate acitivities.
c. Breaks down food, absorbs nutrients.
d. Protects the body & regulates temperature.
e. Returns proteins and fluids into the blood, protects against disease.
f. Bones, joints, and their associated cartilages.
g. Provides strength, balance, posture, movement, and heat for the body to keep warm.
h. Produces sperm and oocytes that unite to form a new organism.
i. Blood , heart, and blood vessels.
j. Encompasses the hormone producing glands and cells.
k. Transfers oxygen and expels carbon dioxide to/from the blood.

402. Basic anatomical terminology

1. Describe normal anatomical position.

2. To what does the term “volar” refer?

3. What is the positional relationship between the cervical spine and the thoracic spine?

4. What does the term “proximal” mean?

403. Body planes and positions

1. Describe the midsagittal plane.

2. Describe a coronal plane.

3. Describe a horizontal plane.

4. Match the positioning terms in column B with the appropriate description in column A. Each term may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Lying or standing with one side against the film.	a. Erect.
____ (2) A position in which the body is turned from 1 to 89 degrees in relation to the plane of the film.	b. Recumbent.
____ (3) Standing in any position.	c. Supine.
____ (4) A position in which the patient is lying down and the beam is directed horizontally.	d. Prone.
____ (5) Lying on one’s stomach.	e. Lateral.
____ (6) Lying with the head lower than the feet.	f. Oblique.
	g. Decubitus.
	h. Trendelenburg.

5. Describe the difference between projection and view.

1–2. Basic Osteology and Arthrology

A large percentage of radiography involves imaging the bones and joints of the human body. For obvious reasons, it is relatively important for you to have a basic understanding of osteology (the study of bones) and arthrology (the study of joints). This section is dedicated to general information about the bones and joints that comprise the human skeleton, as well as some common fracture types that you will encounter in your career as a radiologic technologist.

404. Skeletal structure

The skeletal system is the bony and cartilaginous framework of the body (figs. 1–4 and 1–5). Its functions include supporting the body, giving it shape, protecting vital organs, and providing sites of attachment for muscle and ligaments.

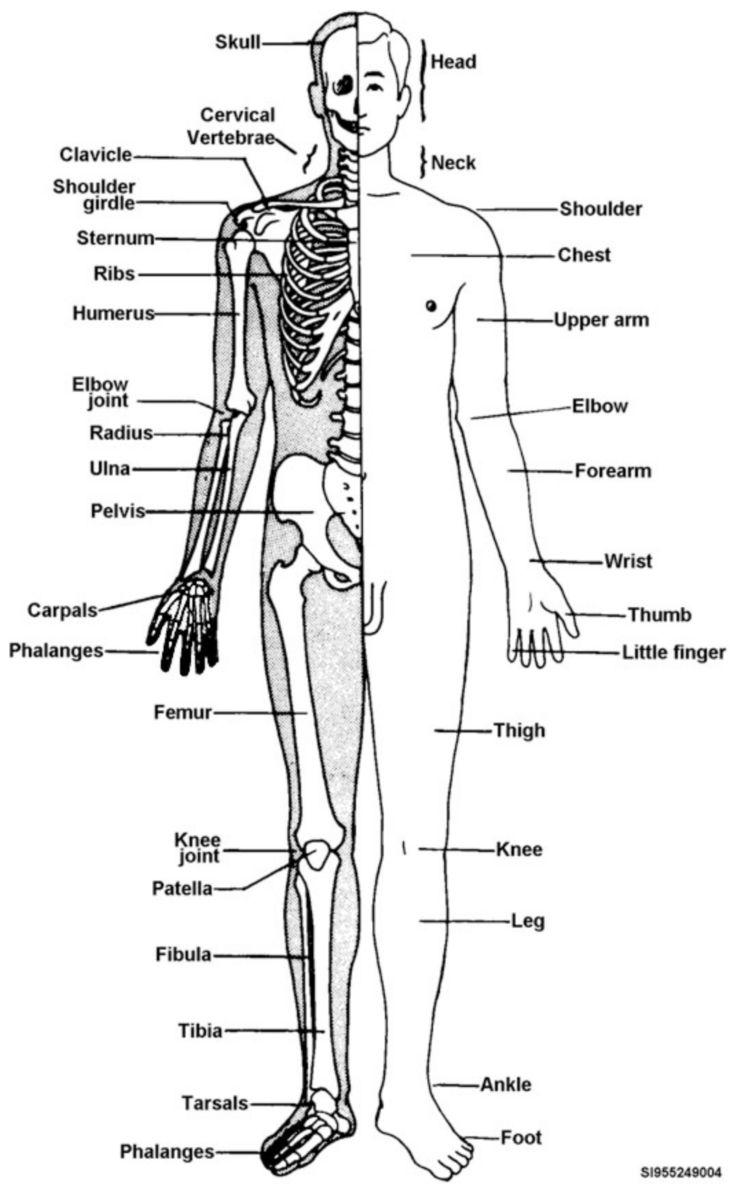


Figure 1–4. Anterior view showing general skeletal structure.

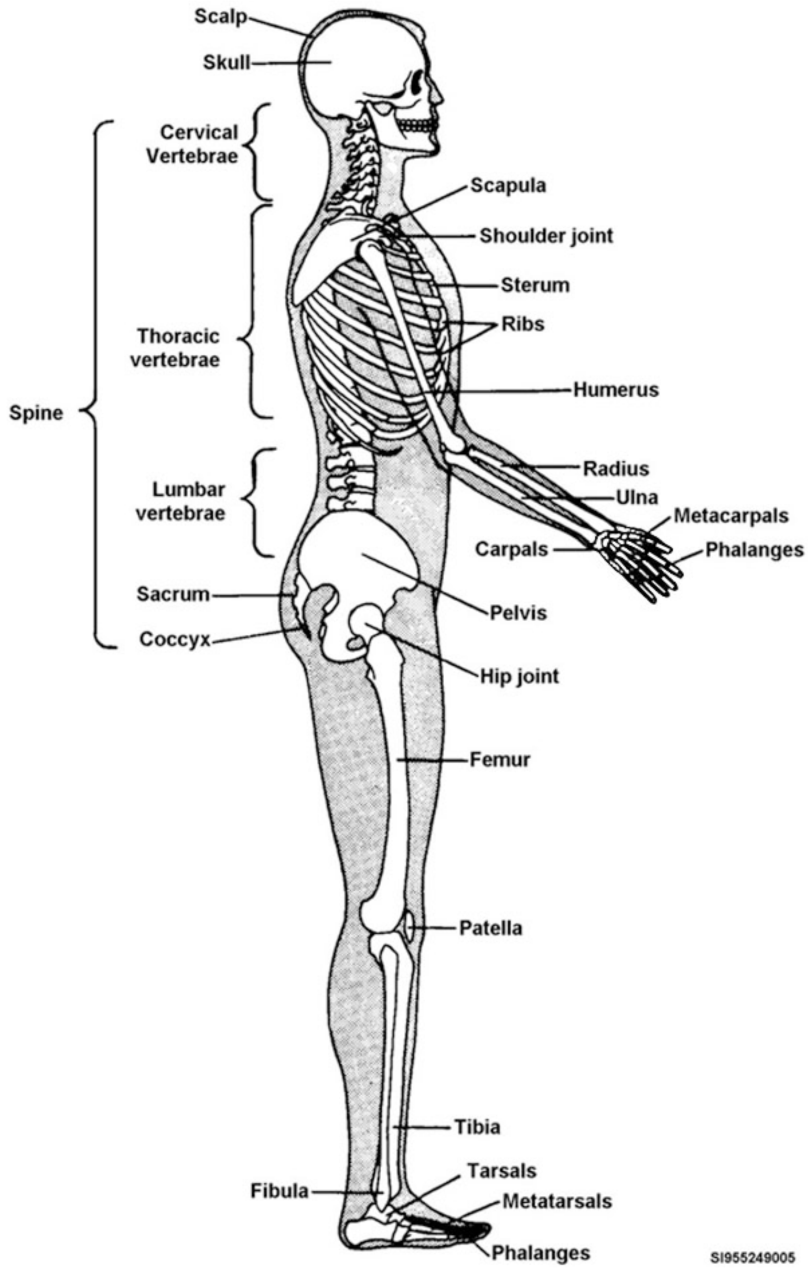


Figure 1–5. Lateral view showing general skeletal structure.

The human skeleton

The adult human skeleton is composed of approximately 206 bones including the auditory ossicles and patellae, but excluding small sesamoid bones. The skeleton is divided into appendicular and axial portions. The appendicular skeleton includes the bones of the upper and lower extremities, shoulder girdle, and pelvic girdle. The axial skeleton includes the bones of the skull, vertebral column, thoracic cage, auditory ossicles, and the hyoid bone.

Bone structure

Bone is a tissue composed of living cells (osteocytes) distributed in an intercellular matrix containing organic and inorganic substances. The organic component, largely collagenous fibers, is responsible for the strength and resilience of bone; the inorganic salts, mostly calcium phosphate, contribute to its hardness and rigidity. Inorganic constituents make up about 67 percent of bony matter in the adult.

The radiopacity of bone depends largely upon the amount of mineral constituents present. Lack of mineral content in the young and aged alters the radiopacity and requires technique compensation when radiographing.

There are two forms of bone tissue: cancellous and compact. Cancellous or spongy (lattice-like) bone consist of irregular strands of tissue that branch and join one another, forming a loose network in which intercommunicating spaces are filled with marrow. Compact or dense bone has a more solid, regular appearance and its intercommunicating canals are microscopic in size.

The basic structure of these two types of bone is essentially the same. They differ mainly in the relative amount of solid substance and the number, size, and arrangement of intercommunicating spaces they contain. Both cancellous and compact forms are present in most bones of the body, but the extent and distribution of each vary considerably. In adults, the exterior of all bones is compact bone, while the interior is usually cancellous.

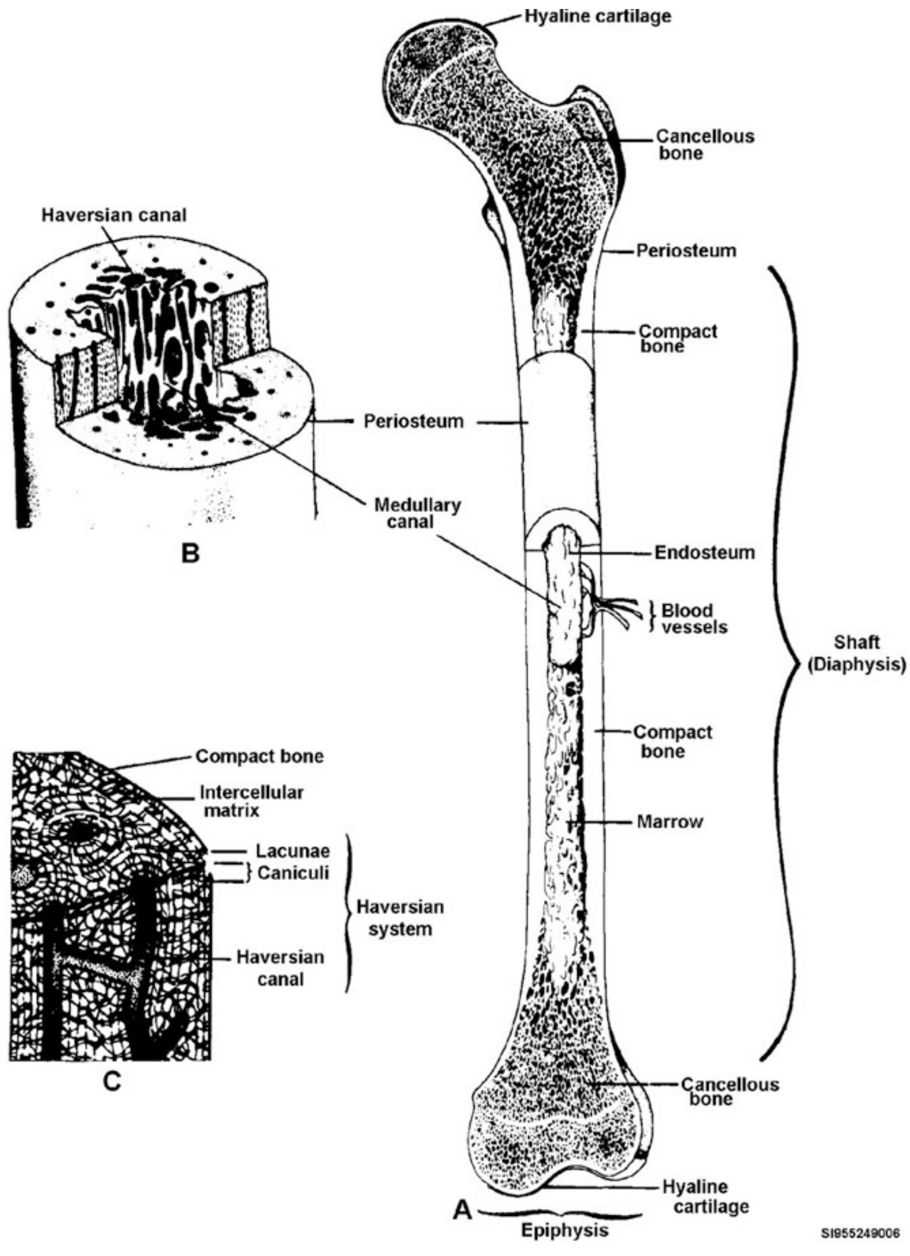


Figure 1–6. Structure of a long bone (femur).

In a typical long bone (fig. 1–6), each end (epiphysis) is largely cancellous and is covered by a small layer of compact bone. The reverse prevails in the shaft (diaphysis), which is mostly compact bone tissue. The central medullary cavity in the shaft of these long bones is continuous, with intercommunicating spaces in the cancellous bone located at the ends.

Depending on the age of the individual and the type of bone considered, either red or yellow marrow fills these cavities. Red marrow, active in the production of blood cells, is present in all bones at birth, and blood cells are produced in all locations. With advancing age the production of blood cells decreases; and red marrow is replaced by yellow marrow that consists mostly of fat cells. During adult life, red marrow is found mainly in the skull, vertebrae, ribs, sternum, and articular ends of some long bones.

A thick fibrous sheet of tissue called the periosteum, which develops when the outer covering of the embryonic skeleton becomes permeated with blood vessels, encloses each long bone, except for its articular surface. A delicate layer of reticular tissue called the endosteum lines both the marrow cavity and the canal system.

In flat bones, such as ribs, one or more plates of compact bone surround the cancellous bone. In many irregular bones, such as the vertebrae, spongy bone is enclosed by a thin shell of compact bone.

Living bone cells are nourished by a system of blood vessels and capillaries. For example, in long bones, blood vessels in the shaft supply the bone marrow. Branches of blood vessels contained in the periosteum supply the compact and cancellous bone areas.

When bone tissue is examined under a microscope, it is seen in layers, as either a series of flat plates (for cancellous bone) or concentric cylinders (for compact bone). The microscopic structure of compact bone is illustrated in Figure 1–6. In compact bone, series of concentric cylinders are formed in units called Haversian systems. Here, living bone cells lie in minute cavities called lacunae. The lacunae communicate with each other and with a central Haversian canal through a system of microscopic canals called caniculi, which contain protoplasmic extensions of bone cells. The living bone cells are nourished by blood vessels from the periosteum that enter the compact bone through small pits on the surface. Branches of these blood vessels penetrate the matrix and enter the central Haversian canal in each Haversian system. The Haversian canal systems, in turn, are connected to the medullary cavity by means of channels, running obliquely or transversely, called Volkman's canals. Thus, the Haversian canal systems allow passage of blood vessels into the bone to nourish the living bone cells.

Cartilage

Cartilage is a living tissue that occurs in three forms: hyaline cartilage, white fibrocartilage, and yellow or elastic cartilage.

Hyaline cartilage, the most common of the three, appears as a bluish-white, translucent substance. It is very flexible and somewhat elastic. In the early embryo, the skeleton is composed of this type of cartilage, but during fetal development most of this embryonic skeleton is replaced by bone. However, in the adult, hyaline cartilage persists in the smooth articular surfaces of joints, in the costal cartilages, rings of the trachea and bronchi, and in the cartilage of the nose.

White fibrocartilage is exceptionally tough and resilient. It is found in pads or disks between the vertebrae where it provides a cushioning effect. It attaches tendons and ligaments to hyaline cartilage and is also found where limited movement occurs; for example, in the symphysis pubis and acromioclavicular (AC) joints.

Yellow or elastic cartilage is more flexible and elastic than true hyaline cartilage. It occurs where movement of cartilaginous structures is necessary; for example, in the epiglottis. Elastic cartilage is also found in the larynx, external ear, and eustachian tube.

405. Bone classification and formation

Scientists love to categorize and classify things of a similar nature. Bones are no exception. We usually classify bones according to shape.

Classification of bones

Bones are classified as: long, short, flat, sesamoid, and irregular.

Long bones

Long bones, as the name implies, are longer than they are wide. Long bones usually consist of a cylindrical shaft (diaphysis), with two expanded ends. The shaft is usually composed of compact bone with a hollow center, the medullary canal. The expanded ends are usually composed of cancellous bone and covered with hyaline cartilage if they articulate. Examples of long bones include the humerus, femur, metacarpals, metatarsals, and phalanges.

Short bones

Short bones are bones whose length, width, and breadth are approximately equal; that is, they are roughly cuboid. They consist mainly of cancellous bone with a thin outer covering of compact bone. The carpals and tarsals are the only short bones in the body.

Flat bones

Flat bones consist of two plates of hard compact bone with a thin layer of cancellous bone and red marrow in between. They are found in places that require special protection and where a broad surface for muscle attachment is needed. They also play an important role in blood production in adults. Examples of flat bones include the calvarium (skull cap), the scapula, and the ribs.

Sesamoid bones

Sesamoid bones are found embedded in tendons that overlie joints. In addition to lessening friction over the joint, they modify pressure and help to protect ligaments and tendons. The patella is, of course, the largest sesamoid bone. Other common locations for sesamoid bones are the popliteal space and beneath the heads of the first metacarpals and metatarsals. Sesamoid bones vary in number, size, and location from individual to individual.

Irregular bones

Bones that do not fit into the previous four categories because of their odd size and shape are called irregular bones. The size and shape of irregular bones are determined by their intended function. Examples of irregular bones include the vertebrae, sphenoid, ethmoid, temporal, and facial bones.

Bone formation

Bone formation begins in early pregnancy around the sixth to eighth week. This process, known as ossification, occurs in two different ways: intramembranous and intracartilaginous.

Intramembranous

Bone formation from a fibrous membrane is called intramembranous ossification. Flat bones of the cranium are examples of this type of ossification. In various portions of the membrane, ossification centers develop where cells known as osteoblasts produce bone cells. From these centers, tiny calcium spines radiate in all directions; thus a compact network of bone is formed centrally with peripheral areas being much less compact. Eventually, the periosteum is formed from the membrane. Osteoblasts directly beneath the periosteum form the inner and outer layers of compact bone while endosteal osteoblasts form the cancellous bone.

Intracartilaginous

Most bone formation in the body takes place in cartilage and is known as intracartilaginous or endochondral ossification. A long bone, for example, in a fetus starts out as an exact cartilage model of how the bone will be. Ossification proceeds from an ossification center toward the extremities, which remain cartilaginous for some time. At the same time, a similar process begins in the extremities (the epiphysis) and gradually proceeds inward toward the center. An area of cartilaginous tissue persists after birth for various periods. In infants and children, this area affords growth in length, and is called the epiphyseal zone.

Bone growth

Growth of cranial bones is effected by formative steps that are modifications of intramembranous formation. It entails ossification of membranous fontanelles (soft spots) which completely fuse when the child is about two years old.

The remaining bones of the skeleton undergo changes similar to that of a long bone during growth (i.e., an increase in diameter and length). The periosteum, which covers the bone, contains osteoblasts that progressively deposit layers of bone to form the external portion of the bone. Correlated with this growth in diameter externally, bone-destroying cells in the endosteum destroy some of the bone internally, thereby enlarging the internal (medullary) canal. Growth in length takes place in epiphyseal zones.

The time required for bones to reach full development varies for different parts of the skeleton. The appearance of epiphyseal centers of ossification and their development can be followed by radiographic examination. This study, which is nothing more than a PA left hand and wrist, is often done on children who fall outside the normal growth curves. The radiologist examines the stages of development of the carpals and the epiphyseal zones to calculate an approximate skeletal age in comparison to the child's chronological age.

406. Joint classification

Bones in the skeleton meet in areas called joints or articulations whose purpose is to provide for varying degrees of movement for the different parts of the body. According to the amount of movement they permit, joints are classified as immovable, slightly movable, and freely movable (fig. 1–7).

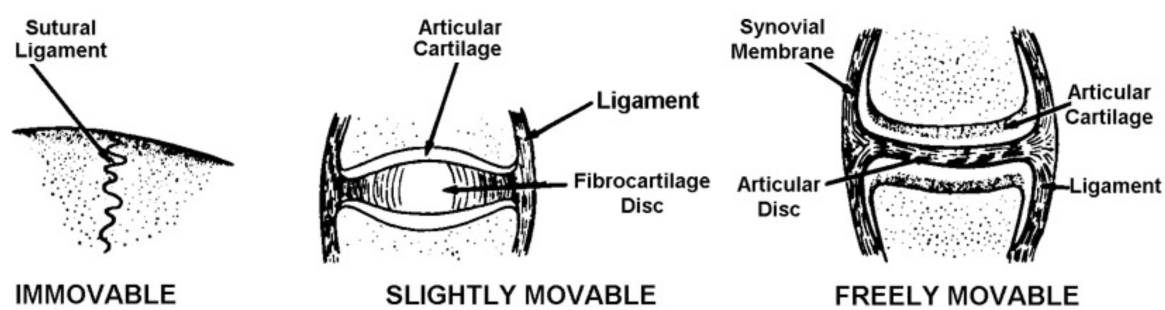


Figure 1–7. Types of joints.

Synarthrodial (fibrous)

Joints that allow no appreciable movement are called immovable or synarthrodial joints. These articulations occur between bones that are fastened together by cartilage or fibrous tissue. A good example of synarthrodial joints is the articulations between the bones of the skull, called sutures.

Amphiarthrodial (cartilaginous)

Joints that permit limited movement are called slightly movable or amphiarthrodial joints. The standard definition of an amphiarthrodial joint is two bony surfaces, connected by fibrocartilage, often in the form of a disk. The most obvious example of this type of joint is the intervertebral disk. The symphysis pubis and acromioclavicular joints also fit in this category.

Diarthrodial (synovial)

Joints that permit a wide range of motion are called freely movable, or diarthrodial joints. Bone extremities that articulate to form this type of joint are covered with hyaline cartilage and encased by an articular capsule ligament that is attached to both bones near the articulating end. The cavity of the capsule contains synovial fluid that lubricates the joint. In some joints, an articular disk is also found between articulating layers. Most joints of the body are freely movable and are further classified by the specific type of movement they allow such as rotation, gliding, or hinge type joints.

407. Common fractures

Traumatic injuries consist of unlimited mental or physical, internal or external variables. In diagnostic imaging, a large part of our work as radiographers is generated because of trauma to various parts of the body. You probably have seen and realize by now that rule out fracture (abbreviated R/O Fx) is one of the most common reasons (history) given in conjunction with an X-ray request. For this reason, you should be somewhat familiar with the most common types of fractures seen on radiographs.

General classifications of fractures

To fracture a bone means to "break" it. Fractures are generally classified as either open (compound) or closed (simple) and *displaced* or *nondisplaced.* An open fracture is one in which the broken bone(s) have penetrated through the overlying skin. A *closed* fracture is when the bone does not penetrate through the overlying skin. A *nondisplaced* fracture is one in which the fractured ends of the bone stays within its normal anatomical alignment. A *displaced* fracture is much more serious; it is a fracture where the fragmented ends of the bones are no longer in alignment with each other.

Specific types of fractures

Fractures are further classified by position, number of fragments, and direction of the fracture line (fig. 1–8). A *longitudinal fracture* line roughly parallels the long axis of the bone. An *oblique fracture* extends diagonally to the long axis of the bone. A *transverse fracture* is usually a straight-line break at right angles to the long axis of the bone.

With an *impacted fracture*, broken ends, or fragments, are jammed firmly together. A *greenstick fracture* is one in which one side of the bone is broken and the other side is only bent. Greensticks are most common in children where the bones are not fully ossified. A *spiral fracture* has an S-shaped fracture line caused by twisting of the bone.

A *depressed fracture* occurs with blunt trauma to the skull in which fragments are driven into the skull cavity. A *button-hole* fracture is a fracture in which the bone is perforated by a projectile. *Compression fractures* occur when too much vertical force is exerted on a bone and most commonly occur in the vertebral column. *Comminuted fractures* are ones in which the bone is crushed or splintered and two or more smaller fragments lie between the two fractured ends. Finally, a *stellate* fracture is a fracture with a central point of injury from which radiates numerous fissures.

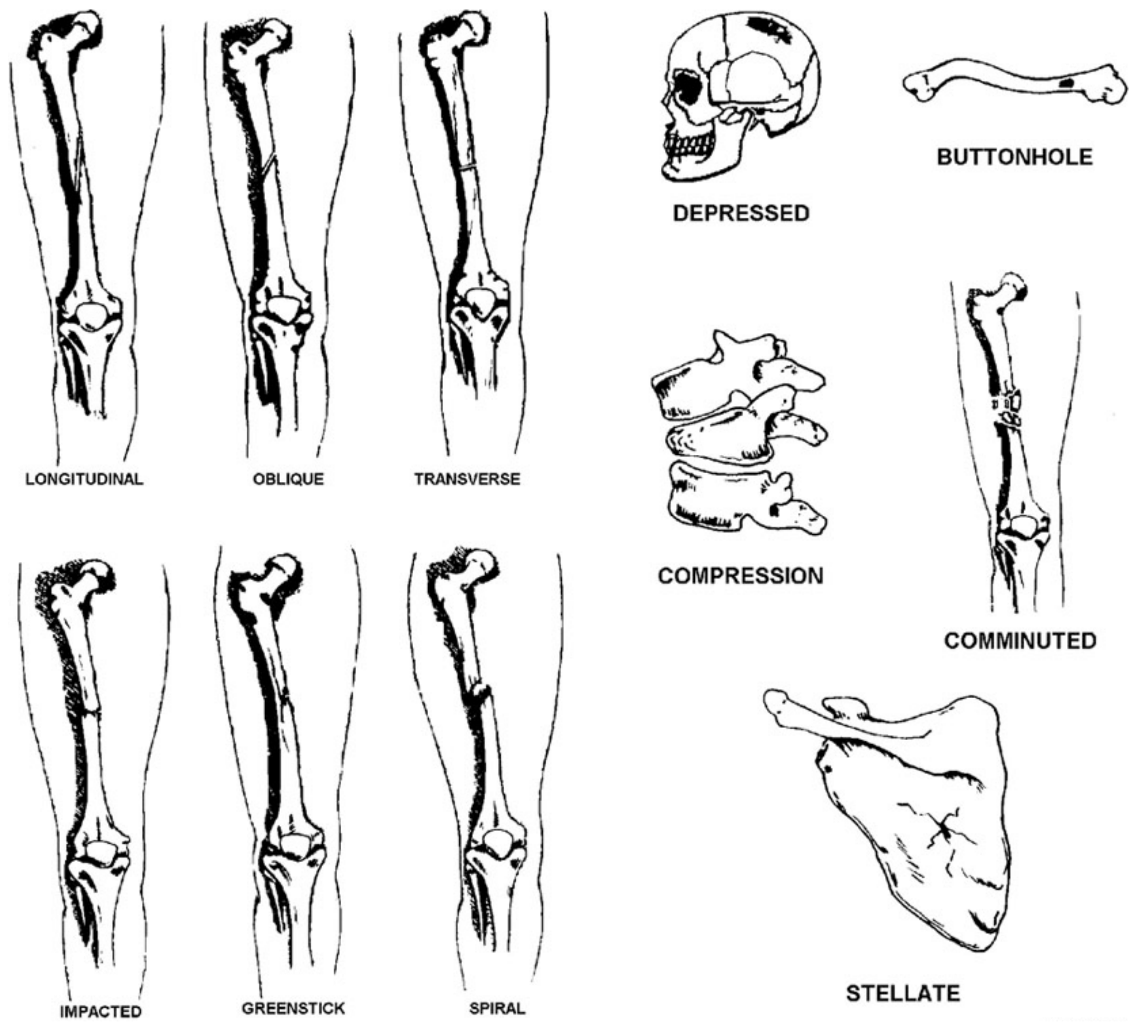


Figure 1–8. Fracture types.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

404. Skeletal structure

1. Name four functions of the skeletal system.

2. What bones are included in the appendicular skeleton?

3. What contributes to bone hardness and rigidity?

4. Describe cancellous bone.

5. Explain the distribution of compact and cancellous bone in a typical long bone.

6. What is the function of red marrow, and where is it found in adults?

7. What is the purpose of Haversian canals?

8. Name the three types of cartilage.

9. Which type of cartilage is the most prevalent in the body?

10. What is the function of white fibrocartilage?

405. Bone classification and formation

1. Match each bone classification in column B with the specific bone listed in column A. Each answer may be used once, more than once, or not at all.

Column A	*Column B*
______(1) Capitate.	a. Long bone.
______(2) Patella.	b. Short bone.
______(3) Phalanges.	c. Flat bone.
______(4) Temporal.	d. Sesamoid bone.
______(5) Ribs.	e. Irregular bone.
______(6) Femur.	
______(7) Scapula.	
______(8) Vertebrae.	
______(9) Metacarpals.	
____ (10) Talus.	

2. What are the two types of bone formation?

3. Through which method of bone formation are long bones formed?

4. What is a bone age exam?

406. Joint classification

1. Describe a synarthrodial joint and give one example.

2. What is the definition of an amphiarthrodial joint?

3. Diarthrodial joints are freely moveable, how are they further classified?

407. Common fractures

1. What is the difference between a simple and a compound fracture?

2. What is an impacted fracture?

3. Describe a spiral fracture?

4. Describe a depressed fracture.

5. What type of fractures most commonly occur in the vertebral column?

6. What term is used to describe a fractured bone in which two or more fragments lie between the two fractured ends?

Answers to Self-Test Questions

401

1. Is the study of the individual structures of the body and their relationships among other structures.
2. Is the study of how the body parts work.
3. Chemical, cellular, tissue, organ, system, and organismal.
4. (1) d.
   (2) f.
   (3) g.
   (4) b.
   (5) j.
   (6) i.
   (7) e.
   (8) k.
   (9) c.
   (10) a.
   (11) h.

402

1. The body is standing erect, the arms are hanging at the sides, and the palms of the hands are turned forward.
2. The anterior surface of the forearm and hand.
3. The cervical spine is superior to the thoracic spine.
4. Nearest the point of origin or attachment of a limb.

403

1. It divides the body into equal right and left halves.
2. Any vertical plane that divides the body into anterior and posterior portions.
3. Any plane that divides the body into superior and inferior portions.
4. (1) e.
   (2) f.
   (3) a.
   (4) g.
   (5) d.
   (6) h.
5. Projection refers to the path of the CR (for instance, PA); view describes the body part as seen by the image receptor.

404

1. (1) Supporting the body; (2) Giving it shape; (3) Protecting vital organs; and (4) Providing sites for attachment of muscle and ligaments.
2. The upper and lower extremities, the shoulder girdle, and the pelvic girdle.
3. Inorganic salts (e.g., calcium phosphate).
4. Consists of irregular strands of tissue that branch and join one another, forming a loose network in which intercommunicating spaces are filled with marrow.
5. Each end (epiphysis) is largely cancellous and is covered by a small layer of compact bone; the reverse prevails in the shaft (diaphysis), which is mostly compact bone tissue.
6. The production of blood cells; in adults, it is found mainly in the skull, vertebrae, ribs, sternum, and articular ends of some long bones.

7. They serve as a passageway for blood vessels to nourish the living bone cells.
8. Hyaline cartilage, white fibrocartilage, and yellow cartilage.
9. Hyaline.
10. It provides a cushioning effect.

405

1. (1) b.
   (2) d.
   (3) a.
   (4) e.
   (5) c.
   (6) a.
   (7) c.
   (8) e.
   (9) a.
   (10) b.
2. Intramembranous and intracartilaginous.
3. Intracartilaginous.
4. A PA left hand and wrist, is often done on children who fall outside the normal growth curves.

406

1. Joints that allow no appreciable movement; the sutures of the skull.
2. Slightly movable; two bony surfaces, connected by fibrocartilage, often in the form of a disk.
3. By the specific type of movement they allow.

407

1. An open fracture is one in which the broken bone(s) have penetrated through the overlying skin. A *closed* fracture is when the bone does ***not*** penetrate through the overlying skin.
2. A fracture in which the fragments are jammed firmly together.
3. It has a S-shaped fracture line caused by twisting of the bone.
4. Fragments of the skull are driven into the skull cavity.
5. Compression fractures.
6. Comminuted.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to Air Force Career Development Academy (AFCDA).

1. (401) Which body system carries waste away from cells and helps regulate body temperature?
   a. Endocrine.
   b. Respiratory.
   c. Integumentary.
   d. Cardiovascular.

2. (402) Which of the following is an accurate description of normal anatomical position?
   a. Erect, arms abducted, palms forward.
   b. Erect, arms at sides, palms forward.
   c. Erect, arms at sides, palms facing inward.
   d. Recumbent, arms at sides, palms forward.

3. (403) A sagittal plane divides the body into
   a. right and left portions.
   b. medial and lateral portions.
   c. superior and inferior portions.
   d. anterior and posterior portions.

4. (404) Approximately how many bones comprise the adult human skeleton?
   a. 201.
   b. 206.
   c. 211.
   d. 216.

5. (405) “Bones that are roughly cuboid and consist mainly of cancellous bone with a thin outer covering of compact bone” is a description of
   a. flat bones.
   b. long bones.
   c. short bones.
   d. irregular bones.

6. (405) Which type of bone is the sphenoid?
   a. Flat.
   b. Long.
   c. Short.
   d. Irregular.

7. (406) Which type of joint is classified as immovable?
   a. Diarthrodial.
   b. Synarthrodial.
   c. Intervertebral.
   d. Amphiarthrodial.

8. (407) A fracture in which one side of the bone is broken and the other side is bent is called
   a. a simple.
   b. a stellate.
   c. an avulsed.
   d. a greenstick.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Osteology of the Extremities

IT SEEMS ONLY APPROPRIATE to begin our study of osteology with the extremities. You might agree that the true effectiveness of your ability to properly put the requested image on the film is directly related to your knowledge of the osteological features of the various bones in the extremities. For that reason, it is necessary to dive into a basic review of the osteology of the extremities starting with the lower extremities and pelvic girdle.

2–1. The Lower Extremity and Pelvic Girdle

We begin with this section discussing the distal appendicular skeleton. Specifically, we will discuss osteology of the toes, foot, ankle, leg, knee, patella, femur, and pelvic girdle.

408. Bones and joints of the toes and foot

Two arches, one longitudinally and another transversely, are formed by the bones of the foot. The arches are composed of wedges, cubes, and long relatively straight sections that join with each other to provide structural strength and mobility. The skeleton of the foot consists of 26 bones that we divide into three sections—the phalanges, metatarsals, and tarsals. Refer to Figure 2–1 as you study the toes and foot.

Phalanges

Each toe (digit) has three phalanges, except the first, which has two. As long bones, each phalanx is composed of a body (shaft), a head (distal end), and a base (proximal end). The phalanges are not named, but are identified by their location and number, counted from medial (great toe) to lateral (little toe). For example, the phalanx of the great toe that joins with the foot is called the proximal phalanx of the first digit; the middle phalanx of the middle toe is called the middle phalanx, third digit; and the distal phalanx of the little toe is called the distal phalanx, fifth digit. The tip of each distal phalanx has a roughened eminence called the ungual tuberosity, or tuft.

The bases of the distal phalanges articulate with the heads of the middle phalanges forming the distal interphalangeal (DIP) joints. The bases of the middle phalanges articulate with the heads of the proximal phalanges forming the proximal interphalangeal (PIP) joints. (The exception to this is, of course, the first digit that has only one interphalangeal joint.) The bases of the proximal phalanges, in turn, articulate with the heads of the metatarsals forming the metatarsal-phalangeal (MP) joints.

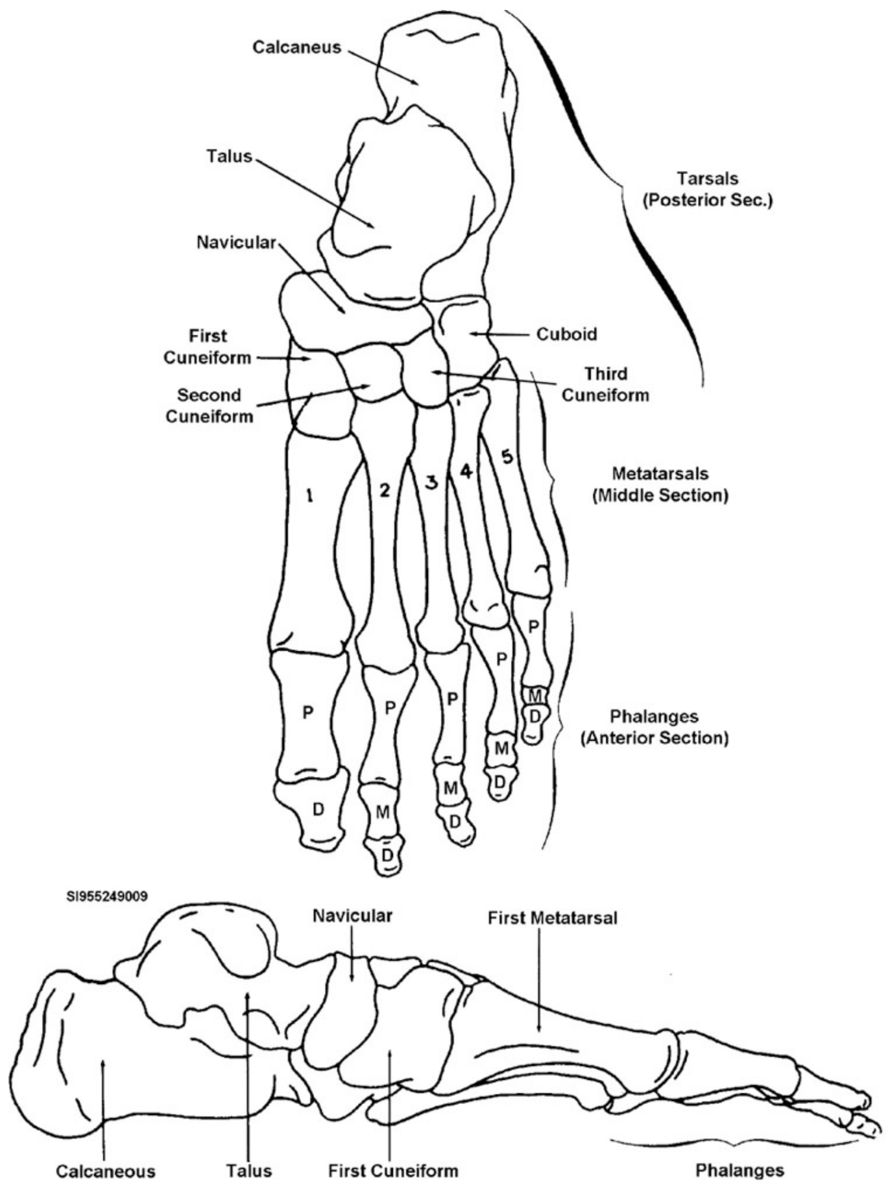


Figure 2–1. Bones of the toes and foot.

Metatarsals

The sole and lower instep are formed by the metatarsals, which are classified as long bones and identified by the numbers one through five from the medial to the lateral sides. As long bones, each has a body, base, and head. The metatarsals join distally with the corresponding proximal phalanges of the toes; proximally, they join the tarsal bones as follows:

1. The first metatarsal joins the distal end of the first cuneiform and the medial surface of the second metatarsal.
2. The second metatarsal joins the medial surface of the first cuneiform, the distal ends of the second and third cuneiforms, and the lateral and medial surfaces of the first and third metatarsals, respectively.
3. The third metatarsal joins the distal end of the third cuneiform, the lateral surface of the second metatarsal, and the medial surface of the fourth metatarsal.

4. The fourth metatarsal joins the distal end of the cuboid, the lateral surface of the third metatarsal, and the medial surface of the fifth metatarsal.
5. The fifth metatarsal joins the distal end of the cuboid and the lateral surface of the fourth metatarsal.

Tarsals

The tarsals, which are described below, make up the posterior part of the foot and part of the ankle. Because of their shape, they are classified as short bones. Some of them have more than one name.

Cuneiforms

The first, second, and third cuneiform bones are wedge shaped. They are located directly behind the first, second, and third metatarsals, and in front of the navicular. They are numbered from the medial to the lateral side.

Cuboid

The cuboid is on the lateral aspect of the foot, directly behind the fourth and fifth metatarsal bones. The navicular (tarsal scaphoid) is on the medial side of the foot, directly behind the cuneiform bones.

Talus

The talus (astragalus), through which the body weight is transmitted to the foot, is the second largest tarsal. It is located behind the navicular and slightly higher than the other tarsals. The talus has a head, a neck, and a body. The head is directed slightly medially and upward to articulate with the navicular, forming the anterior subtalar joints. The superior portion of the body is a smooth, trochlea-like surface, which articulates with the tibia. The inferior surface has two smooth surfaces, which articulate with the calcaneus, forming the posterior subtalar joints. A deep groove, the sulcus tali, separates the articular surfaces.

Calcaneus

The calcaneus (os calcis), the largest of the tarsal bones, is located on the extreme posterior portion of the foot, beneath the talus. The superior surface of its anterior two-thirds supports the talus and receives the body weight transmitted from the talus. The posterior one-third of the calcaneus forms the heel of the foot. The calcaneal tuberosity lies on the posterior part of the inferior surface. It is slightly depressed in the middle and runs to both sides to form the lateral and medial processes.

409. Structure of the ankle

Our discussion of the osteology of the lower extremity continues with the ankle. The ankle is classified as a diarthrodial articulation, specifically, a hinge-type joint. It is formed by the distal articular surface and medial malleolus of the tibia, the superior articular surface of the talus, and the lateral malleolus of the fibula (fig. 2–2). These bony structures form a "mortise" (a carpentry term meaning a preshaped and fitted joint) which is held in place by various ligaments and muscle tissue.

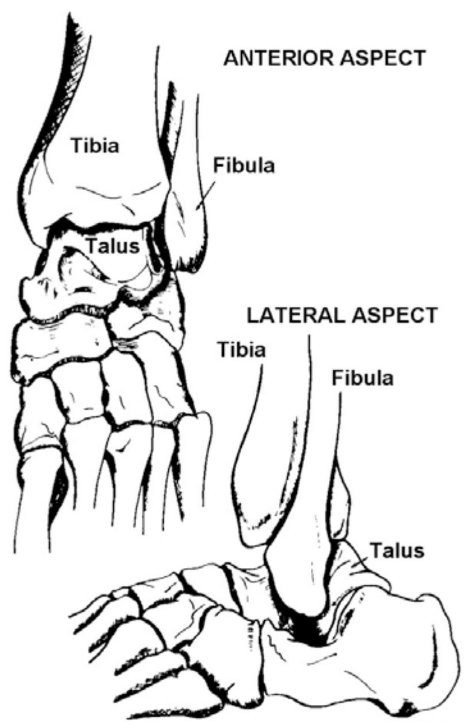


Figure 2–2. The ankle joint.

The distal articular surface of the tibia and the superior articular surface of the talus form the horizontal portion of the mortise. The medial malleolus, which is continuous with the distal portion of the tibia, articulates with the medial aspect of the talus and forms the medial side of the mortise. The lateral malleolus of the fibula articulates with the lateral aspect of the talus and forms the lateral side of the mortise. The distal articular surface of the tibia and the superior articular surface of the talus are parallel to each other and also parallel the horizontal plane.

The malleoli, however, are angled about 10 percent off the perpendicular plane. They form an angle of about 80° with the horizontal articular surfaces of the tibia and the talus. These angles are important for weight-bearing and mobility. When treating injuries to the ankle mortise, every effort is made to maintain these angles. Figure 2–3 illustrates the angles formed by the ankle mortise.

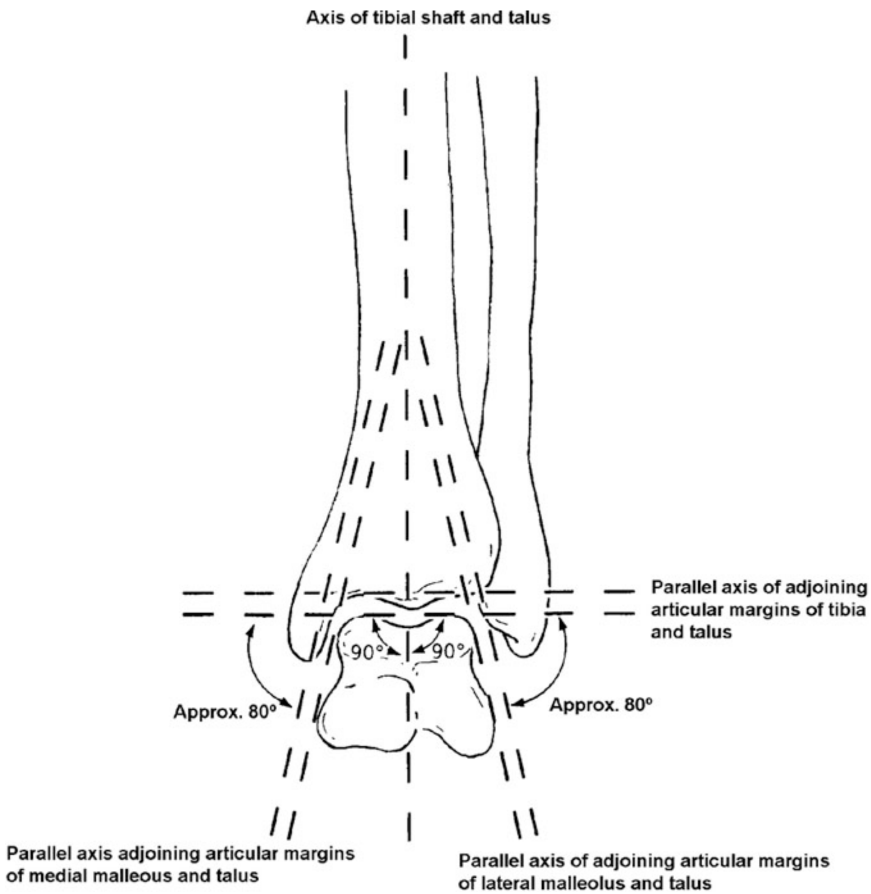


Figure 2–3. The angles formed by the ankle mortise.

410. Osteology of the lower leg

The lower leg consists of two bones—the tibia and the fibula. The tibia is the larger of the two bones. We shall consider each separately, starting with the tibia. Using Figure 2–4 as a reference will help you understand the descriptions.

Tibia

Commonly called the shin bone, the tibia is located on the medial side of the leg. As a long bone, it has a shaft and two widened ends for articulation. The distal end of the tibia is much smaller than the proximal end. The inferior surface is smooth and flat, and the medial surface extends downward to form the medial malleolus.

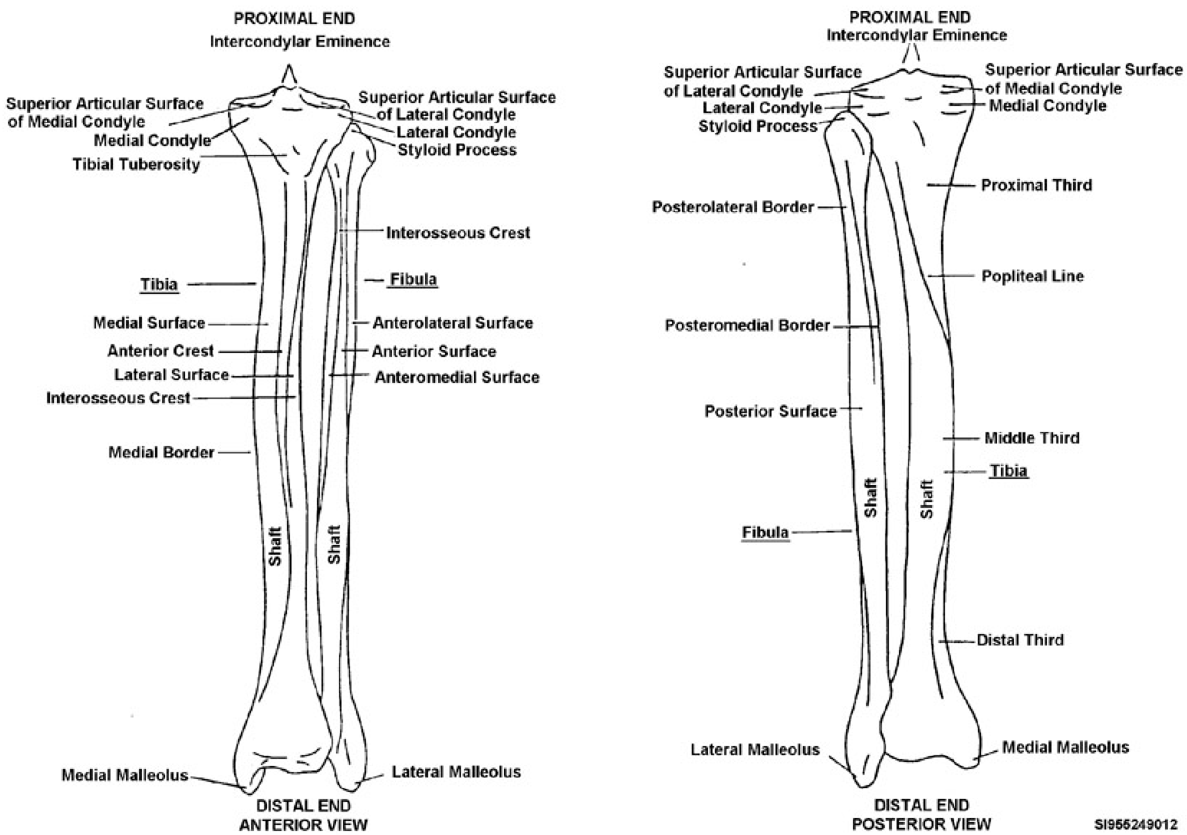


Figure 2–4. Bones of the leg.

The shaft of the tibia is somewhat triangular with three surfaces and three borders. The anterior border, or crest, runs from just above the tibial tuberosity to the anterior margin of the medial malleolus. It can be easily located by palpation. The medial border begins at the posterior portion of the medial condyle and extends downward to the posterior portion of the medial malleolus. The lateral border begins in front of the articular surface of the fibular head and extends down the bone. This lateral border is also called the interosseous crest because it is the attachment point for the interosseous (meaning between bone) membrane that holds the tibia and fibula together.

The medial surface is smooth and slightly convex; the lateral surface is narrower than the medial. We can describe the posterior surface best if we divide it into thirds. The proximal third ends at the popliteal line. The middle third has a vertical ridge that starts at the popliteal line and gradually becomes indistinct as it descends. The distal third is smooth.

The major parts of the proximal tibia are the superior articular surface, medial and lateral condyles, intercondylar eminence, and tibial tuberosity. The superior articular surface (tibial plateau) is divided by a groove. The smooth surface on the medial side is the superior surface of the medial condyle. The corresponding lateral surface is the superior articular surface of the lateral condyle. Both of these surfaces articulate with the corresponding condyles of the femur to form the knee joint.

The grooves that separate these surfaces are the anterior and posterior intercondyloid fossa. Located in the middle of the intercondyloid fossae is the intercondyloid eminence or spine of the tibia. Just below the condyles, anteriorly, is the tibial tuberosity, which serves as the attachment place for the patellar ligament. On the posterior surface of the lateral condyle is an articular surface for the head of the fibula.

Fibula

The fibula, the smaller of the two leg bones, is located on the lateral side of the leg. It is not a weight-bearing bone, but rather it acts as a splint for the tibia. It also serves as an attachment place for muscles and forms the lateral portion of the ankle joint. Like the tibia, it is a long bone with a shaft and two widened ends. The distal end of the fibula is shaped somewhat like a pyramid and contains the lateral malleolus, which extends downward to complete the ankle mortise.

The anteromedial border is called the interosseous crest. It is the portion of the fibula to which the interosseous membrane attaches. The superior, expanded end of the fibula is called the head. It articulates with the fibular articular surface of the lateral condyle of the tibia however, the head of the fibula does not enter into the formation of the knee joint.

411. Osteology of the knee and patella

The knee is classified as a diarthrodial (hinge-type) joint. It consists of the proximal articular surfaces of the tibia, the distal articular surfaces of the femur, and the patella. The tibiofemoral articulations are the parts most generally considered the “knee,” while the patella is thought of as a separate entity. Therefore, we will first consider the knee as it is classically described, and then the patella.

Knee

We have already discussed the proximal articular surface of the tibia, so let’s look at the femur. The distal articular surface of the femur consists of two large condyles—one medial and one lateral. They are separated by a large, tunnel-shaped notch, called the intercondyloid fossa. The distal portions of these condyles are smooth and convex to enable articulation with the tibial condyles. The articulations formed by the femoral and tibial condyles are referred to as the tibiofemoral (knee joint) joints (fig. 2–5).

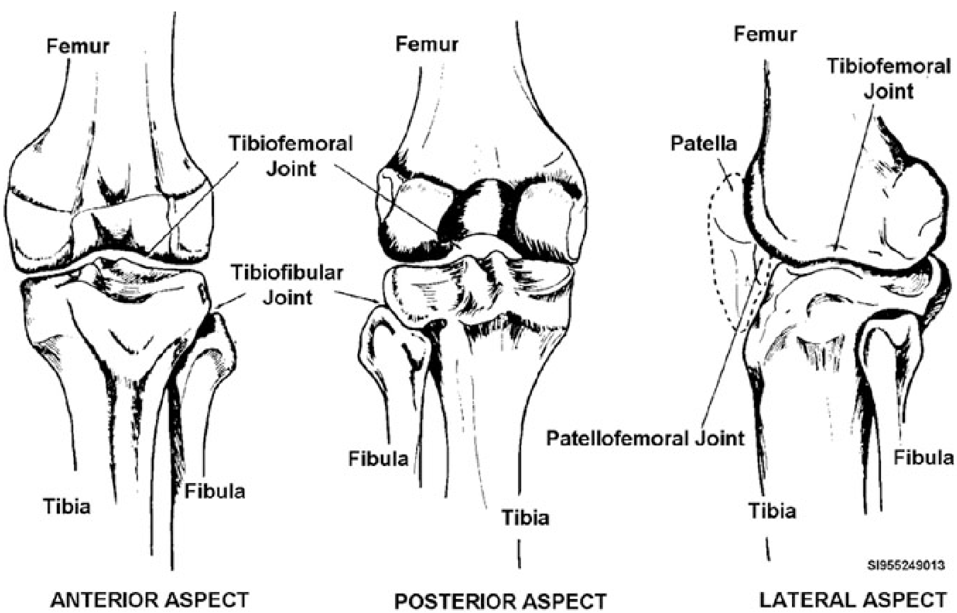


Figure 2–5. The knee.

Two rough elevations, one on the side of the lateral condyle and the other on the side of the medial condyle, superior to the articular surfaces of both, form the lateral and medial epicondyles, respectively. The collateral ligaments, which also join to the tibia to give the knee lateral stability, are attached to these epicondyles.

Patella

The largest sesamoid bone in the body is situated anterior to the knee joint; hence, its common name, "kneecap." It is regarded as a sesamoid bone because it is developed within a tendon, has an ossification center presenting a tuberculated outline, and is comprised of dense, cancellous tissue.

The patella is roughly diamond-shaped, with the apex (narrow inferior end) pointed down (fig. 2–6). The superior aspect (base) of the patella is round and much wider than the apex. The anterior surface is somewhat convex and is pitted by orifices that permit the passage of nutrient vessels. The superior surface of the posterior patella is divided into two articular facets to permit articulation with the slightly v-shaped articular surface of the anterior portion of the distal femur (fig. 2–5). The inferior surface is roughened for the attachment of the patellar ligament.

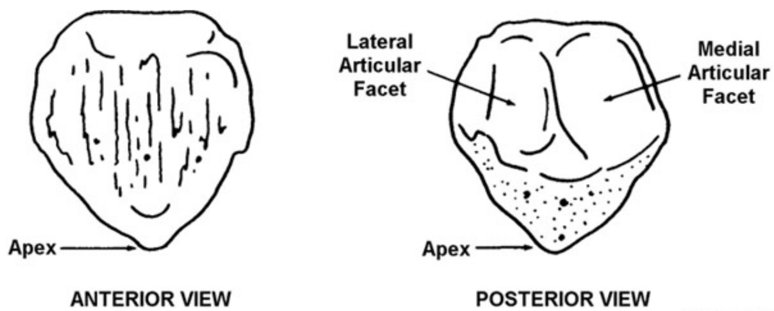


Figure 2–6. The patella.

The patella is superiorly housed in the expansion of the quadriceps femoris tendon (the large muscle group of the anterior thigh) and is inferiorly contained by the fiber of the patellar ligament. Both fibrous bands are continuous with each other, which accounts for the apparent "suspension" of the patella.

412. Osteology of the femur

The femur (thigh bone) extends from the knee joint to the hip joint. From the hip joint, the femur is directed somewhat medially and posteriorly so that, at the knee joint, it is near the center of gravity for the body. The femur, classified as a long bone, consists of a shaft and two widened ends. We have already discussed the distal end, so let's turn to the shaft. Refer to Figure 2–7 for our discussion.

Shaft

The shaft, or diaphysis, is the long, rounded portion of the bone that extends from the intertrochanteric crest, proximally, to just above the epicondyles, distally. It is broader at the ends than in the middle and is widest at the distal end.

The posterior surface of the shaft contains the linea aspera, a rough prominence that occupies the middle one-third. Several less prominent ridges extend above it, and below it, two prominent ridges extend downward to form the triangle on the distal portion of the posterior femoral shaft. The area within the triangle, deriving its name from the popliteal artery, is called the popliteal space.

Proximal end

The proximal end consists of the head, the neck, the greater trochanter, and the lesser trochanter. The lesser trochanter is a small, rounded prominence on the lower portion of the femoral neck. The greater trochanter is a large, palpable, irregular prominence that extends laterally and slightly posterior from the junction of the femoral neck with the femoral shaft. The *intertrochanteric crest* is the ridge of bone that extends obliquely downward from the greater trochanter to the lesser trochanter on the posterior aspect of the femur. A similar feature, the *intertrochanteric ridge,* is located on the anterior surface; it extends from the greater to the lesser trochanter. The intertrochanteric ridge, however, is not nearly as pronounced as the crest.

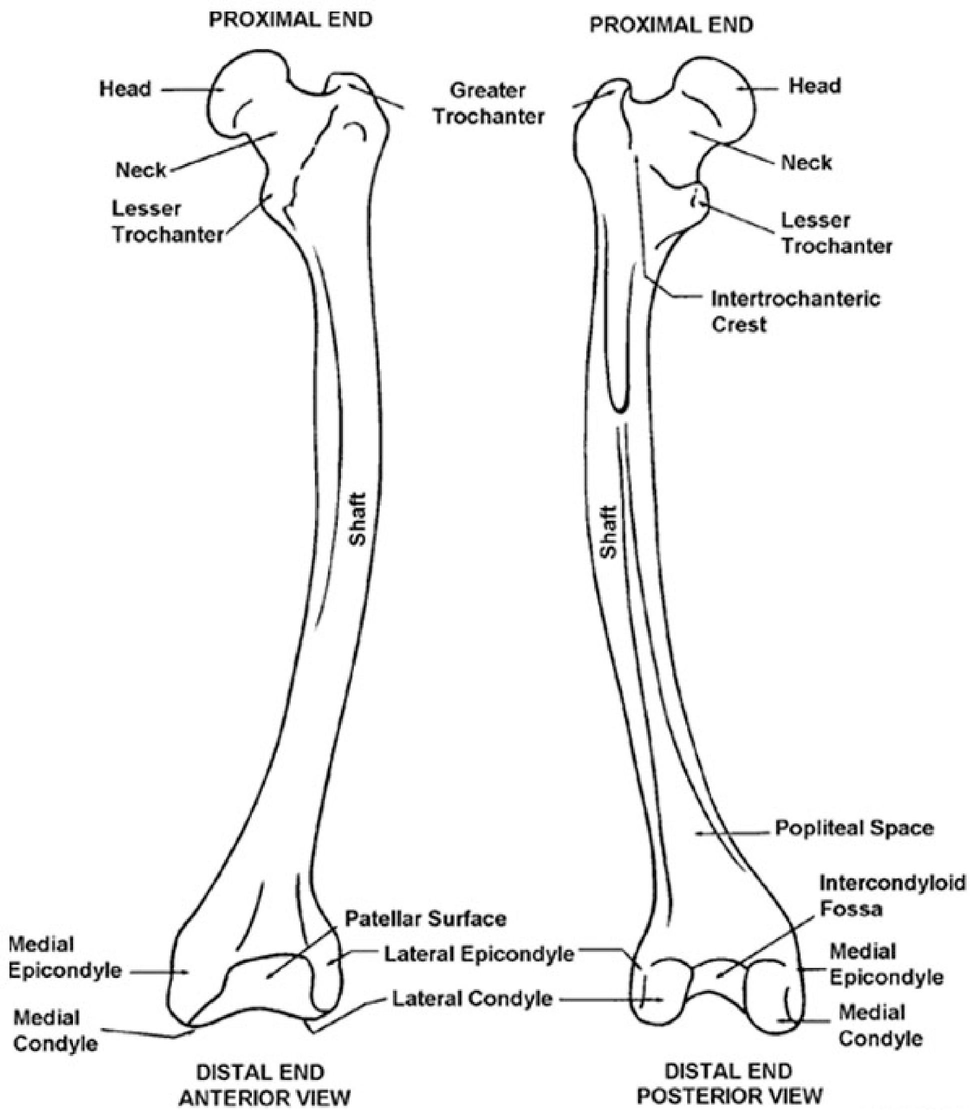


Figure 2–7. The femur.

The neck is the constricted portion that extends medially and superiorly from the shaft to unite the head with the body of the femur. The neck forms approximately a 130° angle with the femoral shaft. The head is the upper, rounded, expanded area that joins with the acetabulum to form the hip joint. Near the center of the head is an ovoid depression called the fovea capitis where the ligamentum teres attaches, fastening the femoral head to the acetabulum.

413. Osteology of the innominate bones and pelvis

The pelvic girdle consists of the two innominate bones, the pelvis, the sacrum, and the coccyx. It also contains five articulations consisting of both hips, both sacroiliac joints, and the symphysis pubis. We will investigate the bony parts first, and then the articulations.

Innominate bone

Each innominate bone (os coxae), commonly called the hip bone, is formed by the fusion of what were once three separate bones. In the adult skeleton, the two innominate bones form the anterior and lateral walls of the pelvic girdle (fig. 2–8).

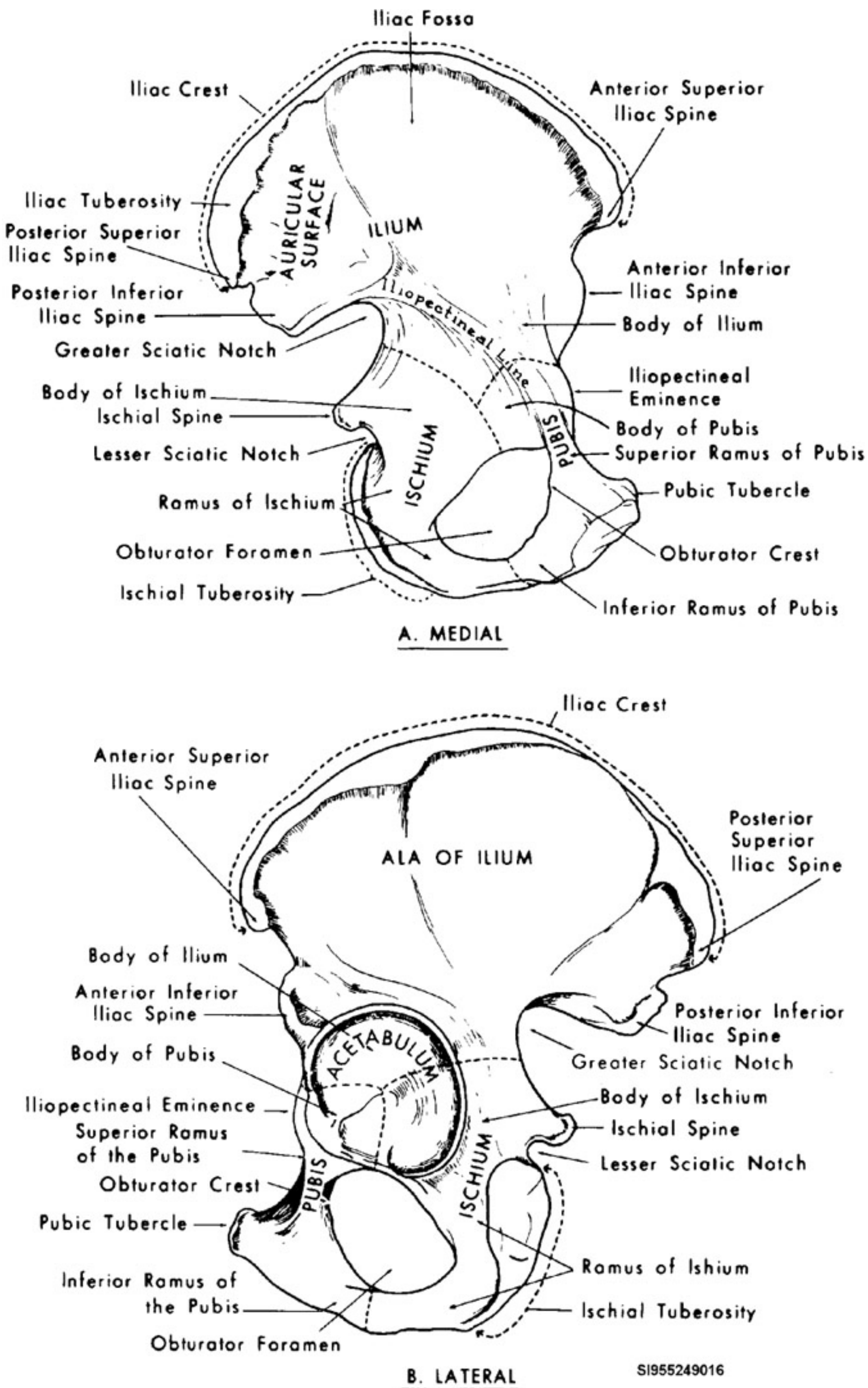


Figure 2–8. The innominate bone.

Ilium

The upper portion of the innominate bone is the ilium. The ilium forms the upper part of the acetabulum. Its major components and landmarks are the body, ala, iliac fossa, articular surface, iliac crest, anterior superior iliac spine (ASIS), anterior inferior iliac spine (AIIS), posterior superior iliac spine (PSIS), posterior inferior iliac spine (PIIS), and greater sciatic notch. The following table describes each of these components.

Parts of the Illium	
Component	**Description**
Body	The thick part of the bone just above the acetabulum.
Ala	From a Latin word meaning "wing", the upper, expanded, flat portion of the ilium.
Iliac fossa	A large area on the inside surface of the ala-bounded by the iliac crest superiorly and by the arcuate (or ileopectineal) line inferiorly.
Articular surface	Often called the auricular surface because of its "ear" shape, that part of the internal alar surface that articulates with the corresponding articular surface of the sacrum to form the sacroiliac joint.
Crest of the ilium (iliac crest)	The upper, curved border of the ala.
Anterior superior iliac spine	Easily palpable bony prominence located where the iliac crest joins the rest of the anterior iliac border.
Anterior inferior iliac spine	A bony prominence located on the anterior border at a level about 1 inch inferior to the anterior superior iliac spine.
Posterior superior iliac spine	Bony prominence located where the iliac crest joins the rest of the posterior border.
Posterior inferior iliac spine	Bony prominence directly inferior to the posterior superior iliac spine on the posterior border.
Greater sciatic notch	A large notch just below the posterior inferior iliac spine.

Ischium

The ischium is the lower posterior part of the innominate bone. Its major parts and landmarks are the body, ischial spine, lesser sciatic notch, superior ramus, ischial tuberosity, and inferior ramus. These components are described on the following table.

Parts of the Ischium	
Component	**Description**
Body	The ischium is the thick part of the bone directly behind and below the acetabulum. It also forms part of the acetabulum.
Ischial spine	A pointed prominence extending backward and medially from the posterior surface.
Lesser sciatic notch	A small notch just below the ischial spine.
Ramus	That part of the bone that descends from the ischial body.
Ischial tuberosity	The large expanded part located on the posterior surface of the ramus.

Pubis

The pubis forms the lower anterior part of the innominate bone. Its major parts and landmarks are the body, superior ramus, pubic tubercle, iliopectineal eminence, obturator crest, and inferior ramus. These parts, and several others, are explained in the following table.

Parts of the Pubis	
Component	**Description**
Body	Part of the anterior portion of the acetabulum.
Superior ramus	Somewhat triangular shaped, and extends upward and backward from the pubic body to the acetabulum.
Pubic tubercle	Often called the pubic spine; it is a small prominence located on the upper border of the pubic body.

Parts of the Pubis	
Component	**Description**
Iliopectineal eminence	Sometimes called the iliopubic eminence; it is a rough eminence marking the fusion site of the ilium and the pubis.
Obturator crest	The lower border of the superior ramus and extends from the pubic tubercle to the lower margin of the iliopectineal eminence in front of the acetabular notch. It is part of the obturator foramen.
Inferior ramus	Part of the bone that extends downward from the pubic body to join the ramus of the ischium.
Obturator foramen	A large hole between the ischium and the pubic bones.
Pubic arch	This is the arch formed by the ramus of the ischium and the inferior ramus of the pubis as they extend upward and join at the inferior aspect of the symphysis pubis. It is usually a broad, rounded curve in the female and a much smaller, narrower, inverted “v” shaped angle in the male.
Acetabulum	The cup-shaped depression that receives the head of the femur in forming the hip joint.

Pelvis

The pelvis is formed by the innominate bones, sacrum, and coccyx. The oval, bony ridge on the inner pelvic surface is the pelvic brim, the line separating the true and false pelvis. It begins at the superior border of the symphysis pubis and extends upward on both sides along the superior rami of the pubis and the arcuate (iliopectineal) lines until it meets at the center of the sacral promontory.

The false pelvis, often called the major or greater pelvis, is the part of the lower abdomen bounded by the pelvic brim and by the alae of the ilia on the sides. The true pelvis, also called the minor or lesser pelvis, is bounded above by the pelvic brim, behind by the sacrum and coccyx, and in front by the symphysis. These structures form the pelvic inlet and outlet (fig. 2–9).

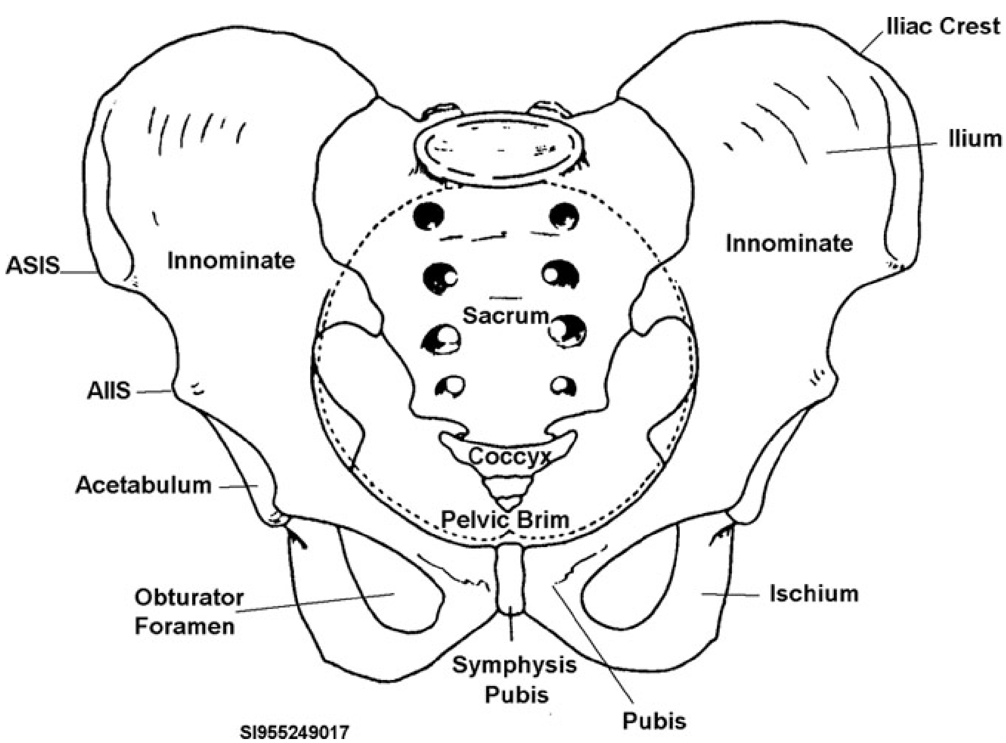


Figure 2–9. The pelvis.

Pelvic articulations

There are five articulations that occur in the pelvis: two hip joints, two sacroiliac joints, and one symphysis pubis. The hip joints are formed by the heads of the femurs articulating with the acetabulums of the innominates. They are classified as diarthrodial, ball-and-socket type joints that provide a wide range of motion for each lower extremity.

The sacroiliac (SI) joints are formed by the articulations of the articular (auricular) surfaces of the innominates with the lateral borders of the sacrum. As amphiarthrodial joints, they allow for some limited movement in the form of expansion and contraction of the true pelvis, especially during child birth.

The symphysis pubis is formed by the articulation of the pubic portion of both innominates. It is also an amphiarthrodial joint for the same reason as the S-I joints, it allows for slight expansion of the true pelvis during child birth.

414. Osteology of the sacrum and coccyx

The sacrum (fig. 2–10), although considered a single atypical vertebra, is formed by five atypical vertebrae, which until about age 18, are separated by cartilage. The coccyx, commonly called the tailbone, is the last segment of the vertebral column and is generally formed by the fusion of five atypical vertebral segments

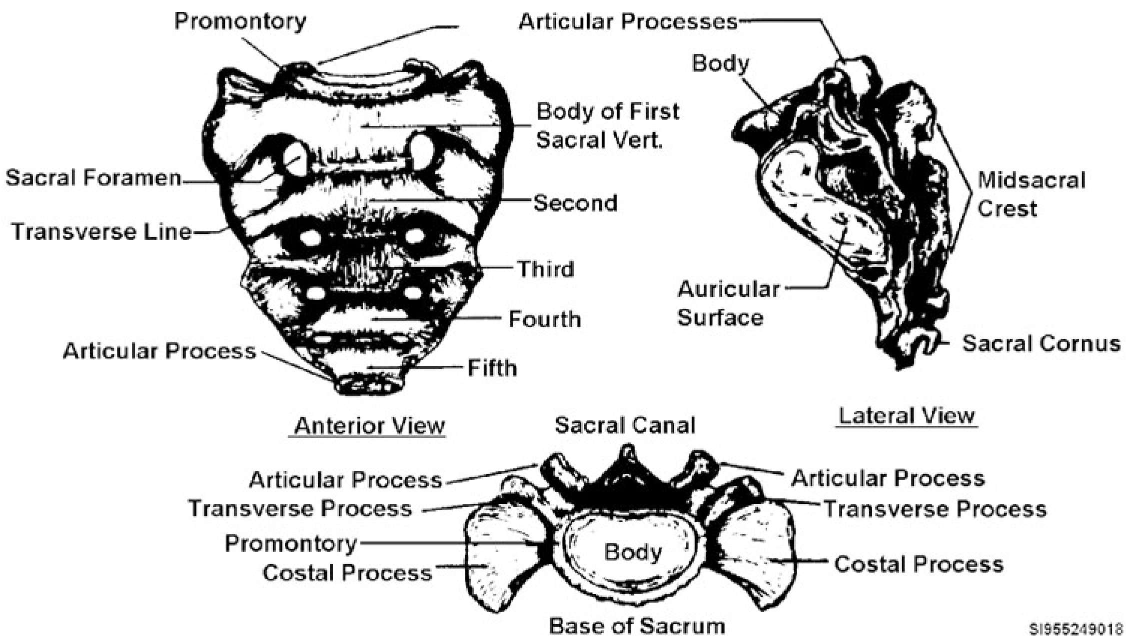


Figure 2–10. The sacrum.

Sacrum

The sacrum resembles a triangular wedge and is located between the two innominate bones at the lower part of the vertebral column directly below the lumbar vertebrae. In this location, it forms part of the posterior border of the pelvic cavity. Its main components and landmarks are its anterior surface, posterior surface, lateral surfaces, base, apex, and sacral canal. We will consider the anterior surface first.

The anterior surface is concave and has four transverse lines representing the original separation of the sacral vertebrae. Between these lines are the bodies of the vertebral segments. The first, or top, segment is the largest; the others become smaller as the sacrum descends. On the sides of the transverse lines are the sacral foramina, which provide passage for several nerves and blood vessels.

The posterior surface is convex and has a prominent ridge, the midsacral crest, descending from its midportion. The first sacral vertebra has superior articular facets with smooth articular surfaces that extend posterior and medially and articulate with the fifth lumbar vertebra. The inferior articular facets of the fifth sacral vertebra are round and extend downward to articulate with the articular processes of the first coccygeal vertebra. Laterally, from the articular crest, are the posterior sacral foramina.

The lateral surfaces, in regard to the posterior portion, have bilateral, ear-shaped surfaces, which articulate with the ilia to form the sacroiliac joints. As the lateral surfaces descend, they become narrower towards the extreme tip of the lateral surface or the inferolateral angle.

The base of the sacrum is formed by the superior surface of the sacral vertebra and has three parts—a middle section and two lateral surfaces. The middle section consists of an oval articular surface on the body of the first vertebra. This area has an important bony landmark called the promontory. The two lateral surfaces of the sacral base, often called the ala (wings) of the sacrum, are formed by the fused transverse processes.

The apex is the pointed, inferior part of the sacrum that joins with the coccyx. The sacral canal is located on the posterior part of the sacrum and extends from the first to the fifth vertebral segments. It is formed by the posterior aspect of the sacral vertebral bodies and the fusion of the laminae and spinous processes.

Coccyx

The coccyx, commonly called the tailbone, is the segment of the vertebral column and is generally formed by the fusion of four atypical vertebral segments. It has an anterior surface, a posterior surface, a base, and an apex (fig. 2–11). The anterior surface resembles the anterior surface of the sacrum because it is concave and has three transverse lines that mark the former separations between the coccygeal vertebrae.

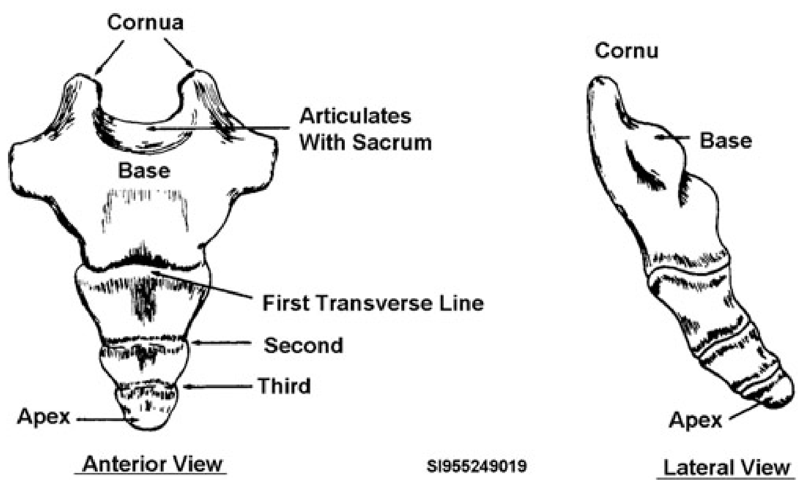


Figure 2–11. The coccyx.

The posterior surface of the coccyx resembles, in miniature, the posterior surface of the sacrum. Extending upward from the coccygeal base are two bony projections. The coccygeal cornua joins the sacral cornua of the sacral apex. The base is the superior surface of the first coccygeal vertebra. It joins with the apex of the sacrum. The apex is the extreme distal tip of the last coccygeal segment.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

408. Bones and joints of the toes and foot

1. Refer to figure 2–12. Identify the bones of the foot by placing the name of each bone or bone group next to the number below that corresponds to the number on the illustration.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

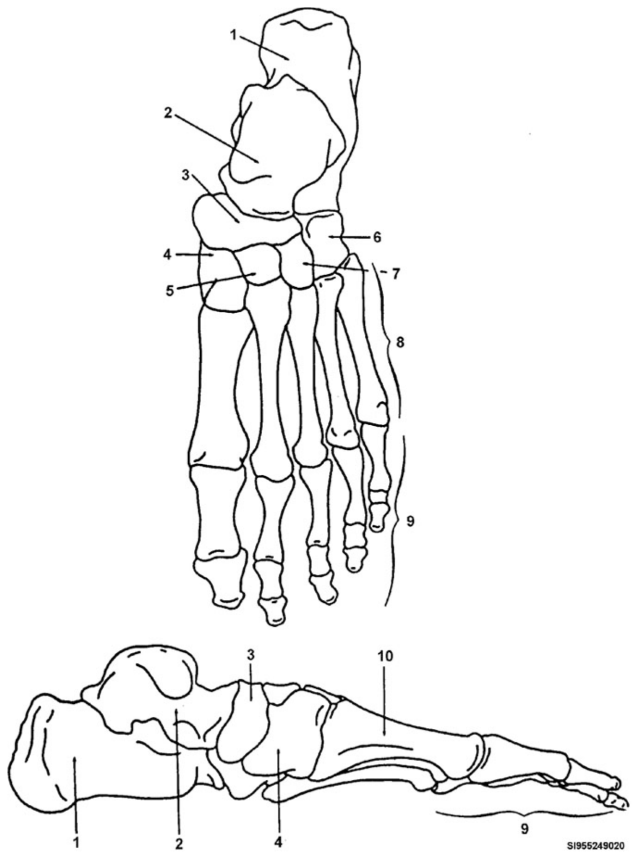


Figure 2–12. Objective 408, self-test question 1.

409. Structure of the ankle

1. What type of joint is the ankle?

2. What three bones make up the ankle joint?

3. On which bone is the medial malleolus?

4. On which bone is the lateral malleolus?

5. What carpentry term is used to describe the ankle joint?

6. Why are the angles formed by the ankle joint important?

410. Osteology of the lower leg

1. What two bones comprise the lower leg?

2. What is the most distal portion of the tibia?

3. What is another name for the lateral border of the tibia?

4. Name the major parts of the proximal tibia.

5. Where does the patellar ligament attach to the tibia?

6. What is the function of the fibula?

7. What is the most distal portion of the fibula?

8. Where is the head of the fibula?

411. Osteology of the knee and patella

1. Match the knee or patellar part in column B with the appropriate statement in column A. Each item in column B may be used once, more than once, or not at all.

Column A	*Column B*
____(1) Area between the femoral condyles.	a. Articular facets.
____(2) The tibiofemoral articulations.	b. Anterior surface of the patella.
____(3) Articulate with tibial condyles.	c. Apex.
____(4) Elevation on lateral side of femoral condyle.	d. Epicondyle.
____(5) Inferior portion of patella.	e. Patella.
____(6) Joins with V-shaped articular surface of femur.	f. Intercondyloid fossa.
____(7) Pitted to permit passage of nutrient vessels.	g. Knee joint.
____(8) Superior portion of patella.	h. Femoral condyles.
____(9) Attachment point for collateral ligament.	i. Base.
____(10) Suspended between the quadriceps femoris tendon and the patellar ligament.	j. Tibial eminence.

412. Osteology of the femur

1. Name the roughened prominence on the middle third of the posterior aspect of the femur.

2. Where is the popliteal space?

3. Describe the intertrochanteric crest.

4. In what direction and angle does the femoral neck extend from the shaft of the femur?

5. What is the name of the depression on the center of the femoral head?

6. What fastens the femoral head to the acetabulum?

413. Osteology of the innominate bones and pelvis

1. Refer to figure 2–13. Label the diagram of the pelvis by placing the name of the structure next to the number below that corresponds with the illustration.

    1. ________________________
    2. ________________________
    3. ________________________
    4. ________________________
    5. ________________________
    6. ________________________
    7. ________________________
    8. ________________________
    9. ________________________
    10. ________________________
    11. ________________________

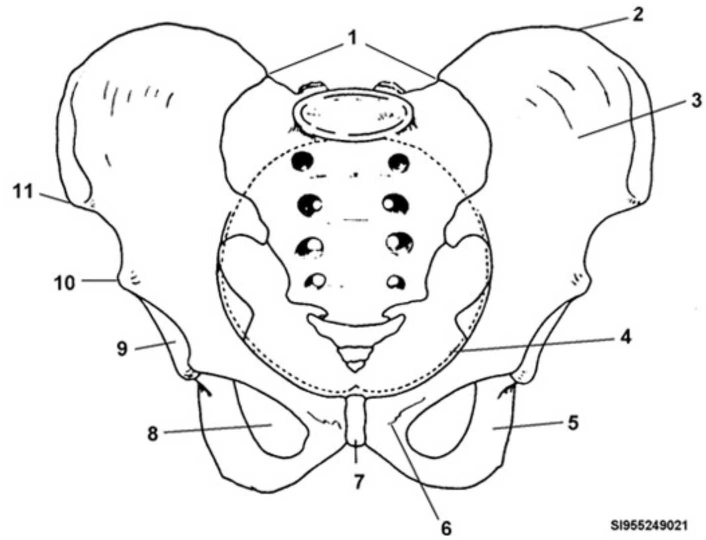


Figure 2–13. Objective 413, self-test question 1.

414. Osteology of the sacrum and coccyx

1. How many atypical vertebrae form the sacrum?

2. What is the function of the sacral foramina?

3. Where is the midsacral crest located?

4. With what vertebra do the superior articular facets of the sacrum articulate?

5. What is the sacral promontory, and where is it located?

6. How many atypical vertebrae fuse to form the coccyx?

7. Name the two bony projections that extend superiorly from the coccygeal base.

8. What is the name of the extreme distal tip of the last coccygeal segment?

2–2. The Upper Extremity and Shoulder Girdle

This section covers osteology of the upper appendicular skeleton. Specifically, we will discuss the fingers, hand, wrist, forearm, elbow, humerus, and shoulder girdle.

415. Osteology of the fingers, hand, and wrist

Nineteen bones form the hand. They are divided into two groups—the phalanges, which form the fingers, and the metacarpals, which form the palm.

Phalanges

The phalanges of the hand are arranged and identified in the same manner as the phalanges of the foot. Each finger (digit) has three phalanges, except the thumb, which has two. Each phalanx has a body, a head or distal end, and a base or proximal end. The phalanges are not named but are identified by their location and number, counted from the thumb to the little finger (fig. 2–14). For example, the phalanx of the thumb nearest the palm is the proximal phalanx of the first digit; the middle phalanx of the middle finger is the middle phalanx, third digit; and the distal phalanx of the little finger is the distal phalanx, fifth digit. The distal phalanges are distinguished by their small size and the ungual tuberosity (tuft) at their distal ends.

Metacarpals

The five metacarpals are the long bones that form the palm of the hand. Each has a body, head (distal end), and base (proximal end). The metacarpals do not have names, but are identified by the numbers 1 through 5, counted from the thumb to the little finger (fig. 2–14). The first metacarpal is shorter and wider than the others.

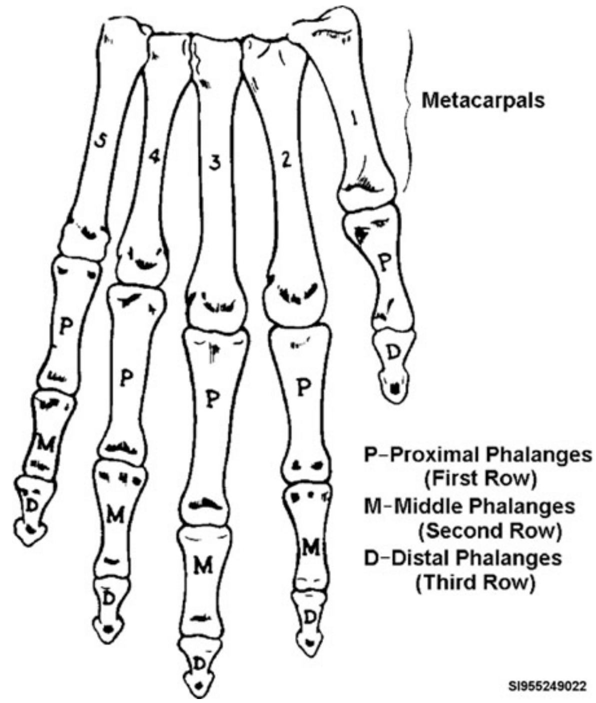


Figure 2–14. The fingers and hand.

Wrist

The wrist, or carpus, is comprised of eight bones arranged in proximal and distal rows (fig. 2–15). The carpals, classified as short bones, are cube-shaped and identified by name. When listed, they are usually identified from lateral to medial beginning in the proximal row. Most of them are referred to by more than one name. The outstanding characteristics of the carpal bones are:

1. Each one, except the pisiform, has six surfaces.
2. The superior surfaces are somewhat convex, the inferior surfaces are concave.
3. The outer surfaces are either articular surfaces or roughened surfaces to provide attachment for ligaments.

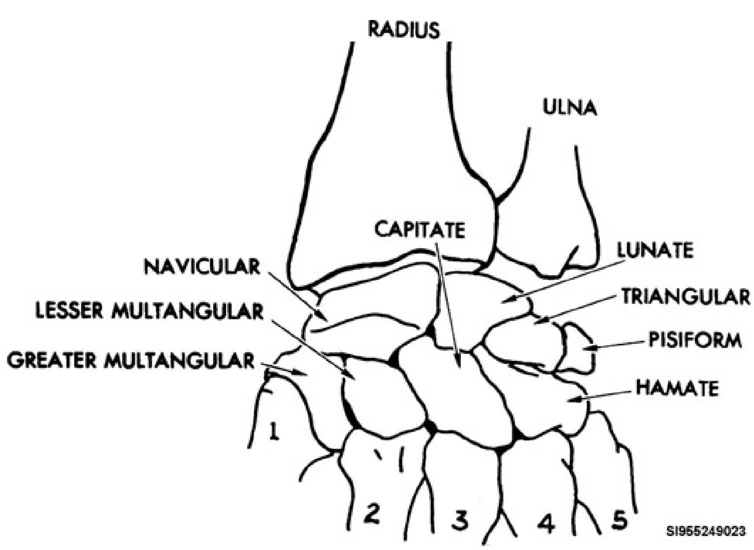


Figure 2–15. The wrist.

The following table describes each of the carpals.

Parts of the Carpals	
Component	**Description**
Navicular (scaphoid)	This bone is the largest carpal in the proximal row. It is located on the lateral aspect of this row. Because this is the most frequently fractured carpal bone, many departments include a special projection for the navicular as part of their standard wrist series.
Lunate (semilunar)	This carpal is located in the center of the proximal row between the navicular and triangular.
Triangular (triquetral or cuneiform)	This bone is located on the medial, or ulnar, side of the proximal row. It is distinguished by its triangular shape.
Pisiform	This is the smallest carpal bone and the last to ossify at approximately age 10. It lies slightly lateral and anterior to the triangular, and can be seen projecting anteriorly on a lateral view of the wrist.
Greater multangular (trapezium)	This carpal is on the lateral, or radial, aspect of the distal row of carpal bones. It has a small tubercle projecting from its anterior surface.
Lesser multangular (trapezoid)	This is the smallest bone of the distal row. Its shape resembles that of a wedge.
Capitate (os magnum)	This is the largest carpal bone. It forms the center of the wrist.
Hamate (unciform)	This carpal is located on the medial, or ulnar, side of the distal row. It is somewhat wedge-shaped and has a hook-like (hamular) process that rises from its anterior surface.

416. Osteology of the forearm

The forearm extends from the wrist to the elbow and consists of two bones, the ulna and the radius. We will consider the ulna first. Coordinate your reading of this material by locating the forearm features in figure 2–16.

Ulna

The ulna, located on the medial side of the forearm, is classified as a long bone with a shaft and both distal and proximal articular ends. It tapers from the proximal to the distal end, and the distal end bends laterally to form a slight bow. The distal end is much smaller than the proximal end and has two outstanding landmarks—the head and styloid process.

The shaft, somewhat rounded at its proximal end, becomes increasingly smaller toward its distal end. A rough wedge on the lateral aspect is the interosseous border, to which the interosseous membrane is attached, fastening the ulna to the radius.

On the proximal end are these prominent landmarks:

1. The radial notch—an oblong depression in the lateral side of the coronoid process.
2. The coronoid process—a large, pyramidal projection from the anterior surface.
3. The semilunar notch—the arched depression extending between the olecranon and coronoid processes.
4. The olecranon process—a large, curved eminence whose purpose is to prevent the elbow from hyperextending.

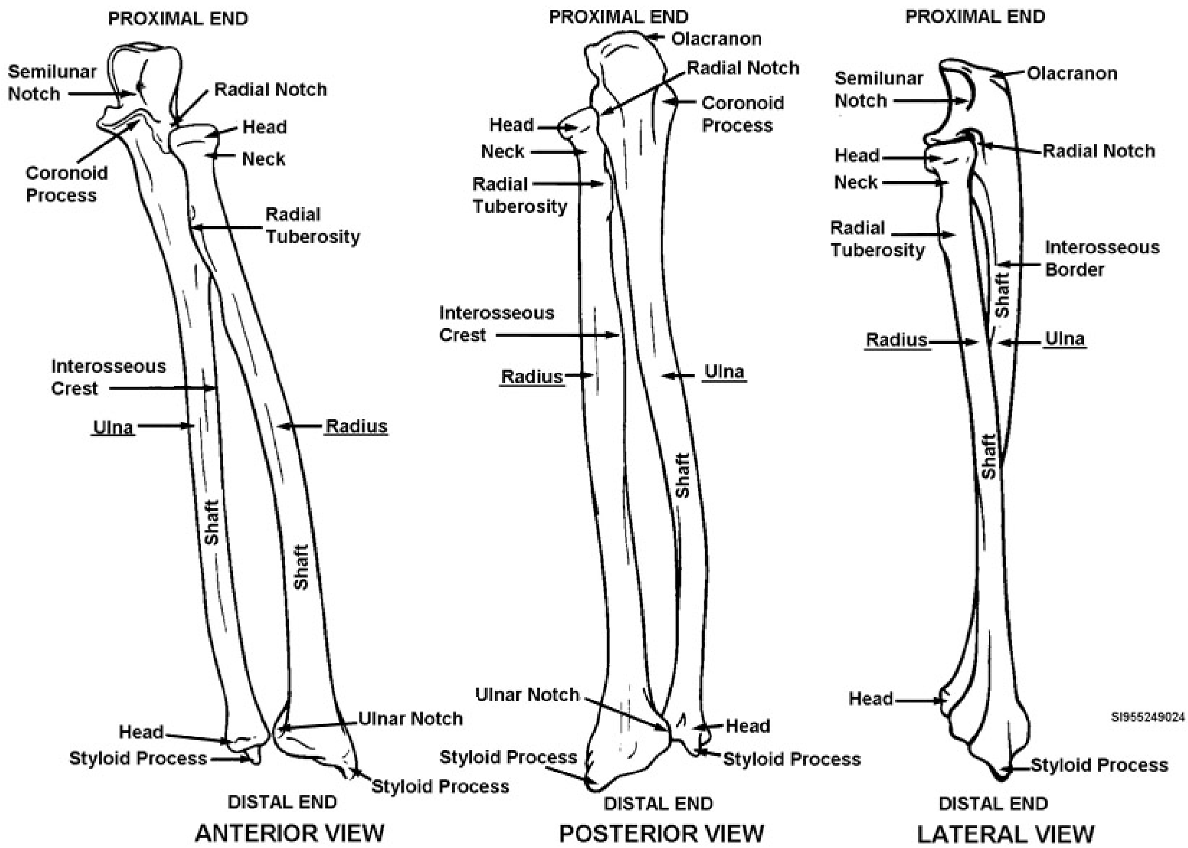


Figure 2–16. The forearm.

Radius

The radius, also shown in Figure 2–16, is the lateral bone of the forearm. Like the ulna, it is a long bone with a shaft and both distal and proximal articular ends. In contrast to the ulna, it tapers from the distal to the proximal end. Prominent landmarks on the distal end are the ulnar notch—a small depression on the medial side, and the styloid process—a conical projection of bone on the lateral side.

The shaft becomes larger as it approaches the distal end and has a slight lateral curvature. The interosseous crest forms the sharp medial side of the shaft.

The proximal end consists of the following:

1. The radial tuberosity—located on the medial side of the neck.
2. The neck—a round, smooth, constricted portion distal to the head.
3. The head—a cup-shaped, disc-like structure for articulation with the capitulum of the humerus.

417. Osteology of the humerus and elbow

The elbow is formed by the articulation of the proximal portions of the ulna and radius and the distal portion of the humerus. Since we have already discussed the proximal radius and ulna, let’s look at the distal humerus.

Distal humerus

The flared, distal end of the humerus (fig. 2–17) presents five surfaces—lateral, medial, anterior, posterior, and inferior—that help form the elbow joint.

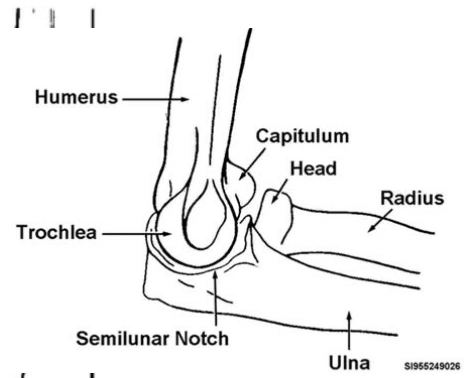
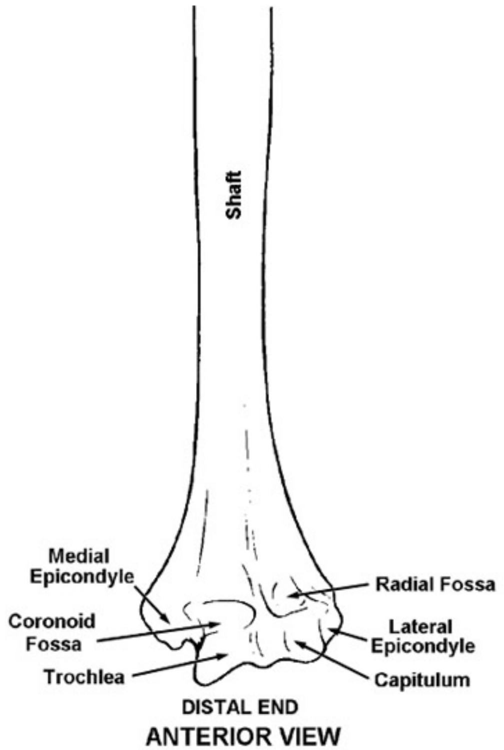


Figure 2–18. The elbow.



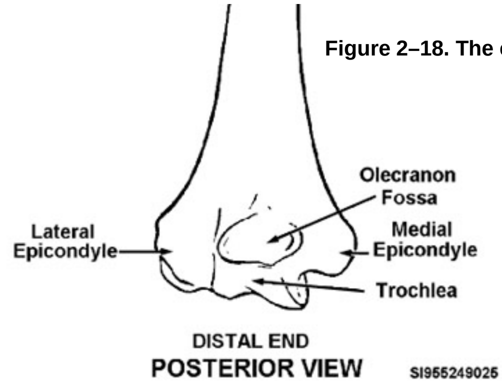


Figure 2–17. The distal end of the humerus.

The anterior and inferior surfaces comprise the articular surface. This surface is divided into two parts by a slight ridge that has two articulating structures. The medial aspect is formed by the trochlea, a “spool-shaped” structure between two well-marked borders. The lateral portion consists of the capitulum—a smooth, rounded eminence marked by a slight groove on its medial aspect.

Directly above the capitulum on the anterior surface is the radial fossa—a small, smooth depression that accepts the head of the radius during hyperflexion. Medial to this fossa and directly above the trochlea is the coronoid fossa that accepts the coronoid process of the ulna during flexion.

The medial aspect of the distal humerus is formed by the medial epicondyle. This radiographic positioning landmark is a tubercular eminence, larger and more prominent than its lateral counterpart, to which are attached various ligaments, tendons, and muscles. The lateral epicondyle, though it serves the same purpose, is smaller.

The posterior portion of the distal humerus is characterized by a deep depression—the olecranon fossa—just above the posterior aspect of the trochlea. The purpose of this fossa, as its name suggests, is to accept the olecranon process of the ulna and help prevent hyperextension of the elbow. This fossa, the trochlea, capitulum, and both coronoid and radial fossae are covered by a synovial membrane. They form the superior aspect of the articular capsule of the elbow.

Elbow joint

The elbow is formed by articulation of the ulna, radius, and humerus. The head of the radius articulates with the capitulum of the humerus and with the radial notch on the lateral aspect of the coronoid process of the ulna.

The trochlea articulates with the semilunar notch of the ulna. In extreme hyperflexion, the medial margin of the radial head is received by the radial fossa on the anterior surface of the distal humerus, and the tip of the coronoid process is received by the coronoid fossa. In extension, the olecranon process is received by the olecranon fossa. Both epicondyles give attachment to the ligaments that bind the joint together (fig. 2–18).

Proximal humerus

The humerus is the bone of the upper arm. It extends distally from the shoulder to the elbow. It is the largest bone of the upper extremity and is classified as a long bone. Since we have previously discussed the distal humerus, we will begin with the shaft (fig. 2–19).

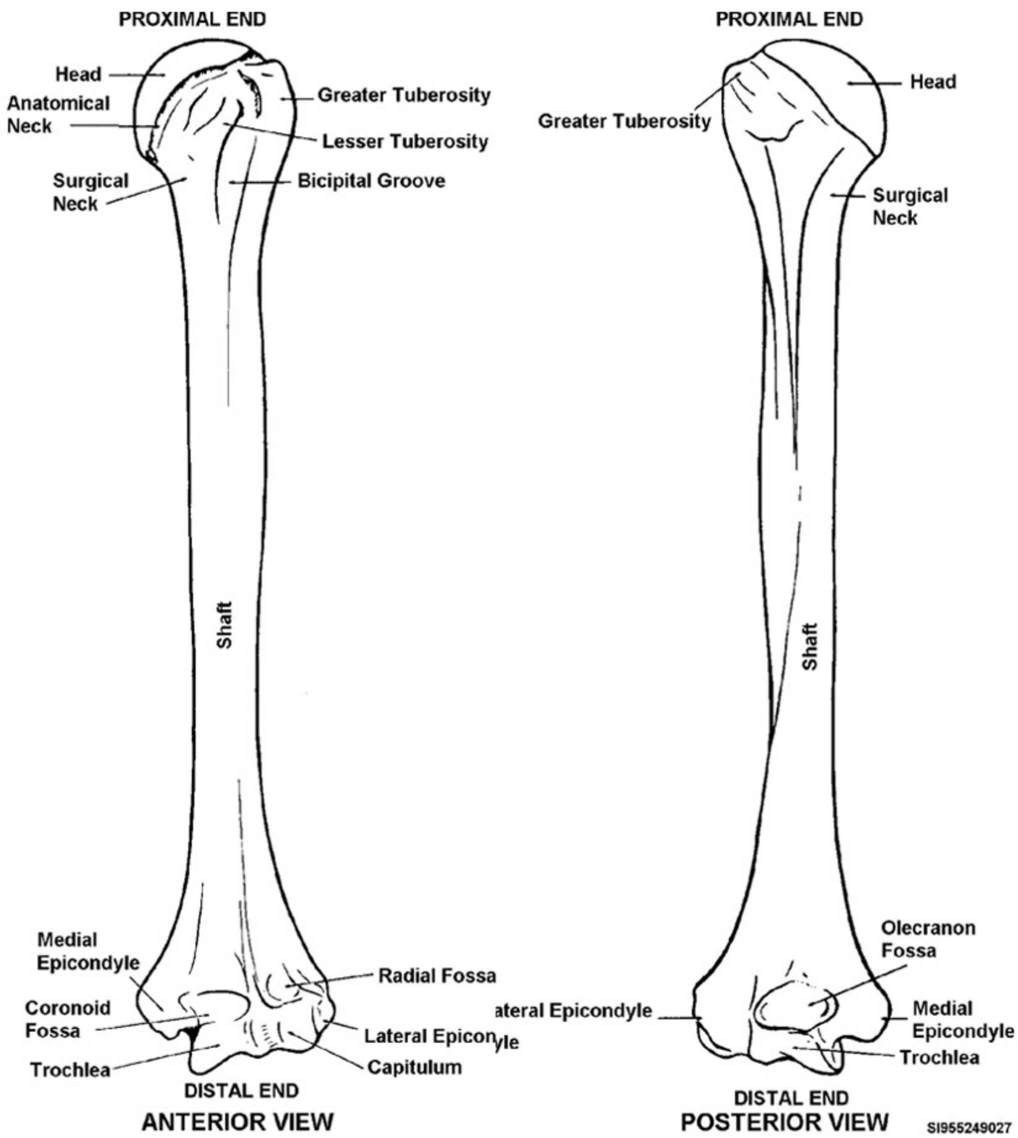


Figure 2–19. The humerus.

Shaft

The shaft, or diaphysis, extends from the tuberosities to the olecranon and coronoid fossae. It is round at the proximal end and becomes flattened toward the distal end.

Proximal end

There are several elements in the proximal end of the humerus. The surgical neck is the constricted portion of the humerus below the tuberosities and comprises the proximal one-third of the shaft. The surgical neck received its name because it is a common fracture site for the proximal humerus.

The lesser tuberosity is a bony eminence located on the anterior surface of the proximal humerus just below the anatomical neck. The greater tuberosity is a rounded eminence on the lateral side of the proximal end just below the anatomical neck. It is an insertion place for the spinatus muscles. The bicipital groove is a deep furrow located on the anterior surface of the proximal humerus between the greater and lesser tuberosities. It runs distally in a slightly medial direction, ending about one-third of the way down the shaft. It is deeper at the proximal end than at the distal.

The anatomical neck is located between the greater and lesser tuberosities and the head. It connects the head with the shaft. The head is the uppermost portion of the humerus and sits obliquely on the proximal, medial surface of the bone directed slightly posterior.

418. Osteology of the shoulder girdle

The shoulder girdle consists of two bones—the clavicle and scapula. We will examine the clavicle, then the scapula, and finally the joint itself.

Clavicle

The clavicle, commonly called the collarbone, is a long bone located on the superior anterolateral portion of the thorax (fig. 2–20).

1. The sternal end—medial portion.
2. The acromion end—the lateral portion.
3. The coracoid tuberosity—a rough eminence located on the posterior border of the lateral third of the bone.
4. The costal tuberosity—a raised area located on the inferior aspect of the medial third of the bone.

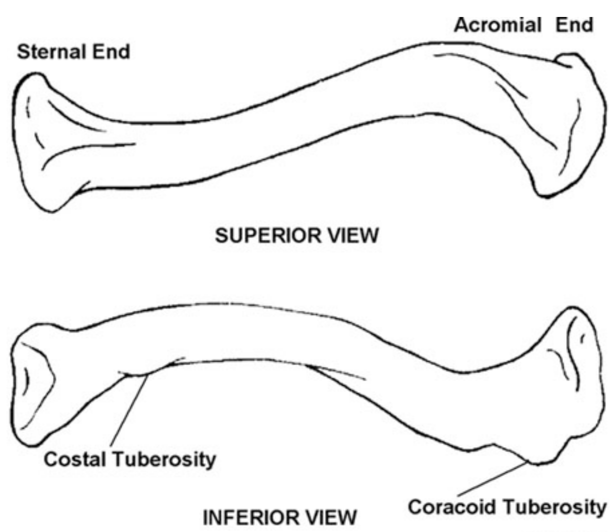


Figure 2–20. The clavicle.

Scapula

The scapula, or shoulder blade, is a flat, triangular-shaped bone located on the posterior superolateral part of the thorax, extending inferiorly from the level of the second rib to about the level of the eighth rib. It forms the posterior part of the shoulder girdle and is connected to the chest wall by muscle only. It has two surfaces, three borders, three angles, and the following other landmarks that are important in radiographic studies: subscapular fossa, scapular spine, supraspinatus fossa, infraspinatus fossa, acromion process, neck of the scapula, glenoid fossa, and coracoid process (fig. 2–21).

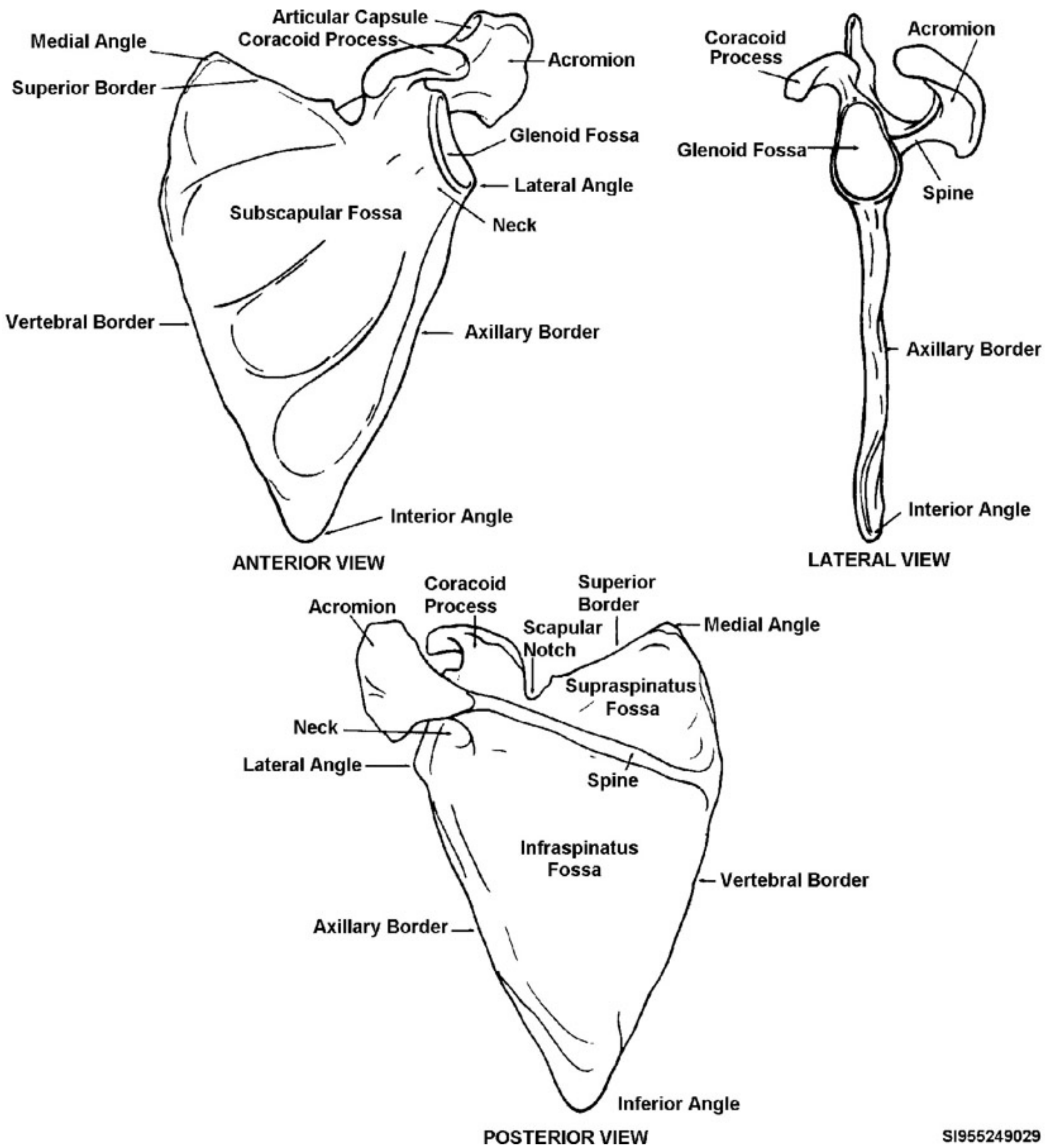


Figure 2–21. The scapula.

The anterior or costal surface of the scapula is concave. This concavity is called the subscapular fossa. The medial two-thirds of the anterior surface contains ridges that begin at the vertebral border and extend superior and laterally.

The posterior or dorsal surface of the scapula is slightly arched. The spine of the scapula is a projecting plate of bone running superior and laterally from the vertebral border ending in the acromion process. The area above the spine is the supraspinatus fossa; the area below is the infraspinatus fossa.

The scapula has three borders: superior, axillary, and vertebral. The shortest and thinnest is the superior, which is concave and extends from the medial angle to the coracoid base. The coracoid process resembles a bent forefinger and extends anterior and laterally from the neck of the scapula. At the base of the coracoid process, where the superior border meets the base, is the scapular notch.

The three angles frequently used as anatomical landmarks are the medial, lateral, and inferior angles. The medial angle is formed where the superior and vertebral borders intersect. The lateral angle, also known as the head, is located laterally on the superior part of the axillary border. The lateral angle contains the glenoid fossa—a cup-shaped depression designed to articulate with the head of the humerus. The inferior angle is formed by the junction of the axillary and vertebral borders.

Joints of the shoulder

There are two joints in the shoulder that are of particular interest to radiographers:

1. The glenohumeral or shoulder joint—a diarthrodial—ball and socket type joint.
2. The acromioclavicular (AC) joint, which is amphiarthrodial.

The shoulder joint is formed by the head of the humerus and the glenoid fossa of the scapula. The AC joint is formed by the acromion process of the scapular spine and the lateral end of the clavicle (fig. 2–22).

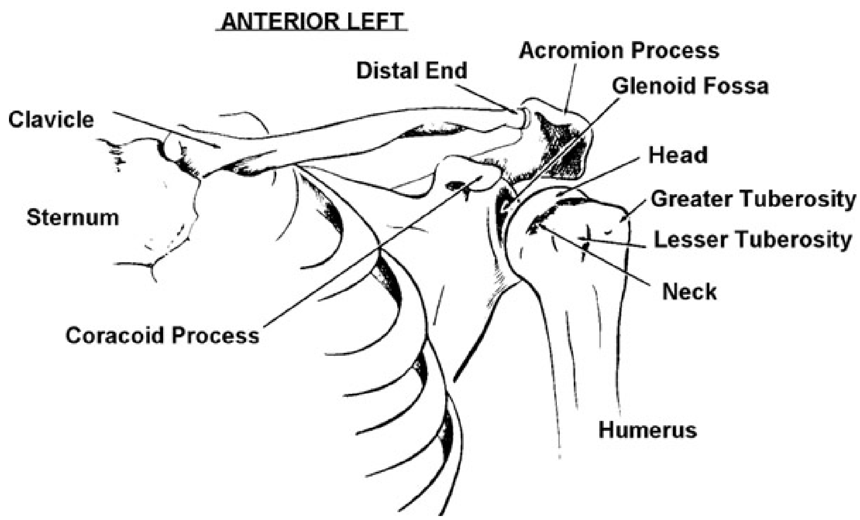


Figure 2–22. The shoulder.

The acromion process is a triangular projection at the lateral end of the scapular spine that extends slightly anteriorly over the shoulder joint. The glenoid fossa is the oval depression on the outer part of the scapular head at the lateral angle. It forms one-half of the shoulder joint.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

415. Osteology of the fingers, hand, and wrist

1. Are the heads of the phalanges proximal or distal?

2. Refer to figure 2–23. Label the diagram of the hand by placing the name of the structure next to the letter (below) that corresponds to the illustration.

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

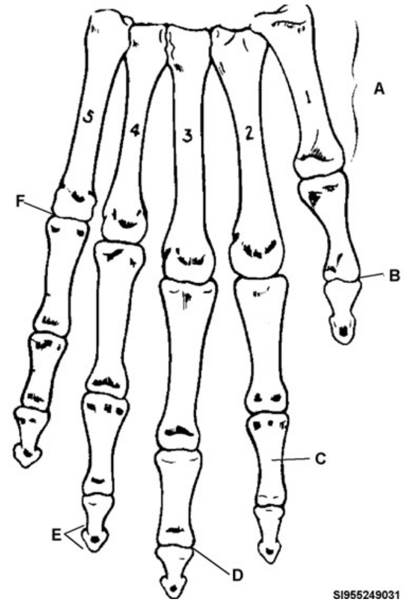


Figure 2–23. Objective 415, self-test question 2, A–F.

3. Refer to figure 2–24. Label the diagram of the wrist by placing the name of the structure next to the letter (below) that corresponds to the illustration.

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

G. ____________________

H. ____________________

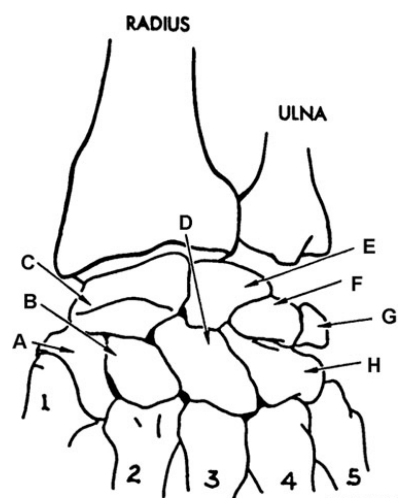


Figure 2–24. Objective 413, self-test question 3, A–H.

4. What is the most frequently fractured carpal bone?

5. What is the smallest carpal bone?

416. Osteology of the forearm

1. Match the forearm bone in column B with the information in column A. Each item in column B may be used more than once.

Column A	*Column B*
____(1) Larger distal end.	a. Radius.
____(2) Coronoid process.	b. Ulna.
____(3) Radial notch.	
____(4) Semilunar notch.	
____(5) Radial tuberosity.	
____(6) Olecranon process.	
____(7) Medial bone.	

417. Osteology of the humerus and elbow

1. Name the two structures on the articular surface of the distal end of the humerus.

2. What is the function of the humeral epicondyles?

3. What two structures work together to prevent hyperextension of the elbow?

4. With what structure on the humerus does the radial head articulate?

5. With what structure does the semilunar notch articulate?

6. Describe the surgical neck of the humerus.

7. Describe the lesser tuberosity.

8. What is the name of the depression on the anterior surface of the proximal humerus between the greater and lesser tuberosities?

418. Osteology of the shoulder girdle

1. What is the medial portion of the clavicle?

2. Give the names of the two tuberosities of the clavicle.

3. What area is directly above and what area is directly below the scapular spine?

4. What is the name of the finger-like projection that extends anterior and laterally from the neck of the scapula?

5. On which border is the scapular notch?

6. Which scapular angle is formed by the junction of the vertebral and axillary borders?

7. What two structures form the shoulder joint?

8. What two structures form the AC joint?

9. What is the name of the large process at the lateral portion of the scapular spine?

10. Name the oval depression at the lateral scapular angle.

Answers to Self-Test Questions

408

1. (1) Calcaneus.
   (2) Talus (astragulus).
   (3) Navicular (scaphoid).
   (4) First cuneiform.
   (5) Second cuneiform.
   (6) Cuboid.
   (7) Third cuneiform.
   (8) Metatarsals.
   (9) Phalanges.
   (10) First metatarsal.

409

1. A diarthrodial, hinge-type joint.
2. The tibia, fibula, and talus (astragulus).
3. The tibia.
4. The fibula.
5. Mortise.
6. They are important for weight-bearing and mobility.

410

1. The tibia and fibula.
2. The medial malleolus.
3. The interosseous crest.
4. The superior articular surface, the medial and lateral condyles, the intercondylar eminence, and the tibial tuberosity.
5. The tibial tuberosity.
6. Acts as a splint for the tibia, as well as serving as an attachment point for muscles and providing lateral stability for the ankle.
7. The lateral malleolus.
8. The superior (proximal end).

411

1. (1) f.
   (2) g.
   (3) h.
   (4) d.
   (5) c.
   (6) a.
   (7) b.
   (8) i.
   (9) d.
   (10) e.

412

1. The linea aspera.
2. On the distal portion of the posterior femoral shaft.

3. It is the ridge of bone that extends obliquely downward from the greater trochanter to the lesser trochanter on the posterior aspect of the femur.
4. It extends medially and superiorly from the shaft at an approximate 130° angle.
5. The fovea capitis.
6. The ligamentum teres.

413

1. (1) Sacroiliac joints.
   (2) Iliac crest.
   (3) Ilium.
   (4) Pelvic brim.
   (5) Ischium.
   (6) Pubis.
   (7) Symphysis pubis.
   (8) Obturator foramen.
   (9) Acetabulum.
   (10) Anterior inferior iliac spine.
   (11) Anterior superior iliac spine.

414

1. Five.
2. Passageways for nerves and blood vessels.
3. In the middle of the posterior surface.
4. L5 (the fifth lumbar vertebra).
5. A bony prominence on the anterior portion of the first sacral segment.
6. Four.
7. The coccygeal cornua.
8. The apex.

415

1. Distal.
2. (1) A. Metacarpals.
   (2) B. Interphalangeal joint, first digit.
   (3) C. Middle phalanx, second digit.
   (4) D. Distal interphalangeal joint.
   (5) E. Ungual tuft, fourth digit.
   (6) F. Metacarpal-phalangeal joint, fifth digit.
3. (1) A. Greater multangular.
   (2) B. Lesser multangular.
   (3) C. Navicular.
   (4) D. Capitate.
   (5) E. Lunate.
   (6) F. Triangular.
   (7) G. Pisiform.
   (8) H. Hamate.
4. The navicular.
5. The pisiform.

416

1. (1) a.
   (2) b.
   (3) b.
   (4) b.
   (5) a.
   (6) b.
   (7) b.

417

1. The capitulum and trochlea.
2. Attachment points for ligaments, tendons, and muscles.
3. The olecranon process and the olecranon fossa.
4. The capitulum.
5. The trochlea.
6. The constricted portion of the humerus below the tuberosities and comprises the proximal one-third of the shaft.
7. A bony eminence located on the anterior surface of the proximal humerus just below the anatomical neck.
8. The bicipital groove.

418

1. Sternal end.
2. Costal tuberosity and the coracoid tuberosity.
3. Supraspinatus fossa and the infraspinatus fossa.
4. The coracoid process.
5. The superior border.
6. The inferior angle.
7. The humeral head and the glenoid fossa.
8. The acromion process and the lateral end of the clavicle.
9. The acromion process.
10. The glenoid fossa.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

9. (408) Which bone forms the heel of the foot?
   a. Talus.
   b. Os calcis.
   c. Astragulus.
   d. Tarsal scaphoid.

10. (409) Which bones form the ankle joint?
    a. Talus, tibia, and fibula.
    b. Tibia, fibula, and os calcis.
    c. Scaphoid, tibia, and fibula.
    d. Talus, calcaneus, and tibia.

11. (410) Which structures are located on the proximal portion of the tibia?
    a. Medial malleolus and apex.
    b. Tibial tuberosity and popliteal region.
    c. Intercondylar eminence and tibial tuberosity.
    d. Intercondylar eminence and lateral malleolus.

12. (411) Where do the collateral ligaments attach to the femur?
    a. Condyles.
    b. Epicondyles.
    c. Intercondyloid fossa.
    d. Intercondyloid eminences.

13. (412) The rough prominence on the posterior surface of the mid-shaft of the femur is called the
    a. linea aspera.
    b. fovea capitis.
    c. popliteal ridge.
    d. intertrochanteric crest.

14. (412) Identify the structures located on the proximal portion of the femur.
    a. Trochanters, head, and neck.
    b. Head, trochanters, and intercondyloid eminence.
    c. Popliteal space, trochanters, and fovea capitis.
    d. Condyles, intertrochanteric crest, and intertrochanteric line.

15. (412) What is the name of the ligament that attaches the femoral head to the acetabulum?
    a. Cruciate ligament.
    b. Ligamentum teres.
    c. Ligament of Treitz.
    d. Falciform ligament.

16. (413) The pelvis is comprised of
    a. ilium, ischium, and pubis.
    b. ilium, ischium, pubis, and acetabulum.
    c. innominate bones, sacrum, and coccyx.
    d. innominate bones, sacrum, and symphysis pubis.

17. (413) The bony ridge that divides the true pelvis from the false pelvis is called the
    a. pubic arch.
    b. pelvic brim.
    c. arcuate line.
    d. iliopectineal eminence.

18. (414) The sacrum is formed from
    a. four atypical vertebrae.
    b. five atypical vertebrae.
    c. four typical vertebrae.
    d. five typical vertebrae.

19. (415) Where in the wrist is the scaphoid located?
    a. Lateral side of the distal row.
    b. Medial side of the distal row.
    c. Lateral side of the proximal row.
    d. Medial side of the proximal row.

20. (415) Another name for the greater multangular bone is
    a. triquetral.
    b. cuneiform.
    c. trapezium.
    d. trapezoid.

21. (416) What bony structure prevents the elbow from hyperextending?
    a. Trochlea.
    b. Radial notch.
    c. Coronoid process.
    d. Olecranon process.

22. (416) Which bony structures are located on the proximal portion of the radius?
    a. Base and ulnar notch.
    b. Neck and radial notch.
    c. Head and radial tuberosity.
    d. Ulnar notch and capitulum.

23. (417) Which structure articulates with the radial head?
    a. Trochlea.
    b. Capitulum.
    c. Medial epicondyle.
    d. Lateral epicondyle.

24. (417) The surgical neck of the humerus is described as the
    a. rounded eminence on the lateral side.
    b. deep furrow between the tuberosities.
    c. constricted portion distal to the tuberosities.
    d. rounded portion between the tuberosities and the head.

25. (418) “A rough eminence located on the posterior border of the lateral third of the clavicle” is the description of the
    a. sternal end.
    b. acromial end.
    c. costal tuberosity.
    d. coracoid tuberosity.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Osteology and Anatomy of the Vertebral Column and Thorax

OUR STUDY OF OSTEOLOGY continues with the vertebral column and bony thorax. As with the extremities, this unit presents a basic review of the vertebral column features and then we will present the basic respiratory tract anatomy that will aid you later in this volume when we discuss radiography of the chest. We begin the discussion with the vertebral column.

3–1. The Vertebral Column

The vertebral column provides flexible support for the body and protection for the sensitive spinal cord. It is comprised of 26 individual vertebrae (22 typical and 4 atypical) which are divided into five areas according to the section of the body they support. Four of them are labeled in figure 3–1. Since we already discussed two of the five divisions, the sacrum and coccyx, we will limit our discussion in this section to the remaining three.

419. Structure of the spine

Our spine is the framework on which all other parts of the body are attached (fig. 3-1). It's the part of the body that makes us by definition "vertebrates". It is very important that we take the time to understand the structures of the spine so that we are able to image it appropriately.

Divisions of the spine

Located in the region of the neck, the C-spine consists of seven vertebrae. The thoracic spine is directly inferior to the cervical in the region of the chest (thorax) and consists of 12 vertebrae.

The third portion of the vertebral column is the lumbar spine. The L-spine is located in the region of the abdomen and consists of five vertebrae. Continuing down the spine, we find two irregular vertebrae, the sacrum and coccyx, forming the posterior aspect of the pelvis at the base of the vertebral column.

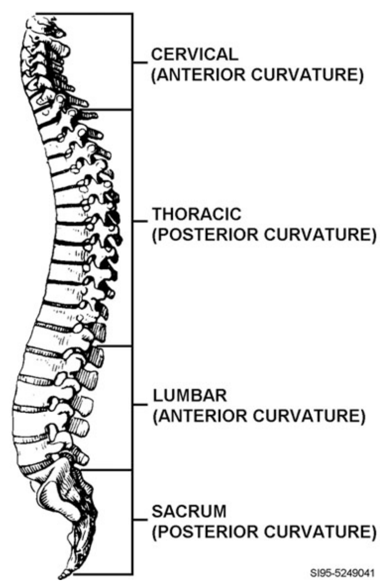


Figure 3–1. The spine.

Vertebrae

The individual bones of the spine are called vertebrae. Each has two primary functions—support and protection. We classify vertebrae as either typical or atypical according to their specific osteologic composition.

A typical vertebra has two sections that are comprised of 12 parts. The sections are (1) the body which provides support and bears weight, and (2) the vertebral (neural) arch which joins with the body to form a protective passageway for the spinal cord called the vertebral foramen.

Intervertebral discs

The intervertebral discs are integral parts of all sections of the spine. Each disc is composed of a tough outer layer of fibrocartilaginous material, called annulus fibrosus, and an inner area containing a pulpy substance, the nucleus pulposus.

The discs are extremely elastic and provide the cushioning effect needed to preclude or limit the transmission of shock from one end of the spine to the other. In essence, they act as shock absorbers for the spine.

Parts of a typical vertebra

As previously stated, we define vertebrae as either typical or atypical. Each typical vertebra has twelve characteristic parts. Let's take a look at the parts that make up one of these vertebrae. Refer to figure 3–2, which has illustrations of each of the three types of typical vertebrae.

Body

This anatomic element forms the anterior part of a vertebra and is somewhat hourglass shaped in that it is narrower in the middle than at the ends. In general, the body is rounded anteriorly and flattened posteriorly. The superior, inferior, and posterior surfaces are concave.

Pedicles

The two pedicles extend posteriorly as short, bony projections on both sides of the posterior surface of the vertebral body. They connect the remaining vertebral parts with the body.

Laminae

These two bony projections extend posterior and medially from the pedicles to complete the vertebral arch by connecting the transverse processes to the spinous process. The vertebral arch, which combines with the body to form the vertebral foramen, consists of the pedicles, laminae, and articular, spinous, and transverse processes.

The articular processes

There are four articular processes—two superior and two inferior. The superior processes are located at the junction of the pedicles and laminae. From here, they extend upward and face posteromedially. In turn, the inferior processes project downward from the junction and face anterolaterally to join with the superior articular process of the adjacent vertebra.

Spinous process

This is a single, bony projection attached to the vertebral arch. It extends posteriorly from the midpoint of the laminae junction. Collectively, the spinous processes prevent hyperextension of the vertebral column.

Transverse processes

These two processes arise on both sides of a vertebra from the pedicle-laminae junctions in some vertebrae and from the pedicle-body junctions in others. They are directed horizontally and slightly backward.

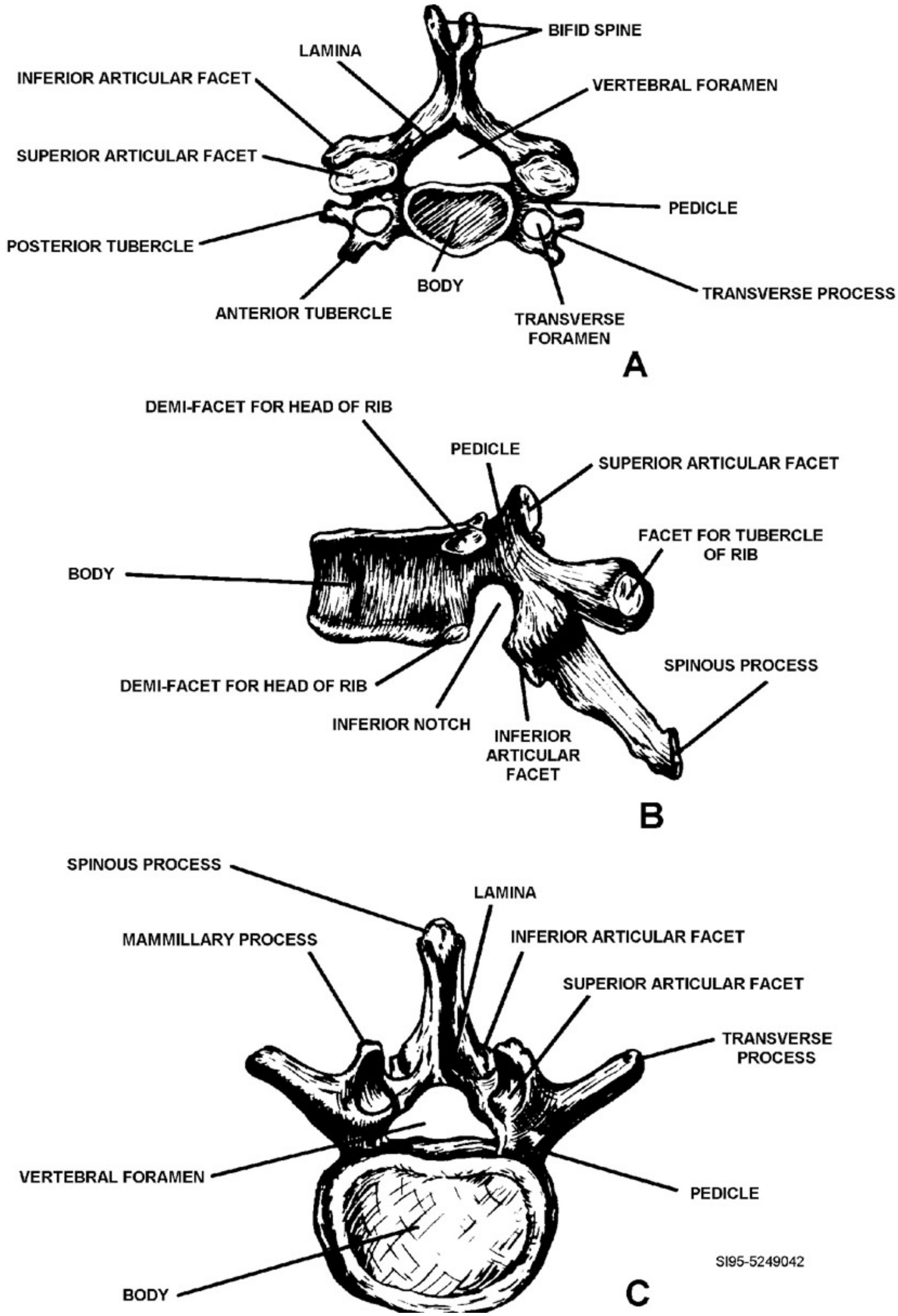


Figure 3–2. The typical vertebrae; A–cervical, B–thoracic, C–lumbar.

420. Osteology of the lumbar spine

Lumbar comes from the Latin word "lumbus" which means loin. As its name suggests, it is the part of the spine that supports the abdominal region.

Lumbar vertebrae

Five typical vertebrae comprise the lumbar spine. They fit together forming the anterior or lordotic (Convex) curvature of the lower back. As you can see in figure 3–3, they are identified by number, from top to bottom. The lumbar are the largest and strongest of the typical vertebrae because they must support the most weight. They may be distinguished from other typical vertebrae in that they have neither transverse foramina (like the cervical spine or C-spine) nor articular facets on their bodies (like the thoracic spine or T-spine).

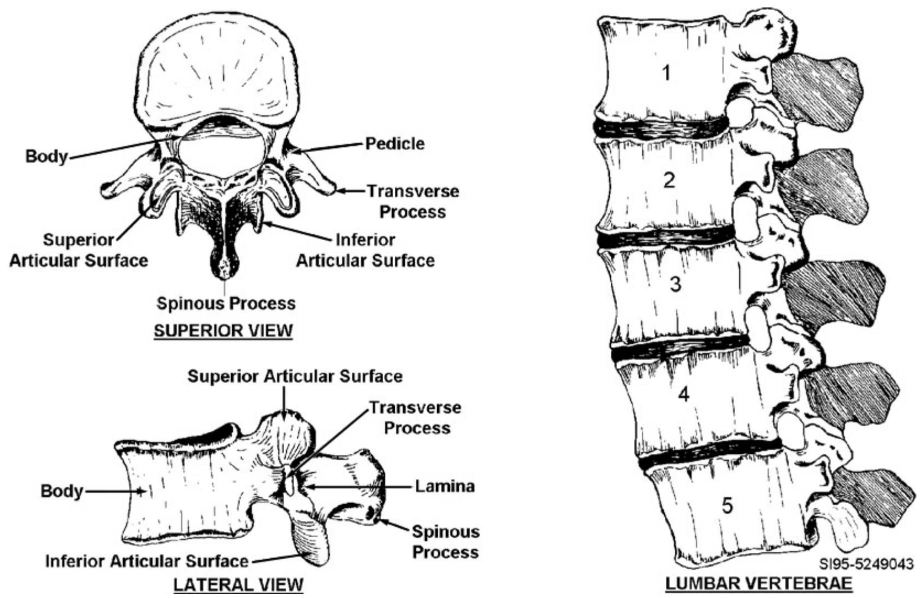


Figure 3–3. The lumbar spine.

Joints of the lumbar spine

There are two types of joints in the lumbar region—intervertebral joints and zygapophyseal joints. Lumbar intervertebral joints (fig. 3–4) are, for all practical purposes, the same as those of the cervical and thoracic regions. The intervertebral joints are located between the bodies of typical vertebrae.The superior and inferior surfaces of each vertebral body join at the intervertebral discs to form amphiarthrodial joints. The lumbosacral joint is the point of union between the 5th lumbar vertebra and the sacrum. This joint is of special interest radiographically and requires a special projection (the L5-S1 spot) to adequately visualize it in most cases.

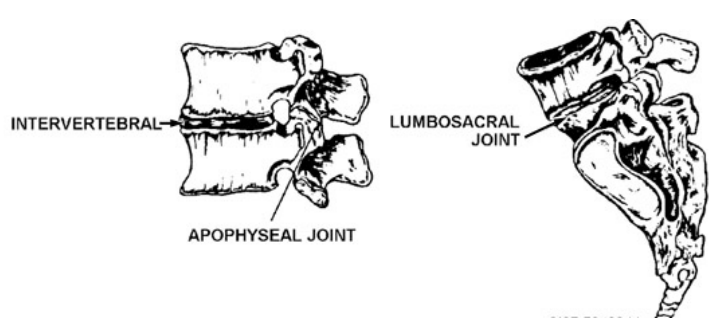


Figure 3–4. Joints of the lumbar spine.

Zygapophyseal (interarticular) joints are formed by the inferior articular processes of one vertebra in articulation with the superior articular processes of the vertebra directly below it.

421. Osteology of the thoracic spine

The thoracic spine (dorsal spine), as its name suggests, supports the region of the thorax, or chest. It is unique from the other regions of the spine in that it provides for posterior attachment of the rib cage.

Thoracic vertebrae

The thoracic vertebrae are located at the posterior portion of the bony thorax and form a posterior or kyphotic (concave) curvature. All 12 thoracic vertebrae are considered typical because they have all of the 12 characteristic parts and each of the thoracic vertebrae attach to one pair of the 12 pairs of ribs.

The thoracic vertebrae are also identified by number, T1, T2, and so on, again from superior to inferior. They increase in size from T1 to T12. What makes them distinguishable are the costal articular facets located on the anterior surface of the transverse processes of T1 through T10 and on the posterolateral surfaces of the bodies of all thoracic vertebrae (fig. 3–5).

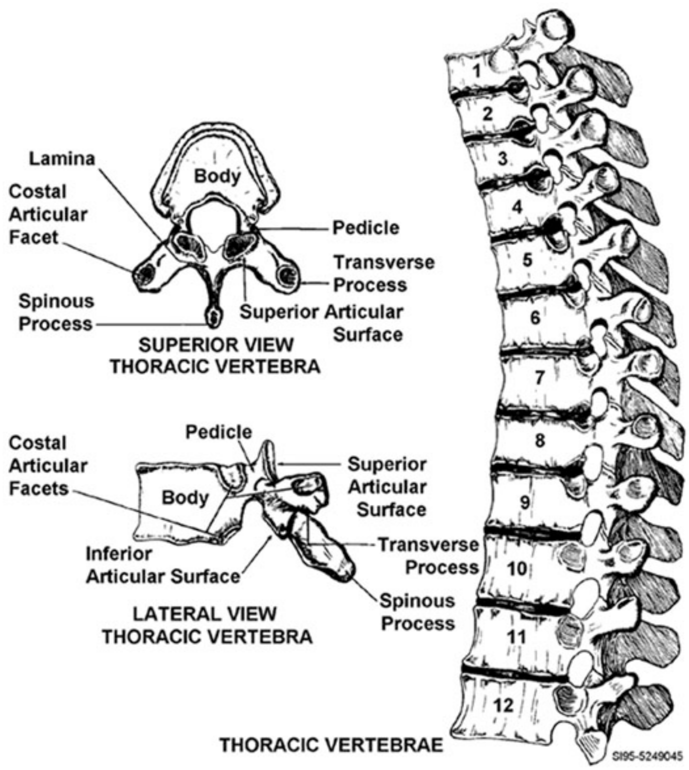


Figure 3–5. The thoracic spine.

T1 has a whole costal facet on the superior border for the head of the first rib and a demifacet (half facet) on the inferior border for the head of the second rib. The bodies of T2-T8 have demifacets both superiorly and inferiorly. T9 presents with only a demifacet on the superior border. For T10-T12, the vertebral bodies have only a whole facet on the superior border for articulation with the eleventh and twelveth ribs.

The posterior surface is concave and thicker than the anterior surface. The transverse processes extend outward in an oblique posterolateral manner and support the ribs. The spinous process is located posteriorly and extends posterior and inferior.

The superior articular processes extend upward and posterolaterally. The inferior articular processes extend downward and anteromedially. The pedicles extend slightly upward and backward from each side of the posterior surface of the vertebral body. The laminae extend posteromedially from the pedicle-transverse process junction to the spinous process. Figure 3–5 illustrates the structure of thoracic vertebrae and the lateral aspect of the thoracic spine.

Joints of thoracic vertebrae

As with the lumbar spine, the thoracic spine has intervertebral and zygapophyseal joints. However, the thoracic spine has two other unique types of joints: the costovertebral and costotransverse joints (fig 3–6).

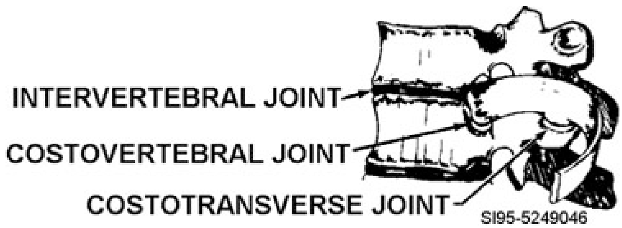


Figure 3–6. Joints of the thoracic spine.

The intervertebral and zygapophyseal joints are of the same type and formed by the same parts as the joints in the lumbar vertebrae. The costovertebral joints are formed when the heads of the ribs articulate with the articular facets, or demifacets, of the vertebral bodies. The costotransverse joints are formed when the articular facets of the transverse processes join the tubercles of the ribs. The costotransverse articulations are only present on T1-10 and therefore are not present on the last two vertebrae.

422. Osteology of the cervical spine

Cervical comes from the Latin word “cervix” which means neck. Not coincidentally, the C-spine supports the area of the neck.

Cervical vertebrae

Seven vertebrae make up the cervical spine forming the anterior curvature of the neck (fig. 3-7). Five are typical, two are atypical. Because of some peculiarities in the construction of some of these vertebrae, we briefly discuss their differences.

First cervical vertebra

The first cervical vertebra, C1, is described as being atypical, because it has no body or spinous process. It is also unique in that it has a larger vertebral foramen than typical vertebrae. C1 is called the *atlas*, because it supports the head as the mythological Atlas supported the Earth. It is round and has an anterior arch, posterior arch, posterior tubercle, two lateral masses, two superior articular facets, two inferior articular facets, and two transverse processes.

Second cervical vertebra

The second cervical vertebra is also atypical, not because it lacks any of the twelve parts, but because it has the odontoid process, or dens. This process is a rounded piece of bone that arises superiorly from its body through the enlarged vertebral foramen of C1. This vertebra is sometimes called the *axis* because it serves as the pivot point for the atlas. Its spinous process is *bifid*, or split in two at the end.

Cervical vertebrae 3 through 7

The remaining vertebrae are similar to each other in construction; however, their bodies are smaller than the bodies of thoracic or lumbar vertebrae. Since each vertebra have the required 12 parts, each is considered a typical vertebra even though all have characteristics unique to cervical vertebrae.

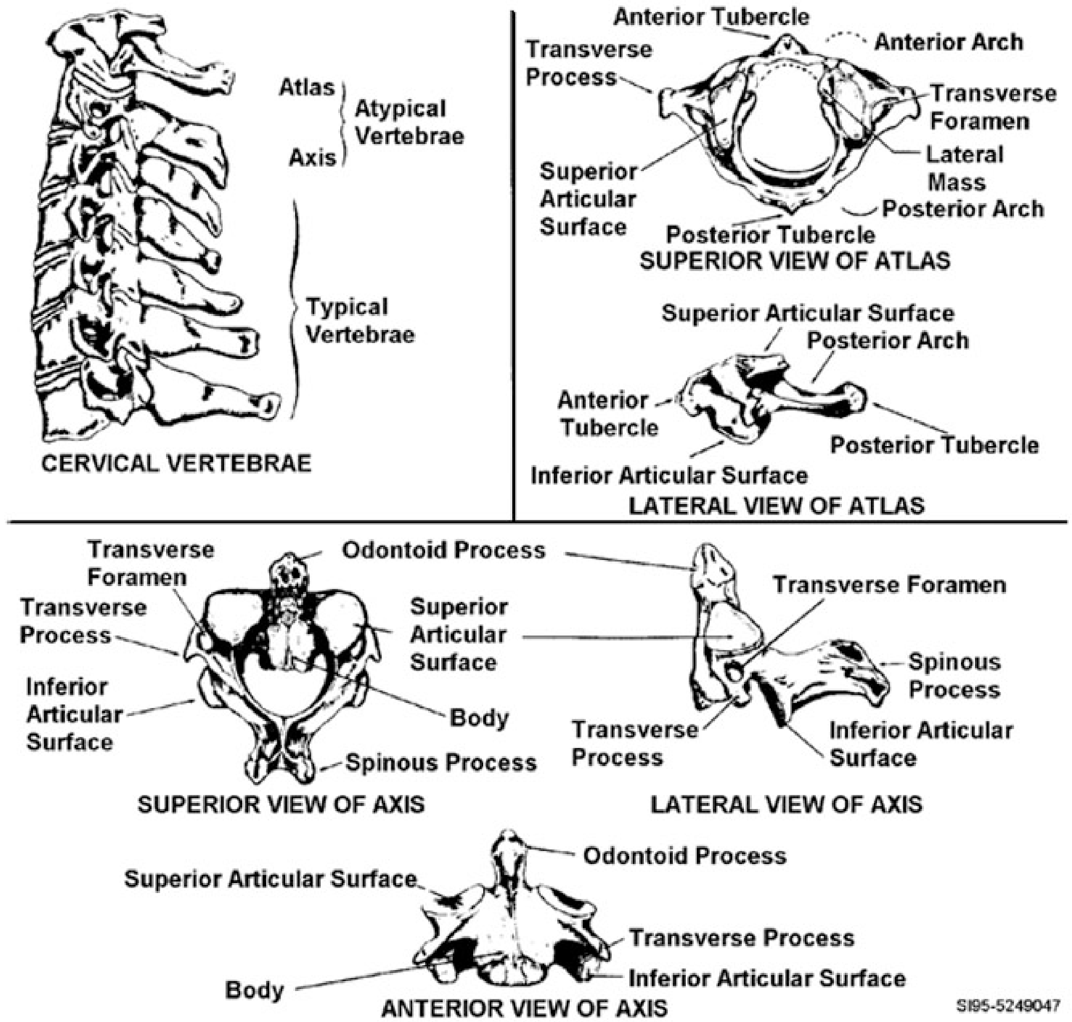


Figure 3–7. The cervical spine.

For instance, every cervical vertebra (including the atlas and axis) has a foramen in each transverse process through which veins, arteries, and nerves pass. The transverse foramina are found only in the cervical vertebrae. Another peculiar characteristic is the bifid spinous processes of vertebrae 2 through 6. The 7th cervical vertebra is particularly distinctive in that its spinous process is not bifurcated and extends farther outward than the spinous process of the other cervical vertebrae. As a radiographic positioning landmark, it is called the vertebral prominence.

Joints of the cervical spine

The joints of the cervical spine are the atlanto-occipital joints (atlas and occipital bone), the atlanto-axial joint (atlas and axis), the intervertebral joints, and the zygapophyseal joints. The atlanto-occipital joint is formed by the superior articular surfaces of the atlas in articulation with the condyles of the occipital bone of the skull. It helps provide for rocking motion such as nodding the head. The atlanto-axial articulation is formed by the atlas and axis and provides pivoting motion. The intervertebral and zygapophyseal joints are similar to those of other vertebrae (fig. 3–8).

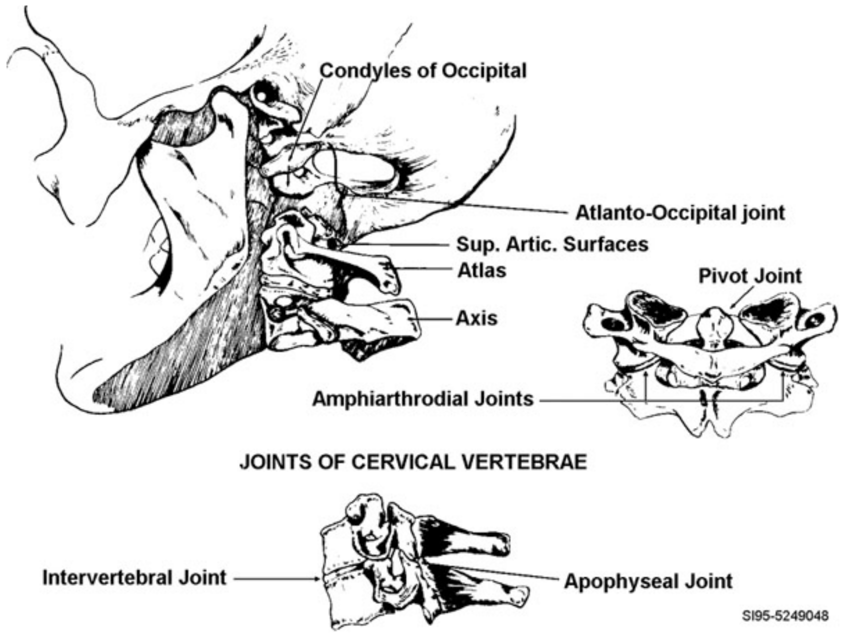


Figure 3–8. Joints of the cervical spine.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

419. Structure of the spine

1. What are the five divisions of the spine and the number of vertebrae in each region?

2. What are the two main sections of a typical vertebra and what are their functions?

3. What are the parts of an intervertebral disc?

4. What is the function of the intervertebral discs?

5. What are the 12 parts of a typical vertebra?

6. Label the diagram of the typical vertebra in figure 3–9 by placing the name of the structure next to the letter (below) that corresponds with the illustration.

A. ___________________

B. ___________________

C. ___________________

D. ___________________

E. ___________________

F. ___________________

G. ___________________

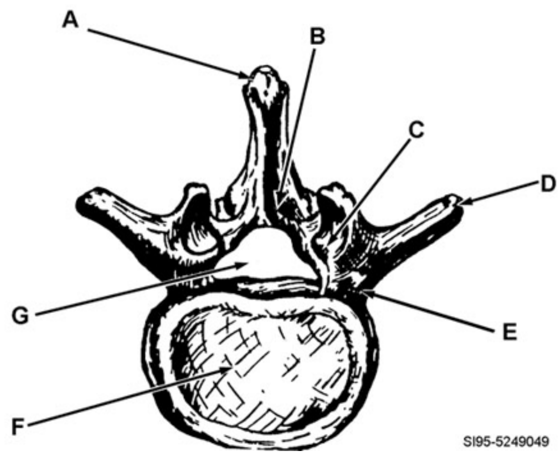


Figure 3–9. Objective 419, self-test question 6.

420. Osteology of the lumbar spine

1. What type of curvature is formed by the lumbar vertebrae?

2. How can you distinguish a lumbar vertebra from other typical vertebrae?

3. Name the two types of joints formed by the lumbar vertebrae.

4. Where are the intervertebral joints of the lumbar spine located?

5. What structures form the zygapophyseal articulations?

421. Osteology of the thoracic spine

1. What type of curvature is formed by the thoracic vertebrae?

2. Which of the thoracic vertebrae are typical?

3. How can you distinguish thoracic vertebrae from other typical vertebrae?

4. What are the four types of thoracic vertebrae joints?

5. What structures are involved in forming the costovertebral joints?

6. What structures are involved in forming the costotransverse joints?

7. Which vertebrae are involved in costotransverse articulations?

422. Osteology of the cervical spine

1. Match the cervical vertebrae in column B with the description in column A. Each answer may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Have transverse foramina.	a. C1.
____ (2) Have bifid spinous processes.	b. C2.
____ (3) The atlas.	c. C1–C7.
____ (4) Has the odontoid process.	d. C2–C6.
____ (5) Has the vertebral prominence.	e. C2–C7.
____ (6) Are typical.	f. C3–C6.
____ (7) Has no body.	g. C3–C7.
____ (8) The axis.	h. C7.

3–2. The Bony Thorax

The ribs and sternum comprise the majority of the bony thorax. They protect the heart, lungs, and great vessels from injury. The bony thorax also serves as the attachment for various muscles and acts as a mechanical agent in the breathing process.

423. Osteology of the ribs

The ribs are curved, flat bones that form most of the posterior and anterior structure and all of the lateral structure of the bony thorax.

Rib classification

Usually, there are 12 ribs on each side of the thorax, extending from the 1st through the 12th thoracic vertebrae. Collectively, they are referred to as the rib cage.

As you can see in figure 3–10, ribs are identified by number. These numbers correspond to the thoracic vertebra to which the rib is attached. They are also identified by the side of the body in which they are located (e.g., the right 5th rib). The first seven pairs are considered *true ribs*.They are attached to cartilage, which joins directly to the sternum.

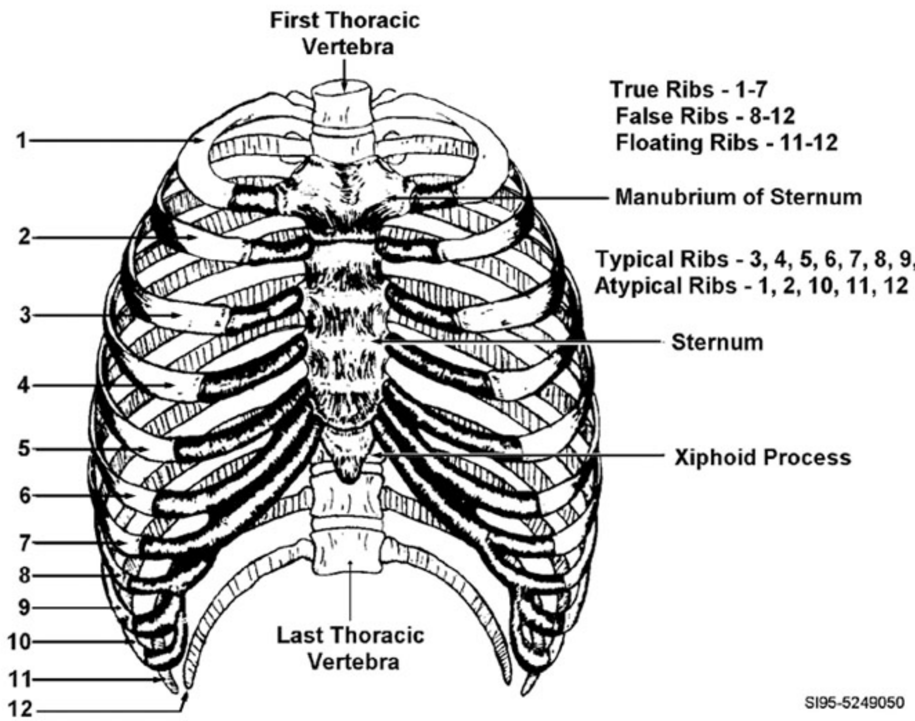


Figure 3–10. The bony thorax.

The remaining five pairs are considered *false ribs*. They do not articulate *directly* with the sternum. Rib pairs 8, 9, and 10 articulate anteriorly with the costal cartilage of the 6th and 7th ribs, and therefore, *indirectly* with the sternum. Rib pairs 11 and 12 do not articulate anteriorly at all, and for this reason are frequently called *floating ribs*.

Osteology

A typical rib has a body and two extremities, or ends—a posterior or vertebral end, and an anterior or sternal end (fig. 3–11). The vertebral extremity contains the head for articulation with the facets or demifacets of the corresponding vertebra. The neck is the flattened portion that extends outward from the head. At the junction of the neck and body, we find the costal tubercle. This tubercle is located on the inferior portion of the rib and articulates with the transverse process of the T-spine. The sternal end is flattened and has an oval pit that attaches to the costal cartilage.

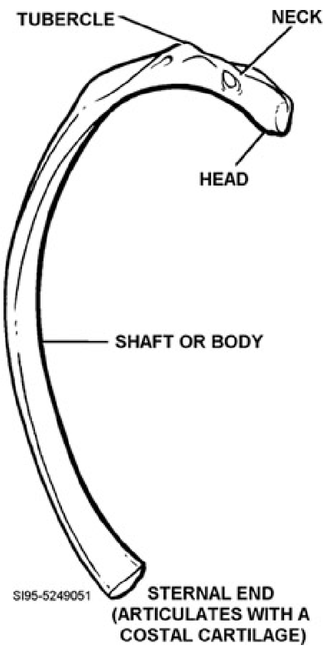


Figure 3–11. A typical rib.

424. Osteology of the sternum

The sternum, or breastbone, forms the central portion of the anterior bony thorax. It is the point at which most of the ribs and the clavicles articulate.

Sternum

The sternum is a flat bone, situated almost vertically in the midanterior part of the thoracic cage. The major parts of the sternum are the manubrium, body, and xiphoid process. The parts of the sternum are illustrated in figure 3–12.

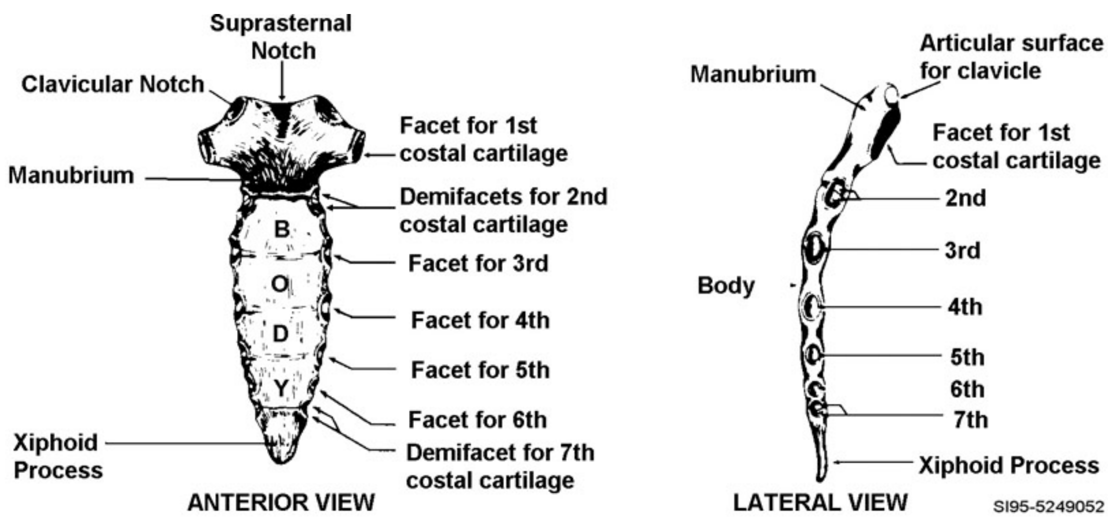


Figure 3–12. The sternum.

Manubrium

Located at the level of T1–T2, the manubrium is the uppermost part of the sternum. About 2 inches long, it is thick and broad superiorly, and becomes narrow as it descends toward the body of the sternum. The superior surface contains the jugular notch. On both sides of this notch are the clavicular notches, where the clavicles articulate with manubrium. Just below the clavicular notches on the sides of the manubrium are the facets for articulation with the first pair of ribs.

Body (breast bone)

The body of the sternum, also called the breast bone, is about 4 inches long. It is actually composed of four bony segments connected by cartilage that fuse together in early adulthood. The superior part of the body articulates with the inferior part of the manubrium joining at the sternal angle. The joint formed at the sternal angle is known as the manubriosternal joint. On each lateral border of the body are articular facets for rib pairs 2 through 7.

Xiphoid process

The xiphoid process forms the distal portion of the sternum. It is the smallest and thinnest of the three major sternal components and remains cartilaginous until advanced adulthood. Its posterior surface continues with the posterior surface of the sternal body, and each of its superolateral borders has a demifacet. The xiphoid is the anterior attachment point for the diaphragm. As a positioning landmark, it can be used to locate the level of T10, as well as the median plane.

Joints of the ribs and sternum

We have already discussed the costovertebral and costotransverse joints, so let’s examine the other joints of the ribs and sternum. Refer to figure 3–13 as we discuss these joints.

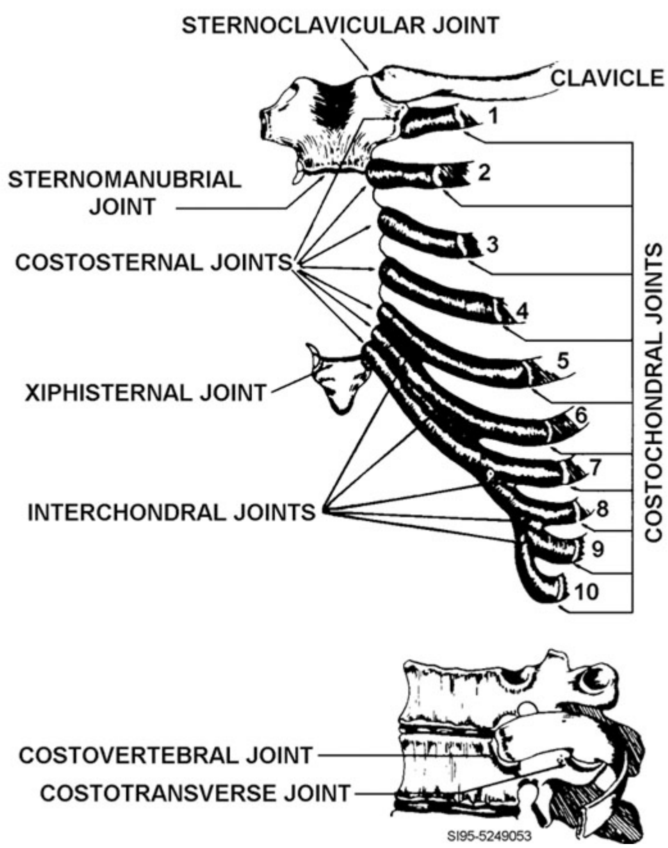


Figure 3–13. The costal joints.

Joints	Description
Sternocostal joints	Only the true ribs are involved in the sternocostal joints, which are formed by the articulation of the costal cartilage of the ribs with the sternum. Only the first sternocostal joint does not contain cartilage, and as such, is synarthrodial (fibrous). All of the others are diarthrodial (synovial) joints.
Interchondral joints	The costal cartilage of rib pairs 6 through 10 articulate with each other to form the interchondral joints.
Costochondral joints	These joints are formed by the costal cartilage in articulation with the sternal ends of the ribs.
Sternoclavicular joints	The sternoclavicular joints are formed by the sternal ends of the clavicles in articulation with the clavicular notches of the manubrium. They are diarthrodial (synovial), gliding-type joints.
Manubriosternal joint	The manubriosternal joint is formed by the inferior surface of the manubrium in articulation with the superior surface of the sternal body. Often referred to as the sternal angle, or angle of Louis, this articulation is an amphiarthrodial (cartilaginous) joint. Although the manubrium remains stationary, the sternal body is able to move anteriorly and posteriorly. This movement is important in the mechanics of respiration.
Xiphisternal joint	The xiphisternal joint is formed by the superior surface of the xiphoid process in articulation with the inferior surface of the sternal body.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

423. Osteology of the ribs

1. Which pairs of ribs are considered true ribs? Why?

2. Which pairs of ribs are considered false ribs? Why?

3. Do rib pairs 8, 9, and 10 articulate anteriorly? If so, how?

4. Why are the 11th and 12th rib pairs considered floating ribs?

5. Label the diagram of the rib in figure 3–14 by placing the name of the structure next to the letter (below) that corresponds to the illustration.

A. ___________________

B. ___________________

C. ___________________

D. ___________________

E. ___________________

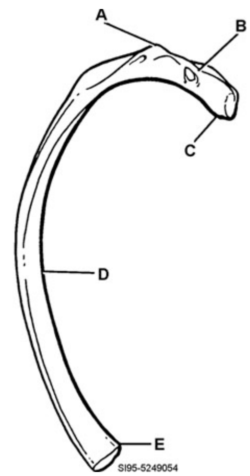


Figure 3–14. Objective 423, self-test question 5.

424. Osteology of the sternum

1. Name the three major parts of the sternum.

2. What is the name of the notch on the superior surface of the manubrium?

3. Which rib pairs articulate directly with the body of the sternum?

4. The xiphoid is located at the level of which vertebrae?

5. What structures form the sternocostal joints?

6. Which sternocostal joint is synarthrodial?

7. Describe the interchondral joints.

8. Describe the costochondral joints.

9. What is the angle of Louis?

10. What type of joint is the manubriosternal joint?

3–3. The Respiratory System

Along with our discussion of the bony thorax, we wish to include a brief section dealing with anatomy of the soft tissue thorax. As you are aware by this point in your career, chest X-rays are the single most common type of radiograph. It is therefore, necessary for us to have a basic understanding of the anatomy covered in this type of radiograph. In this section, we examine the anatomy of the respiratory system, from the larynx to the alveolar sacs.

425. Anatomy of the upper respiratory tract

The upper respiratory tract includes the mouth, nose, pharynx, larynx, trachea, and primary bronchi. However, for purposes of chest radiography, we are only interested in the larynx, trachea and primary bronchi (fig. 3–15).

Larynx

The *larynx*, sometimes called the voice box, is located in the upper anterior portion of the neck, extending from the 4th to the 6th cervical vertebrae. It serves as a passageway for air between the pharynx and trachea. The larynx is suspended from the hyoid bone and is made up of various structures, including the *thyroid* and *cricoid* cartilages. The *epiglottis* is a finger-like cartilaginous projection that guards the entrance of the larynx, preventing food from entering the trachea during the act of swallowing.

Trachea

The trachea is commonly called the windpipe. It is a rounded cartilaginous tube about 4½ inches long located just anterior to the esophagus. It extends from the larynx to the level of the superior border of the 5th thoracic vertebra, where it bifurcates into the right and left primary bronchi.

The internal walls of the trachea are lined with mucosa. The innermost surface of this mucosa is composed of stratified, ciliated epithelium, while its deeper portion is composed of a looser meshwork of connective tissue containing the mucous glands, nerves, and blood vessels. The mucosal cilia, along with the mucous secretions, filter any inhaled dust particles and move them upward to the pharynx.

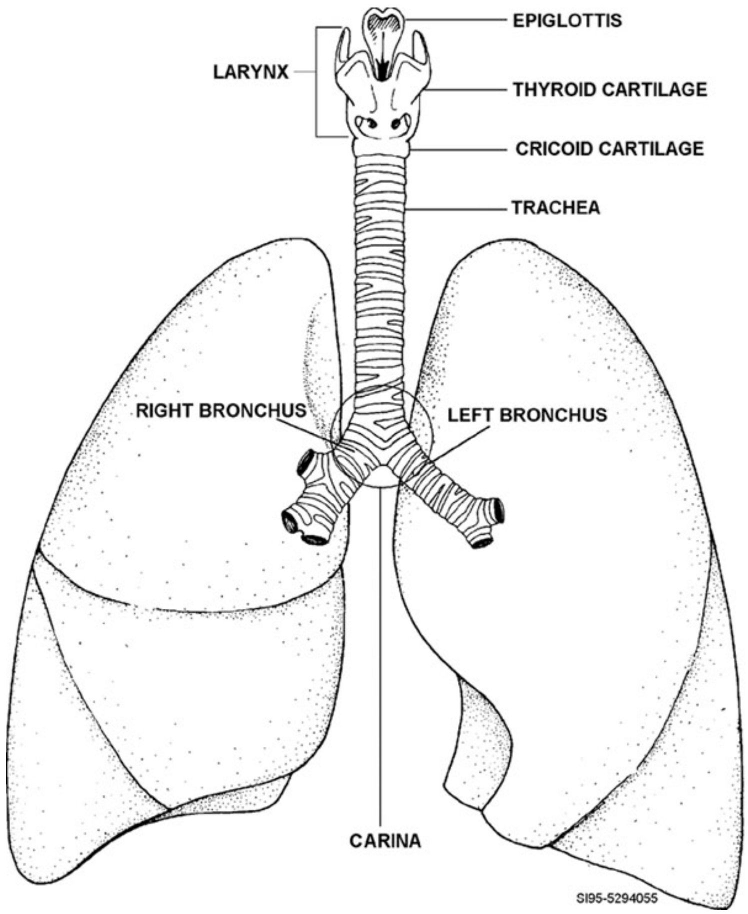


Figure 3–15. The trachea and primary bronchi.

The external surface consists of C-shaped cartilaginous rings embedded in fibrous tissue to give the trachea its rigidity. The C-shaped rings open posteriorly, leaving gaps covered by strips of muscular tissue to form a flat posterior surface where the trachea overlies the esophagus. These gaps permit the esophagus to enlarge during peristalsis to permit the passage of food.

Primary bronchi

At its inferior aspect, the trachea bifurcates into two smaller tubes—the right and left primary bronchi—which are similar in construction to the trachea.One bronchus goes to the right lung, the other to the left. This bifurcation is called the *carina*.

Right bronchus

The right bronchus consists of six to eight cartilaginous rings that are smaller than, but otherwise identical to, those of the trachea. It enters the right lung through an opening called the *hilum* at the level of the 5th thoracic vertebra. It is shorter, wider, and more vertical in position than the left bronchus.

Left bronchus

The left bronchus is smaller in diameter and longer than the right bronchus. It has from nine to 12 cartilaginous rings and enters the *hilum* of the left lung at about the level of the 6th thoracic vertebra.

426. Pulmonary structure and function

In order to understand the lung and its appearance, we need to discuss its structures and how they contribute to respiratory function.

Bronchial tree

Once the main bronchi enter the lungs, they began to divide into smaller and smaller branches. These branches within the lungs are known as the bronchial tree and are demonstrated by figure 3–16.

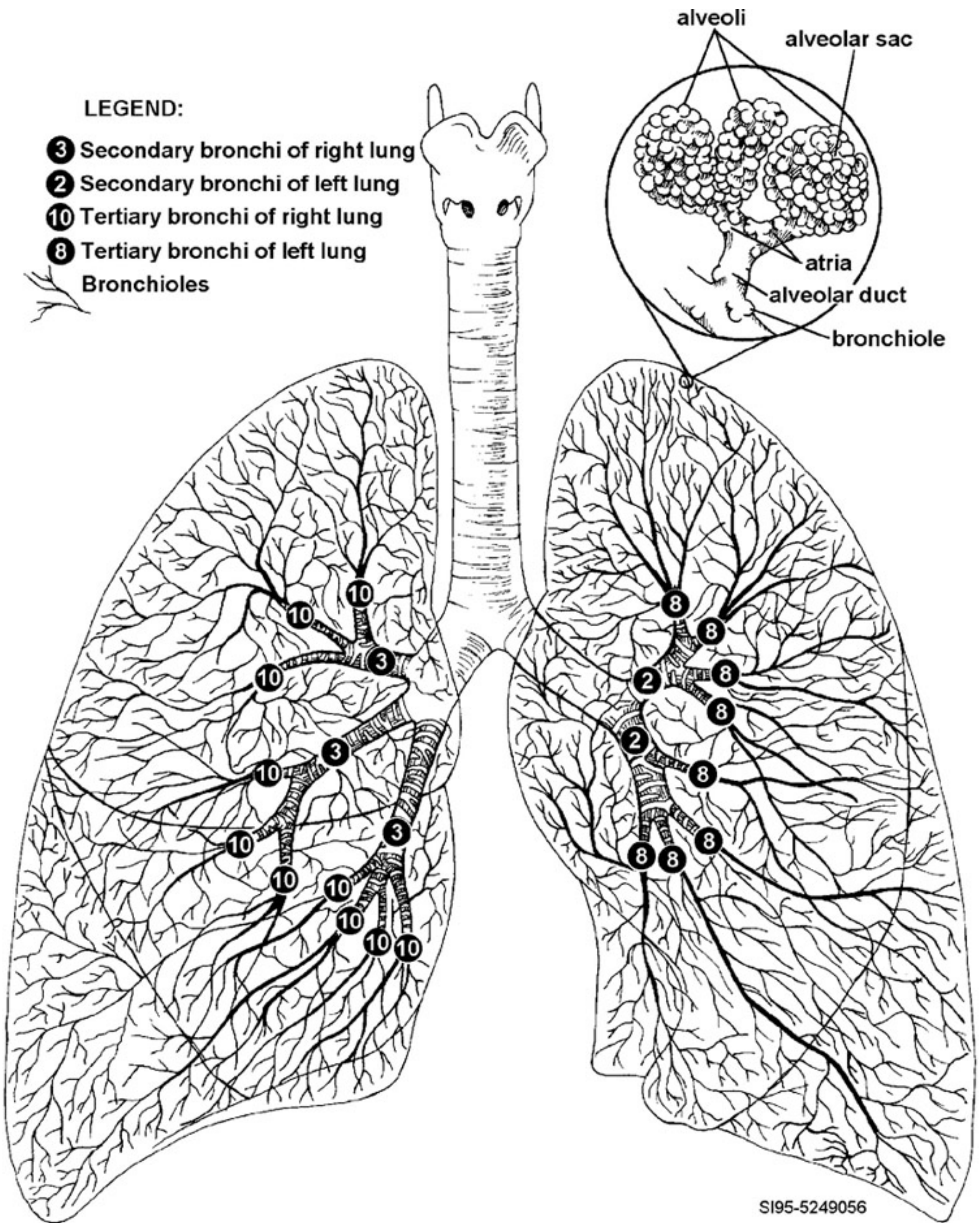


Figure 3–16. The bronchial tree.

Secondary bronchi

The two primary bronchi branch into five *secondary*, or lobar, bronchi. The right lung has three secondary bronchi; the left has two. There is one secondary bronchus for each lobe of the lungs.

Tertiary bronchi

The secondary bronchi are further divided into *tertiary*, or segmental, bronchi. The right lung usually contains 10 tertiary bronchi, one for each bronchopulmonary segment. The left lung has eight tertiary bronchi for its eight bronchopulmonary segments.

Bronchioles

Next in the order of subdivisions are the *bronchioles* (little bronchi), which enter the lung tissues. To this point, the bronchi and their subdivisions are composed of fibrous tissue and resemble the C-shaped cartilaginous rings of the trachea and the primary bronchi. But when the bronchi become bronchioles, their diameter is decreased to 1 mm or less, and the cartilage is no longer present. Each bronchiole penetrates deeper into the lung tissue, where it divides into several ducts called the *alveolar ducts.*

Atria

Next in the subdivision are the *atria*, which are irregularly shaped, elongated air sacs continuous with the alveolar ducts. From the atria, the alveolar sacs continue the subdivisions.

Alveoli

Finally, the *alveoli*, the functional units of the lung, are reached. These are minute, cup-shaped air cells that project from the walls of the bronchioles, alveolar ducts, atria, and alveolar sacs, and which become more numerous at the terminal portion of the respiratory system. They consist of a very delicate, thin layer of epithelial tissue and are surrounded by a network of capillaries. It is here, where the alveoli are close to the bloodstream, that carbon dioxide and oxygen are exchanged through diffusion.

Lungs

As a whole, the lungs as shown in figure 3–17 are located on both sides of the *mediastinum*, where they occupy the right and left portions of the thoracic cavity. Each extends from about 1 to 1½ inches above the clavicle to the superior border of the diaphragm. They are separated from each other by a space called the *mediastinum*, which contains the heart, esophagus, part of the trachea, the great vessels, primary bronchi, and many other smaller structures. The cancave depression on the mediastinal surface of each lung that serves as a passage way for the right and left bronchi, arteries, veins, and nerves that enters and leave the lung at this point. This area is called the *hilum*.

The lungs are composed of a light, porous and spongy, elastic tissue. Each resembles an inverted cone in shape and consists of an apex, a base, costal and mediastinal surfaces, lobes and fissures, and a bronchial tree. The apex is the rounded, superior portion that extends to about 1 to 1½ inches above the level of the sternoclavicular joints, bilaterally.

The lung base, or diaphragmatic surface, consists of a broad, concave, inferior surface that rests on the convex superior surface of the diaphragm. The base of the right lung has a deeper concavity and lies slightly higher than the left because it sits on top of the right lobe of the liver.

The interlobar (oblique) fissure divides the left lung into two parts—a superior (upper) lobe and an inferior (lower) lobe; the latter is the larger of the two. The right lung has three lobes. An interlobar fissure, similar to that of the left lung, separates the inferior lobe from the middle and superior lobes. A horizontal fissure at the level of the 4th costal cartilage makes a wedge-shaped middle lobe between the inferior and superior lobes.

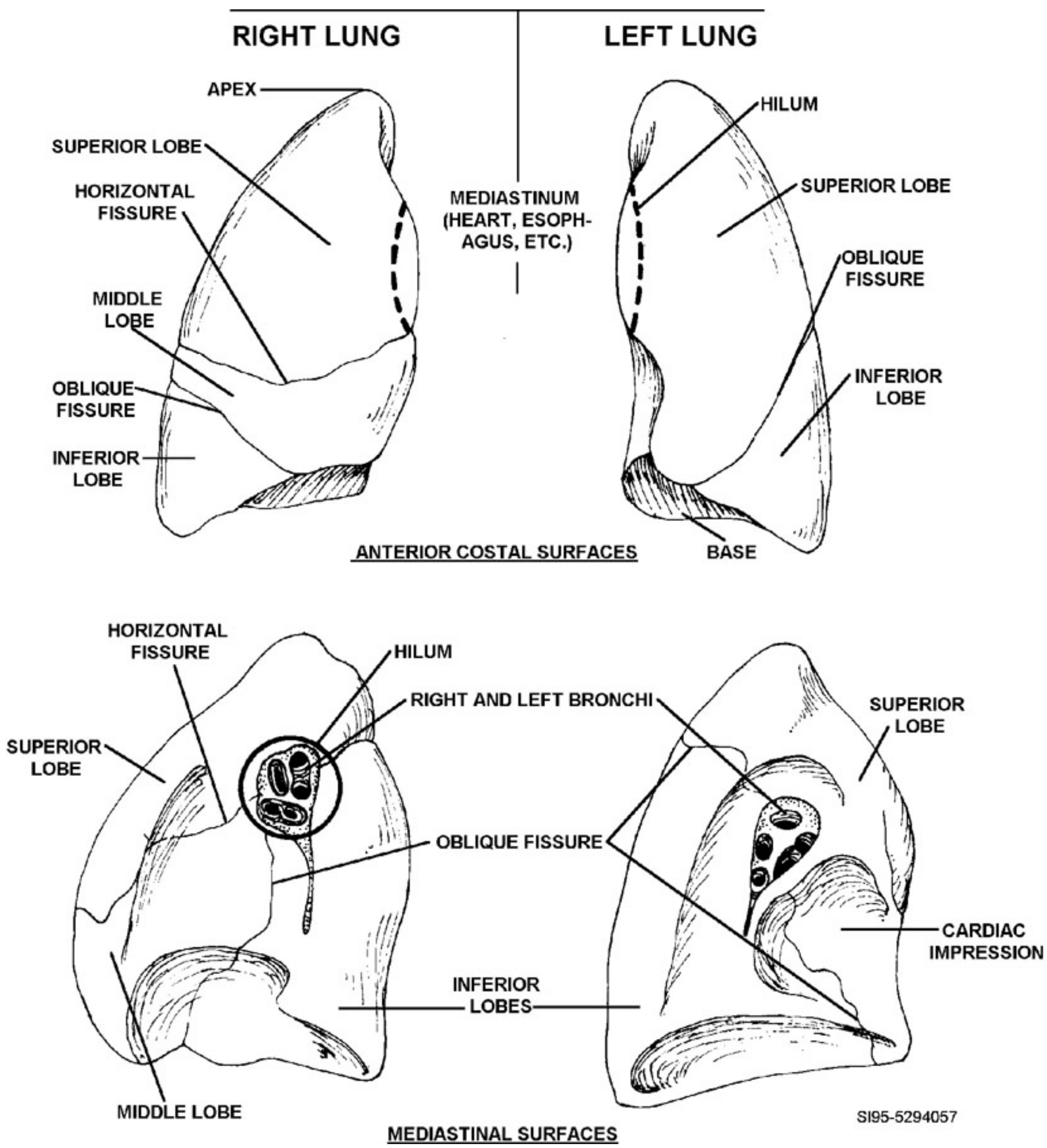


Figure 3–17. The lungs.

Pleural membrane

Each lung is covered by a dual layered serous membrane called the *pleura*. The inner layer that comes in contact with the lung tissue is called the pulmonary or visceral pleura. The outer layer is called the parietal pleura.

The space in between the pulmonary pleura and the parietal pleura is the *pleural cavity*. It is filled with a serous fluid that moistens and lubricates the opposed surfaces of the pleura, thereby reducing friction during respiration. The two pleural cavities are entirely separate from one another. Therefore, if one side is punctured and the lung collapses, the other is not affected.

The *costophrenic angle* is the triangular space between the wall of the thorax and the lower margin of the diaphragm. The angle is readily seen on PA chest radiographs as the inferior, lateral corner of the lung where the rib cage meets the diaphragm; hence the name costo-(rib) phrenic (diaphragm). Further evaluation of this angle on a lateral projection shows it to be in the posterior aspect of the chest.

Mechanics of respiration

Respiration is the act or function of breathing. The process of breathing may be subdivided into inspiration (breathing in) and expiration (breathing out). Breathing is accomplished by coordinated movements of lungs, diaphragm, abdomen, and associated muscles.

During inspiration, intercostal muscles contract to raise the anterior ends of ribs. At the same time, the diaphragm contracts, flattening the dome-shaped muscle. By these combined actions, the thoracic cavity is enlarged in all directions. As a result, each pleural cavity is also enlarged and, since it is completely airtight, a partial vacuum is formed within. Due to the lowering of the pressure in the pleural cavity and the elasticity of the lung, the air pressure within the lung is lowered. Since lungs communicate freely with the outside air, air rushes in to equalize the pressure.

At the end of each inspiration, intercostal muscles and the diaphragm relax, and the thoracic wall returns to its usual resting position. This decrease in the size of the thoracic cavity increases the pressure in the cavity and in each lung. As a result, air flows out of the lungs until the pressure within them is again equal to that of the atmosphere.

On full inspiration, the right dome of the diaphragm (the right hemidiaphragm) lays at about the level of the 11th thoracic vertebra and the left dome at the level of the 12th. On full expiration, the right hemidiaphragm lies at about the level of the 8th thoracic vertebra and the left hemidiaphragm at the level of the 9th.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

425. Anatomy of the upper respiratory tract

1. The larynx serves as an air passage between what two structures?

2. What structure prevents food from entering the trachea when you swallow?

3. At what level does the trachea bifurcate?

4. In which direction do the C-shaped rings of the trachea open? Why?

5. What is the next level of the respiratory tract, after the trachea bifurcates?

6. What name is given to the bifurcation of the trachea?

7. How does the right primary bronchus differ from the left?

426. Pulmonary structure and function lungs

1. How many lobar bronchi are there?
2. What is the first division of the bronchial tree that does not have cartilaginous rings?
3. What ducts appear immediately after the bronchioles?
4. What are the functional units of the lung?
5. What is the name of the space between the lungs?
6. What is the hilum?
7. Where is the apex of a lung located?
8. On what structure does the base of the lung rest?
9. How many lobes does the right lung have? The left?
10. What divides the lobes of the left lung? Right lung?
11. What is the name of the serous membrane that covers the lung?
12. What is contained in the pleural cavity?
13. Where is the costophrenic angle located?
14. What is the function of the diaphragm during inspiration?

15. At what level is the right hemidiaphragm during full inspiration?

Answers to Self-Test Questions

419

1. Cervical–7; thoracic–12; lumbar–5; sacrum–1; and coccyx–1.
2. The body which provides support and bears weight and the vertebral arch which protects the spinal cord.
3. The annulus fibrosus and the nucleus pulposus.
4. Act as shock absorbers for the spine.
5. One body, two pedicles, two laminae, two superior articular processes, two inferior articular processes, one spinous process, and two transverse processes.
6. (A) Spinous process.
   (B) Lamina.
   (C) Superior articular process.
   (D) Transverse process.
   (E) Pedicle.
   (F) Body.
   (G) Vertebral foramen.

420

1. A lordotic (anterior) curvature.
2. They are the largest and strongest, and they do not have transverse foramina or articular facets.
3. Intervertebral joints and zygapophyseal joints.
4. Between the bodies of the typical vertebrae.
5. The inferior articular processes of one vertebra in articulation with the superior articular processes of the vertebra directly below it.

421

1. Kyphotic (posterior).
2. All of them.
3. They have costal articular facets located on the anterior surface of the transverse processes of T1 through T10 and on the posterolateral surfaces of the bodies of all thoracic vertebrae
4. Intervertebral, zygapophyseal, costovertebral, and costotransverse.
5. The heads of the ribs and the articular facets or demifacets of the vertebral bodies.
6. The costal tubercles and the articular facets of the transverse processes of the T-spine.
7. T1 through T10.

422

1. (1) c.
   (2) d.
   (3) a.
   (4) b.
   (5) h.
   (6) g.
   (7) a.
   (8) b.

423

1. The first seven, because their costal cartilages articulate directly with the sternum.
2. The 8th through the 12th pairs, because they do not articulate directly with the sternum.
3. Yes, their costal cartilages articulate with the costal cartilage of the 6th and 7th pairs, and therefore, indirectly with the sternum.
4. Because they do not articulate anteriorly.
5. (A) Costal tubercle.
   (B) Neck.
   (C) Head.
   (D) Shaft.
   (E) Sternal end.

424

1. The manubrium, the body, and the xiphoid process
2. The jugular notch.
3. Two through seven.
4. T10.
5. The costal cartilages of the ribs and the sternum.
6. The first.
7. The costal cartilage of rib pairs 6 through 10 articulate with each other to form the interchondral joints.
8. These joints are formed by the costal cartilage in articulation with the sternal ends of the ribs.
9. The articulation of the inferior surface of the manubrium with the superior surface of the sternal body, which is also called the sternal angle.
10. Amphiarthrodial (Cartilaginous).

425

1. The pharynx and trachea.
2. The epiglottis.
3. The superior border of the 5th thoracic vertebra.
4. Posteriorly, to permit the esophagus to enlarge during peristalsis.
5. The primary bronchi.
6. Carina.
7. It is shorter, wider, and more vertical.

426

1. Five (one for each lobe).
2. The bronchioles.
3. The alveolar ducts.
4. The alveoli.
5. The mediastinum.
6. The cancave depression on the mediastinal surface of each lung that serves as a passage way for the right and left bronchi, arteries, veins, and nerves that enters and leave the lung at this point.
7. On the superior aspect of the lung, about 1 to 1½ inches above the level of the sternoclavicular joints.
8. On the convex superior surface of the diaphragm.
9. Three; two.
10. Interlobar (oblique) fissure; horizontal fissure.
11. The pleura.
12. A serous fluid that moistens and lubricates the pleura.

13. At the inferior, lateral, posterior aspect of the lung between the wall of the thorax and lower margin of the diaphragm.
14. To contract.
15. At the level of the 11th thoracic vertebra.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

26. (419) What is the name of the passageway formed by the junction of the vertebral body with the neural arch?
    a. Foramen magnum.
    b. Vertebral foramen.
    c. Transverse foramen.
    d. Intervertebral foramen.

27. (419) Which of the 12 parts of a typical vertebra extend posterior from the body and connect the remaining parts to the body?
    a. Laminae.
    b. Pedicles.
    c. Transverse processes.
    d. Zygapophyseal articulations.

28. (420) Which structure is formed by the articulation of the superior and inferior articulating processes of two adjacent vertebrae?
    a. Intervertebral joint.
    b. Pars interarticularis.
    c. Zygapophyseal joint.
    d. Intervertebral foramen.

29. (421) What distinguishes thoracic vertebrae from other typical vertebrae?
    a. They have transverse foramina.
    b. They have costal articular facets.
    c. They are the largest and strongest.
    d. They have bifid spinous processes.

30. (422) Which characteristic describes all cervical vertebrae?
    a. Their transverse processes have foramina.
    b. They do not have intervertebral disks.
    c. Their spinous processes are bifid.
    d. They are atypical.

31. (423) What type of bones are the ribs?
    a. Flat.
    b. Long.
    c. Short.
    d. Irregular.

32. (423) Which structure is located on the inferior portion of a rib and articulates with the transverse processes of T-spine vertebrae?
    a. Head.
    b. Neck.
    c. Groove.
    d. Tubercle.

33. (424) With which part of the sternum does the first pair of ribs articulate?
    a. Xiphoid.
    b. Gladiolus.
    c. Manubrium.
    d. Sternal angle.

34. (424) The name given to the joints formed by the articulation of the cartilage of the true ribs and the sternum is
    a. xiphisternal.
    b. sternocostal.
    c. interchondral.
    d. costochondral.

35. (425) The bifurcation of the trachea is called the
    a. apex.
    b. hilum.
    c. carina.
    d. mediastinum.

36. (426) What is the *first branch* of the bronchial tree that is not composed of cartilaginous rings?
    a. Primary bronchi.
    b. Secondary bronchi.
    c. Bronchioles.
    d. Tertiary bronchi.

37. (426) Vessels enter and leave the lung at a point called the
    a. apex.
    b. hilum.
    c. fissure.
    d. mediastinum.

38. (426) What is the name of the dual layered serous membrane that covers the lungs?
    a. Pleura.
    b. Periosteum.
    c. Peritoneum.
    d. Pericardium.

Please read the unit menu for unit 4 and continue ➔

Student Notes

Unit 4. Osteology of the Skull and Facial Bones

PERHAPS NO OTHER BONY BODY PARTS are as difficult to demonstrate radiographically as certain parts of the skull. The main reasons for the difficulty are that the skull is not flat and the skull houses many internal structures which tend to superimpose one another. Many examinations require precise angulations of the skull, film, and CR in order to clearly visual structures for radiographic interpretation. Without a good working knowledge of the osteology of the skull, it is difficult to position the skull properly and evaluate the quality of the radiographs.

4–1. The Cranium

In our discussion of the cranium, we will examine the cranial bones, sutures, junctions, and fontanelles.

427. Bones of the cranium

The cranium has eight bones—one frontal, two parietal, two temporal, one occipital, one sphenoid, and one ethmoid. Use Foldout 1 (FO1), located in the back of this volume, as a reference while you study.

Frontal bone

The frontal bone forms the forehead, anterior roof of the cranium, superior part of the orbits, part of the nose, and the anterior floor of the cranial fossa. It has two major parts—the orbital and squamosal. The orbital portion of the frontal bone, which makes up the superior parts of the orbits, consists of two thin, triangular plates. The squamosal portion of the frontal bone makes up the forehead. Its outstanding landmarks are the frontal eminences, supraorbital foramina, zygomatic processes, nasal process, frontal sinuses (discussed later in this unit), and sagittal sulcus.

Structures of the Frontal Bone

Part	Description
Frontal eminences	Large, rounded, bony elevations located anteriorly on each side of the midsagittal plane, above the supraorbital ridges.
Supraorbital ridges	The prominent bony ridges that form the upper anterior boundaries of the orbits. They mark the junction of the squamosal and orbital portions of the frontal bone, and can be easily felt under the eyebrows.
Supraorbital foramina	Small holes that provide passage for the supraorbital nerves and blood vessels.
Zygomatic processes	Prominent bony processes on the lateral parts of the supraorbital ridges, connecting the frontal and zygomatic bones.
Nasal process	The piece of bone projecting downward and forward, extending from the nasion. It supports the bridge of the nose.
Sagittal sulcus	A vertical groove on the internal surface of the frontal bone, formed by the fusion site of the original two parts of the frontal bone.

Parietal bones

Two parietal bones make up most of the lateral walls and the roof of the cranium. Anteriorly, they unite with the frontal bone; superiorly, they unite with each other; and posteriorly, they join with the occipital bone. The anterior, posterior, and superior borders are serrated for articulation. Inferiorly, they articulate with the temporal and sphenoid bones.

Temporal bones

The two temporal bones form part of the inferior, lateral walls of the cranium, bilaterally. Each bone has certain parts that deserve special consideration. These parts are the mastoid process, petrous ridge, styloid process, tympanic portion, mandibular fossa, and zygomatic process.

Parts of the Temporal Bone	
Part	**Description**
Mastoid process	A large, bony prominence is located on the inferior, posterior part of each temporal bone, directly behind each external auditory meatus (EAM). This process contains air cells of different sizes and shapes called mastoid cells.
Petrous ridge	The pyramid shaped wedge of bone that forms part of the cranial base between the sphenoid and occipital bones. It houses the internal auditory canal.
Styloid process	A long, slender projection extending forward and downward from the inferior part of each temporal bone.
Tympanic portion	The tympanic portion of the temporal bone that lies anterior to the mastoid process and directly above the styloid process. The anterior, inferior portion makes up the superior part of the mandibular fossa.
Mandibular fossa	This depression is located in the anterior, inferior portion of the tympanic parts of each temporal bone. It forms part of the temporomandibular joints, since it provides articulation for the condyloid process of the mandible.
Zygomatic process	A slender bony projection extending anteriorly from the inferior aspect of the temporosquamosal area just above each external auditory meatus (EAM). Its anterior end is serrated for articulation with the temporal process of the zygomatic bone. Together, these processes form the zygomatic arch.

Occipital bone

The occipital bone makes up the posterior inferior portion of the cranium forming the posterior half of the base of the cranuim. Its notable parts are the foramen magnum, external and internal occipital protuberances, and occipital condyles.

Parts of the Occipital Bone	
Part	**Description**
Foramen magnum	A large opening in the base of the occipital bone through which a portion of the medulla oblongata and spinal cord pass to the spinal column.
External occipital protuberance	A bony prominence located midline on the outer surface where the occipital bone curves inward to form the posterior portion of the cranial base. It may be easily felt at the posterior base of the skull
Internal occipital protuberance	Located on the internal surface of the occipital bone in the same area as the external protuberance, this marks the junction of the four original divisions of the occipital bone.

Parts of the Occipital Bone	
Part	**Description**
Occipital condyles	Oval-shaped, smooth, bony prominences, lying on each side of the foramen magnum on the external surface, that articulate with the superior articular surfaces of the atlas forming the atlanto-occipital joint. The skull joins the vertebral column at this point.

Sphenoid bone

The sphenoid bone is located at the base of the cranium, where it makes up the middle portion of the cranial floor. Its major parts are the body, optic foramina, sella turcica, anterior and posterior clinoid processes, greater wings, and lesser wings.

Part of the Sphenoid Bone	
Part	**Description**
Body	The middle section. It is hollow, forming two sphenoid sinuses that lie directly behind the nose.
Optic foramina	These two foramina, one on each side, are located at the anterior, lateral part of the body of the sphenoid bone. Through these holes, the optic nerves and vessels leave the cranial vault and enter the orbits.
Sella turcica	This “Turkish saddle,” located on the superior surface of the body of the sphenoid bone, is a saddle-shaped depression on which the pituitary gland is situated.
Clinoid processes	Bony projections that arise from the lesser wings and dorsum sella respectively, they bend backward and forward over the sella turcica to form a partial protective roof over the pituitary gland.
Greater wings	These wings extend laterally from the sides of the body. They form part of the floor of the cranium, a small part of its lateral walls just anterior to the temporal bones, and the posterior part of the lateral walls of the orbits
Lesser wings	These wings lie anterior to the sella turcica. They are thin, triangular pieces of bone that extend laterally from the body. Part of the posterior roof of the orbits is formed by their inferior surface.

Ethmoid bone

The ethmoid bone, the smallest of the cranial bones, is located behind the bridge of the nose and forms part of the anterior base of the cranium and orbits. Its major parts are the cribriform plate, crista galli, perpendicular plate, and labyrinths.

Parts of the Ethmoid Bone	
Part	**Description**
Cribriform plate	Has a vast number of foramina (cribriform foramina) through which the olfactory nerves (nerves of smell) pass to enter the nasal cavity. Articulating with the ethmoid notch of the frontal bone, this plate forms the roof of the nasal cavity.
Crista galli	This bony projection, shaped like a shark’s fin, extends upward from the cribriform plate. It is the attachment point for the anterior brain.
Perpendicular plate	A thin sheet of bone that extends downward from the inferior surface of the cribriform plate and forms part of the nasal septum.
Labyrinths	Also called *lateral masses*, each labyrinth contains the superior and middle nasal conchae or turbinate bones (fig. 4–1). These project into the nasal cavity and allow for circulation and filtration of inhaled air before it passes to the lungs.

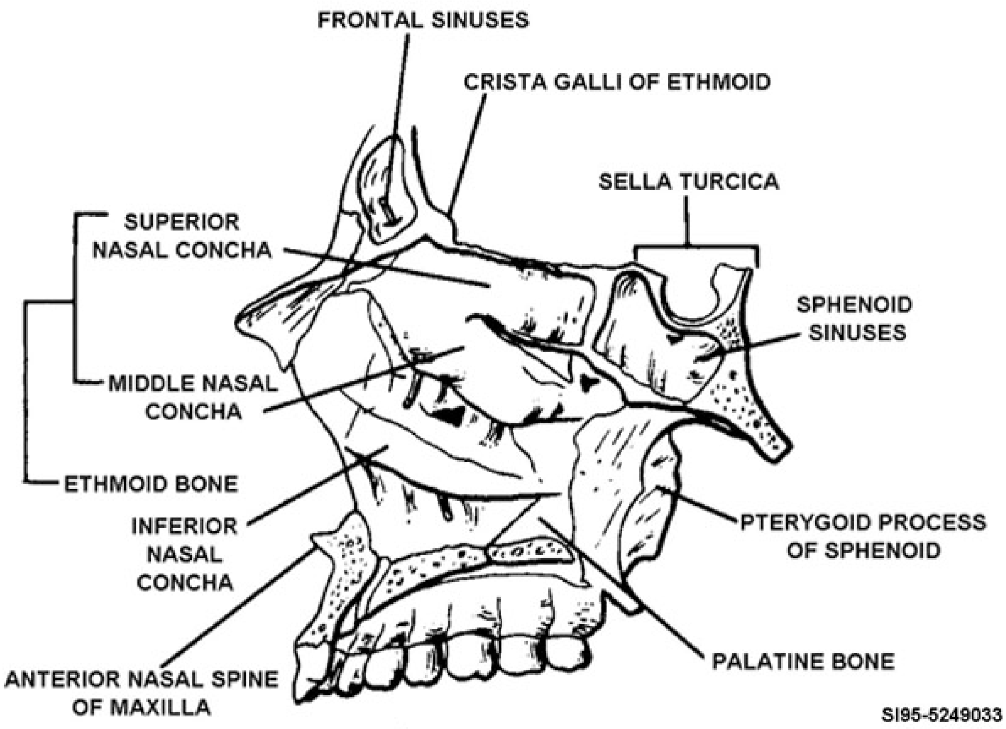


Figure 4–1. Sagittal section of skull showing lateral wall of nasal chamber.

428. Cranial sutures and junctions

The articulations of the cranial bones are called sutures. They are synarthrodial joints because they allow for no appreciable movement. The places where two or more sutures meet are known as junctions. They are not fully fused at birth to allow for some compression of the skull during childbirth. However, they usually fuse completely by two years of age.

Cranial sutures

The following table describes the cranial sutures (fig. 4–2):

The Cranial Sutures	
Suture	**Description**
Coronal	The frontal bone in articulation with the parietal bones.
Sagittal	The two parietal bones in articulation with each other (not shown).
Lambdoidal	The occipital bone in articulation with the parietal bones.
Squamosal	The temporal bone in articulation with the parietal bone.
Sphenosquamosal	The sphenoid bone in articulation with the temporal bone.
Sphenofrontal	The sphenoid bone in articulation with the frontal bone.
Sphenoparietal	The sphenoid bone in articulation with the parietal bone.
Occipitomastoidal	The occipital bone in articulation with the mastoid process of the temporal bone.
Parietomastoidal	The parietal bone in articulation with the mastoid process of the temporal bone.

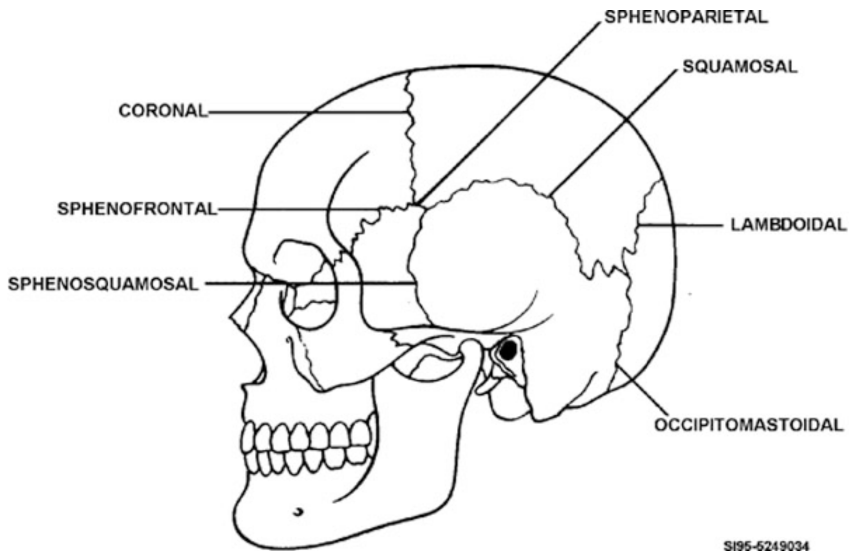


Figure 4–2. Cranial sutures.

Cranial junctions

The cranial junctions consist of the junctions described in the following table (fig. 4–3):

The Cranial Junctions	
Junction	**Description**
Bregma	The junction of the coronal and sagittal sutures.
Lambda	The junction of the sagittal and lambdoidal sutures.
Asterion	The junction of the lambdoidal, squamosal, occipitomastoidal, and parietomastoidal sutures on the posterior, lateral surface on each side of the skull.
Pterion	The junction of the squamosal, sphenosquamosal, sphenofrontal, and sphenoparietal sutures on the anterior, lateral surface on each side of the skull.

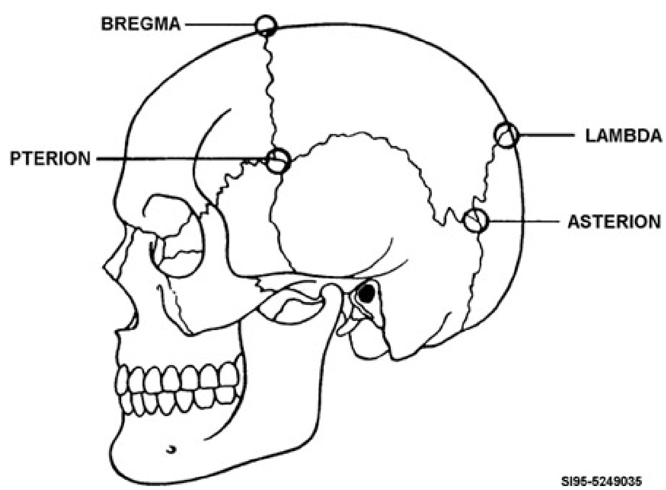


Figure 4–3. Cranial junctions.

Cranial fontanelles

The cranial fontanelles are membranous areas in the cranium located at several junctions of the cranial bones. They are found only in infants and represent the future sites of the cranial junctions. The ossification of the fontanelles is usually complete at 2 years of age. There are six fontanelles—one anterior, one posterior, two anterolateral, and two posterolateral.

The Cranial Fontanelles	
Fontanelle	**Description**
Anterior fontanelle	Often called the *frontal fontanelle*, it is located where the two parietal bones join the frontal bone. It is the future site of the bregma and is usually the last fontanelle to ossify.
Posterior fontanelle	Often called the *occipital fontanelle*, it is located where the two parietal bones join the occipital bone. It is the future site of the lambda.
Anterolateral fontanelles	Often called the *sphenoidal fontanelles*, they are located bilaterally at the junction of the parietal bones with the sphenoid and frontal bones. They are the future sites of the pterion.
Posterolateral fontanelles	Often called the *mastoid fontanelles*, they are located bilaterally at the junction of the parietal bone with the mastoid process of the temporal bone and the occipital bone. They are the future site of the asterion.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

427. Bones of the cranium

1. Refer to figure 4–4. Label the illustration of the skull by placing the name of the cranial bone next to the letter (below) that corresponds to the illustration.

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

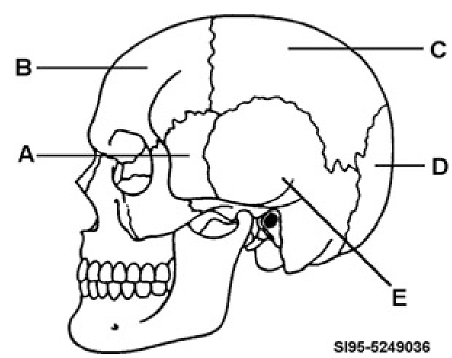


Figure 4–4. Objective 427, self-test question 1.

2. Which bone forms the superior portion of the orbits?

3. Which portion of the frontal bone makes up the forehead?

4. Describe the sagittal sulcus of the frontal bone.

5. What bone(s) join posteriorly with the occipital and anteriorly with the frontal?

6. The mastoid process is part of what bone?

7. What part of the temporal bone is described as a pyramid shaped wedge of bone?

8. What part of the temporal bone helps form the temporomandibular joint?

9. Name the large foramen in the occipital bone.

10. What part of the occipital bone articulates with the first cervical vertebra?

11. What bone makes up the middle portion of the floor of the cranium?

12. On which part of the sphenoid is the pituitary gland situated?

13. What processes located on the sphenoid bone forms a partial protective roof over pituitary gland?

14. What is the smallest cranial bone?

15. What portion of the ethmoid bone forms the roof of the nasal cavity?

16. What is the attachment point for the anterior brain?

17. What is the name of the thin sheet of bone extending inferiorly from the bottom of the cribriform plate?

18. Which portion of the ethmoid bone circulates and filters inhaled air?

428. Cranial sutures and junctions

Match the cranial sutures and junctions in column B with the appropriate descriptions in column A. Each item in column B may be used once or not at all.

Column A	*Column B*
____ (1) Articulation of the sphenoid and temporal bones.	a. Coronal suture.
____ (2) Junction of coronal and sagittal sutures.	b. Sagittal suture.
____ (3) Articulation of temporal and parietal bones.	c. Lambdoidal suture.
____ (4) Articulation of occipital and parietal bones.	d. Squamosal suture.
____ (5) Junction of lambdoidal, squamosal, occipito-mastoidal, and parietomastoidal sutures.	e. Sphenosquamosal suture.
	f. Bregma.
____ (6) Articulation of the parietal bones.	g. Lambda.
____ (7) Articulation of frontal and parietal bones.	h. Asterion.
____ (8) What the posterior fontanelle becomes once it ossifies.	i. Pterion.

4–2. The Facial Bones and Paranasal Sinuses

Radiography of the facial bones can be particularly challenging because of the precise positioning and tube angulation often required to visualize many facial structures adequately. Compounding the difficulty is the decreasing frequency of these types of examinations since the advent of computed tomography. Years ago, radiographic examinations of the facial bones were performed routinely, so that most technologists acquired the experience to obtain superior radiographs with minimal repeats.

Today, however, the infrequency of this type of examination, compounded by the fact that most of the exams still being performed are for trauma situations, makes it increasingly important that you have a thorough knowledge of the osteology of the structures involved. This will aid you immensely in obtaining high quality images with the rapidity required during trauma radiography.

429. Facial bones

There are 14 bones that make up the facial portion of the skull—two maxillae, two lacrimal bones, two zygoma, two palatine bones, two nasal bones, two inferior nasal conchae, one vomer, and one mandible. The maxillae, the zygoma, and the mandible form most of the facial contour. Use foldout 1, during this discussion

Maxillae

The maxillae form the upper jaw and hold the upper teeth in place. They meet and fuse in the midline at the anterior borders of the face. Also, they form part of the medial floor of the orbits, the medial part of the infraorbital ridge, the lateral parts of the nasal fossa, and the anterior part of the roof of the mouth. Each maxilla consists of a body, frontal process, infraorbital foramen, infraorbital margin, zygomatic process, palatine process, anterior nasal spine, and alveolar process.

Parts of the Maxilla	
Part	**Description**
Body	Comprises most of the bone and has a large cavity, the antrum of Highmore, which houses the maxillary sinus.
Frontal process	Extends upward to form part of the lateral border of the nose and the medial portion of the infraorbital margin.
Infraorbital foramen	A small hole just below the center of the infraorbital margin, through which the infraorbital nerve and blood vessels pass to the cheeks.
Infraorbital margin	The anterior, inferior margin of the orbit formed partly by the maxilla.
Zygomatic process	Extends laterally from the body and articulates with the maxillary process of the zygoma.
Palatine process	A horizontal plate of bone extending medially to meet the corresponding bone of the other side to form the anterior part of the hard palate (roof of the mouth) and the floor of the nose.
Anterior nasal spine	A sharp projection of bone on the lower part of the midanterior surface of the maxilla.
Alveolar process	The portion of the maxilla that contains the cavities of different sizes and shapes that hold the teeth of the upper jaw.

Lacrimal

These are the smallest and most delicate bones of the facial skeleton. They form a small portion of the anterior, medial part of the orbital walls, bilaterally. They also house the lacrimal (tear) ducts.

Zygoma

The two zygoma or *malar bones*, often called the cheek bones, are located in the superior lateral aspect of the face, bilaterally. They form the prominent portion of the cheeks and part of the orbits. The parts of each bone that deserve consideration are the frontosphenoidal, orbital, maxillary, and temporal processes.

Structures of the Zygoma	
Structure	**Description**
Frontosphenoidal	Articulates with the zygomatic process of the frontal bone, helping to complete the lateral wall of the orbit.
Orbital	Extends medially from the infraorbital margin to form part of the floor and lateral walls of the orbits. The lateral part of the infraorbital margin is formed by the anterior portion of the orbital process of the zygoma.
Maxillary	Articulates with the zygomatic process of the maxilla.
Temporal Process	The long, narrow projection that articulates with the zygomatic process of the temporal bone to form the zygomatic arch.

Palatine

The palatine bones are small L-shaped bones located behind the nose. The perpendicular part of each bone forms part of the lateral wall of the nasal cavity. The horizontal part of each articulates with the corresponding horizontal part of the other palatine to form the posterior part of the hard palate.

Nasal

Two nasal bones form the bridge of the nose and articulate superiorly with the nasal notch of the frontal bone. They project anterior and inferior from this junction. Laterally, they articulate with the frontal processes of the maxillae.

Inferior nasal conchae

The inferior nasal conchae, also called the *inferior turbinate bones*, are long, thin bones located along the lateral walls of the nasal cavity (fig. 4–1).

Vomer

The vomer, a thin plate of bone, forms the posterior, inferior part of the nasal septumand is located posterior and inferior to the perpendicular plate of the ethmoid bone. The upper border of its anterior portion articulates with the inferior surfaces of the perpendicular plate of the ethmoid bone. The lower part of the anterior border articulates with the cartilage of the nasal septum.

Mandible

The mandible, or jawbone, houses the lower teeth. It has several prominent structures that should be studied—the body, mental symphysis, mental foramina, angles, rami, coronoid and condyloid processes, and mandibular notches.

Structures of the Mandible

Structure	Description
Body	The curved part of the bone that is shaped like a horseshoe extending from one mandibular angle to the other.
Mental symphysis (symphysis menti)	The anterior part of the body where the two L-shaped halves fuse together early in life—usually during the second year.
Mental foramina	Located about 1 1/4 inches on each side of the symphysis menti below the level of the second premolar (bicuspid) tooth on the anterior surface of the body of the mandible.
Angles of the mandible	The rounded areas of the lower jaws where the horizontal part of the body bends upward to an almost vertical position. They are located bilaterally at the posterior-inferior part of the mandible and mark the junctions of the body and the rami.
Rami of the mandible	Those parts of the bone extending upward at about 45° from the angles of the mandible at the posterior aspects of the bone, bilaterally.
Coronoid processes	Extend from the superior, anterior border of the rami.
Condyloid processes	Bony projections extending from the superior, posterior borders of the rami. They articulate with the mandibular fossae of the temporal bone forming the temporomandibular joints. Each process has two parts—the neck and the condyle.
Mandibular notches	The semicircular, or half-moon, depressions between the coronoid and condyloid processes of the mandibular rami.

430. Paranasal sinuses

The paranasal sinuses are mucous-lined cavities in the frontal, maxilla, ethmoid, and sphenoid bones. Their locations are, of course, responsible for their names—maxillary, frontal, sphenoidal, and ethmoidal sinuses. Refer to figure 4–5 as we briefly describe each.

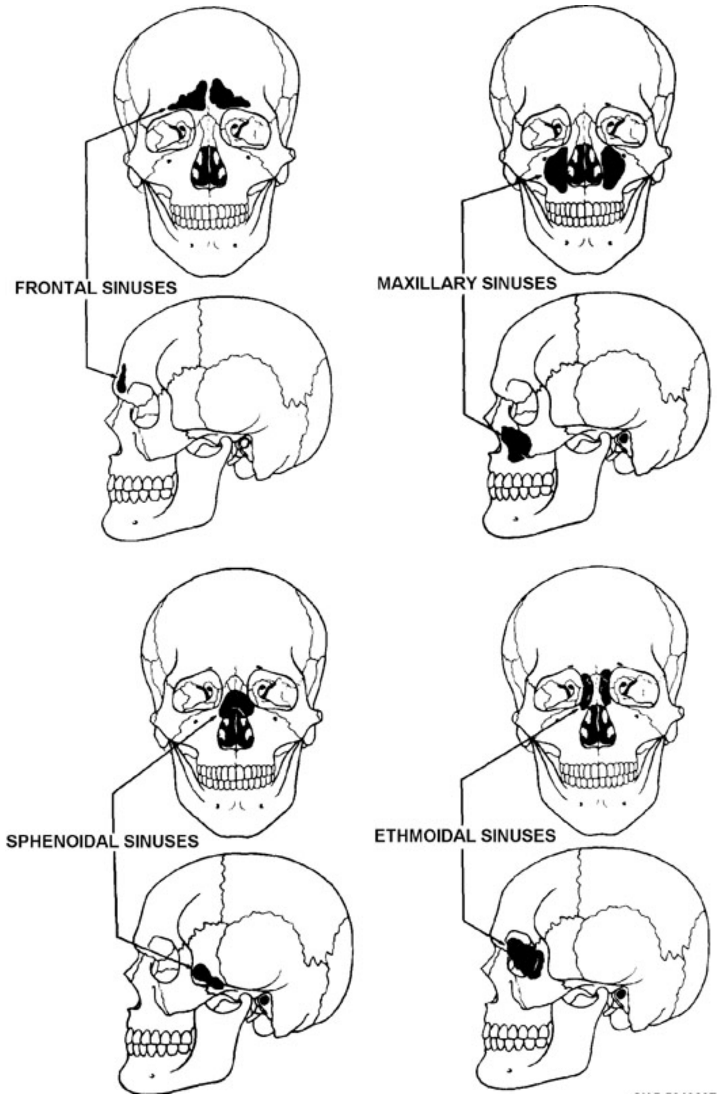


Figure 4–5. The paranasal sinuses.

Maxillary sinuses

These large, pyramidal cavities are contained in the bodies of the maxillae in a space known as the antrum of Highmore. They communicate with the nasal cavity through two small orifices in the superior, medial aspects of each antrum. The floor of each cavity is formed by the alveolar processes of the maxillae, and if the sinuses are of average size, this floor is level with the floor of the nose. The maxillary sinuses, like the frontals, vary in size and configuration, even in the same patient. Both cavities are lined by a mucoperiosteal membrane that is continuous with that of the nasal cavity. The maxillary sinuses are usually sufficiently developed and aerated enough at birth to be demonstrated radiographically.

Frontal sinuses

These cavities are between the inner and outer tables of the frontal bone in an area just above the bridge of the nose. These sinuses vary considerably in shape and size, extending upward, backward, and laterally from a central point just above and behind the bridge of the nose. They are separated by a thin, bony septum, which very often deviates from one side to the other. They are lined with a mucous membrane, and each cavity communicates with the corresponding nasal cavity by means of the frontonasal duct.

Sphenoid sinuses

The sphenoidal sinuses are directly posterior to the ethmoidal sinuses. They are a pair of cavities in the body of the sphenoid bone, separated from each other by a bony septum. This septum is rarely perpendicular to the base of the body, but is bent to one side or the other. This accounts for the asymmetrical appearance of the sinuses. The sphenoids are lined by a mucoperiosteal membrane that is continuous with that of the nasal cavity. They communicate with that cavity through the sphenoethmoidal recess, situated high in the posterior aspect of the nasal cavity. For the ethmoidal and sphenoidal sinuses, it takes until age six to seven years old for these two sinus groups to develop. At that time, the sphenoid sinuses are typically distinguishable from the ethmoid air cells, which they resemble in both size and position.

Ethmoid sinuses

These sinuses form the medial wall of each orbit as well as the superior portion of the nose on either side. The air cells of the ethmoids develop in puberty, vary in number and size, and are not completely developed until age 16 or 17 years old. There may be many small cavities or a few larger cavities. The anterior ethmoidal cells communicate with the middle nasal meatus. The posterior cells, located at the back of the nasal fossa, communicate with the superior meatus. The ethmoidal cells are lined by mucoperiosteal membrane continuous with that of the nasal cavity.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

429. Facial bones

1. Refer to figure 4–6. Label the illustration of the skull by placing the name of the facial bone or structure next to the letter that corresponds to the illustration.

A. ______________________

B. ______________________

C. ______________________

D. ______________________

E. ______________________

F. ______________________

G. ______________________

H. ______________________

I. ______________________

J. ______________________

K. ______________________

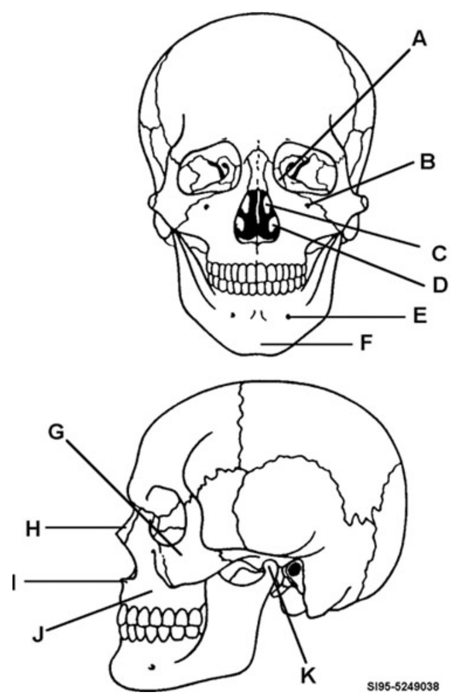


Figure 4–6. Objective 429, self-test question 1.

2. Which portions of the maxillae form the anterior part of the hard palate?

3. Which portions of the maxillae contain the cavities that hold the teeth?

4. Which are the smallest facial bones?

5. What is another name for the zygomas?

6. Which portion of the zygoma helps form the zygomatic arch?

7. Which facial bones form the posterior part of the hard palate?

8. Which facial bone forms the posterior, inferior part of the nasal septum?

9. Describe the mandibular notches.

430. Paranasal sinuses

1. Referring to figure 4–5 (in the text), which sinuses are located directly below the orbits?

2. What is the name of the cavity located in the body of each maxilla?

3. Which sinuses are located above and behind the bridge of the nose?

4. Through what duct do the frontal sinuses communicate with the nasal cavity?

5. Which sinuses are located directly posterior to the ethmoids?

6. Which sinuses form the medial walls of the orbits?

Answers to Self-Test Questions

427

1. (A) Sphenoid.
   (B) Frontal.
   (C) Parietal.
   (D) Occipital.
   (E) Temporal.
2. Frontal.
3. Squamosal.
4. A vertical groove on the internal surface of the frontal bone, formed by the fusion site of the original two parts of the frontal bone.
5. Parietals.
6. Temporal.
7. The petrous ridge.
8. The mandibular fossa.
9. The foramen magnum.
10. The occipital condyles.
11. Sphenoid.
12. The sella turcica.
13. The anterior and posterior clinoid processes.
14. The ethmoid.
15. The cribriform plate.
16. The crista galli.
17. The perpendicular plate.
18. The labyrinths.

428

1. e.
2. f.
3. d.
4. c.
5. h.
6. b.
7. a.
8. g.

429

1. (A) Lacrimal bone.
   (B) Infraorbital foramen.
   (C) Middle nasal concha.
   (D) Inferior nasal concha.
   (E) Mental foramen.
   (F) Mandible.
   (G) Zygoma.
   (H) Nasal bone.
   (I) Anterior nasal spine.
   (J) Maxilla.
   (K) Mandibular condyle.
2. The palatine processes.
3. The alveolar processes.
4. The lacrimals.
5. The malar bones.
6. The temporal process.
7. The palatines.
8. The vomer.
9. The semicircular, or half-moon, depressions between the coronoid and condyloid processes of the mandibular rami.

430

1. The maxillary sinuses.
2. The antrum of Highmore.
3. The frontals.
4. The frontonasal duct.
5. The sphenoid sinuses.
6. The ethmoids.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

39. (427) Which structures are located on the frontal bone?
    a. Infraorbital foramina and vomer.
    b. Zygomatic process and nasal process.
    c. Frontal eminences and perpendicular plate.
    d. Supraorbital foramina and tympanic portions.

40. (428) Which two fontanelles, when ossified, become the bregma and lambda?
    a. Both anterolaterals.
    b. Both posterolaterals.
    c. Anterior and posterior.
    d. Anterior and right posterolateral.

41. (429) Which structures are located on the maxilla?
    a. Alveolar process, orbital process, and perpendicular plate.
    b. Inferior turbinate, anterior nasal spine, and zygomatic arch.
    c. Infraorbital foramen, zygomatic process, and palatine process.
    d. Infraorbital foramen, anterior nasal spine, and temporal process.

42. (429) Which facial/cranial bone houses the tear ducts?
    a. Frontal.
    b. Maxilla.
    c. Lacrimal.
    d. Zygomatic.

43. (429) Which bone forms the posterior, inferior part of the nasal septum?
    a. Vomer.
    b. Palatine.
    c. Ethmoid.
    d. Inferior nasal concha.

44. (429) Which structure on the mandible forms part of the temporomandibular joint?
    a. Alveolar process.
    b. Symphysis menti.
    c. Coronoid process.
    d. Condyloid process.

45. (430) Which sinuses form the medial wall of each orbit?
    a. Frontal.
    b. Ethmoid.
    c. Sphenoid.
    d. Maxillary.

Please read the unit menu for unit 5 and continue ➔

Unit 5. Positioning of the Upper Extremities

IN THIS UNIT WE DISCUSS POSITIONING by discussing the upper extremities. This unit is not, nor was it intended to be, a complete guide for radiographic positioning. Several excellent civilian published texts offer comprehensive instructions for the vast majority of radiographic projections performed today. If your department does not already have a copy of one of these civilian texts, we highly encourage you to speak to your NCOIC about obtaining at least one copy for your department.

Although this is not a comprehensive guide for positioning, many of the standard routine projections are discussed for the various body parts as well as some of the more common additional projections. A sincere effort was put forth to include the majority of the projections that a competent, modern day technologist should be able to perform without reference. Included in each lesson discussion, we will also review the related anatomy that should be demonstrated by most of the projections and present pertinent information that will help you when evaluating radiographic quality.

NOTE: Throughout this unit, any reference to film, a cassette, and/or image receptor is meant to be synonymous with each other. As well, always expose each image with the appropriate right or left lead anatomical marker. Using stickers, sharpie permanent markers, or computer aided text is neither authorized nor legal in a court of law to mark human radiographic images.

5–1. The Thumb, Fingers, and Hand

Positioning of the upper extremity includes the fingers, hand, wrist, forearm, elbow, humerus, and shoulder. We begin distally, as we did in the osteology unit, and will work our way proximally.

NOTE: All source-to-image distances (SID) are assumed to be 40 inches unless otherwise indicated.

431. Routine radiographic projections of the thumb and fingers

The digits of the hand are frequent subjects of radiographic examination. Positioning for these digits is quite simple. The only potential difficulty comes from trauma, which may inhibit the patient's ability to attain the lateral position free of superimposition from the other digits.

Thumb

The thumb is a digit that requires a discussion separate from the rest of the fingers. Due to its opposable nature, it has unique radiographic positioning requirements.

Image receptor

Expose one projection per 8x10 inch cassette table top. Always reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

For all projections, seat the patient at the end of the radiographic table. Instruct the patient to remove all rings and watches that may obscure desired anatomy. For all extremity radiographs in which the patient is seated at the end of the table, it is especially important to shield the gonads because the path of the divergent central ray will come very close to the patient. As always, proper collimation to include only the area of interest is vital. There are three standard projections for the thumb—anteroposterior (AP), oblique, and lateral.

Anterior posterior

Figure 5–1 demonstrates proper positioning for an AP projection of the thumb. Notice the arm is fully extended and in extreme internal rotation. Place the posterior aspect of the thumb on the cassette and ensure the remaining digits and metacarpals are pulled free of superimposition.

Align the long axis of the thumb parallel with the long axis of the cassette so all views are in the same direction for each exposure. Center the first metacarpophalangeal or MP joint to the center of the cassette and direct the perpendicular CR to that point.

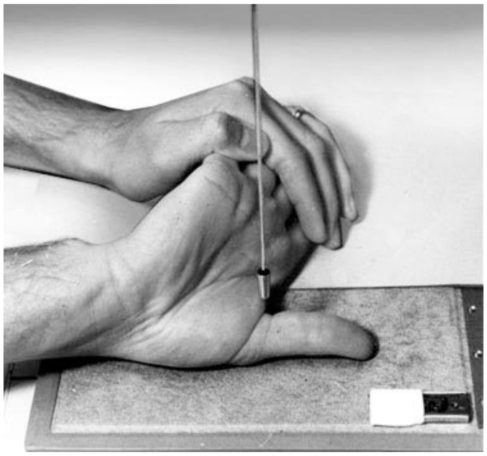


Figure 5–1. Patient positioned for an AP thumb.

Oblique

With the hand and fingers extended palm down, center the thumb on cassette and direct the CR perpendicular through the metacarpophalangeal joint. The position is very similar to a PA hand radiograph. The thumb naturally lies oblique when the hand is in the PA position. As with all thumb positions, be sure to include the entire first metacarpal within your collimation. Sometimes small linear or chip fractures may be present causing pain to irradiate to the phalanges of the thumb. This view shows chip fractures at the ends of phalanges not readily seen on the AP or lateral.

Lateral

From the oblique position, have the patient flex the fingers of the affected hand to form a natural arched position or loose fist with the thumb extended. This procedure places the phalanges of the thumb in a true lateral position. Again, center the metacarpophalangeal joint to the center of the cassette and direct your perpendicular CR to that point.

Anatomy demonstrated

All radiographs of the thumb show the two phalanges of the thumb, the first metacarpal, related soft tissue structures, and articulations. The interphalangeal joint, first metacarpophalangeal joint, and first carpometacarpal joint should be visible.

Fingers

The routine projections for fingers are posterior anterior, PA oblique, and lateral. Some radiology departments include the entire hand on the PA projection. For our discussion, we will describe the finger projections only.

Image receptor

Use an 8x10 inch cassette. Expose one projection per cassette table top. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

Again, the patient should be seated at the end of the radiographic table and jewelry that may inhibit visualization of the part of interest should be removed. As always, shield the gonads to protect them from the divergent CR. The standard accepted positions for radiographing the fingers that we will discuss are the PA, PA oblique, and lateral.

Posterior anterior

When you are positioning for a PA projection of the finger, ensure the finger is fully extended and the anterior surface is placed flat on the cassette. Arching of the finger may superimpose articular surfaces upon one another. This makes accurate diagnosis of interphalangeal pathology nearly impossible.

Center the affected finger to the cassette. Ensure the long axis of the finger is parallel to the long axis of the cassette. Direct the CR perpendicular to the PIP joint space and collimate to the affected digit (finger).

Posterior anterior oblique

The oblique projection commonly done for fingers is the PA (medial) oblique. From the PA projection rotate the entire hand, keeping the fifth digit in contact with the cassette, until the plane of the hand forms a 45° angle with the film. Center the affected finger parallel to the cassette keeping the same axis as the PA projection. Direct the CR perpendicular to the PIP joint and collimate to the affected finger.

There is one common problem associated with this position. It is that the patient tends to drop their fingertips to the film therefore closing the interphalangeal joint spaces because the phalanges are no longer parallel to the film. This problem can be easily overcome with the use of a 45° foam positioning wedge. This device keeps the patient's fingers parallel with the film. Figure 5–2 demonstrates proper positioning for the PA medial oblique finger.

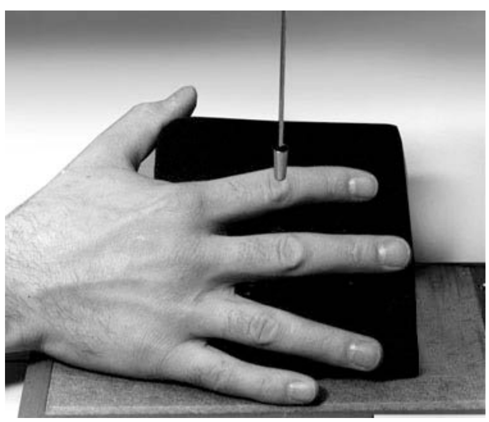


Figure 5–2. Patient positioned for a PA oblique third finger.

Lateral

When performing the lateral projection for a finger series, you should do the lateral that will place the affected finger closest to the film to minimize object-to-image distance (OID). For instance, a lateral projection with the radial surface of the hand down is best for the second and third digits (fig. 5–3). A lateral projection with the ulnar surface of the hand down should be done for fourth and fifth digits (fig. 5–4). Whichever lateral is accomplished, center the finger to the cassette and direct the CR perpendicular to the proximal interphalangeal joint. Collimate to the affected finger.

Pain associated with trauma may prevent the patient from fully extending the finger, or it may cause part motion. A finger may be immobilized with the use of a foam block, wooden tongue depressor, tape, or similar object. Always be sure the fingers are parallel to the film and not superimposed over each other.

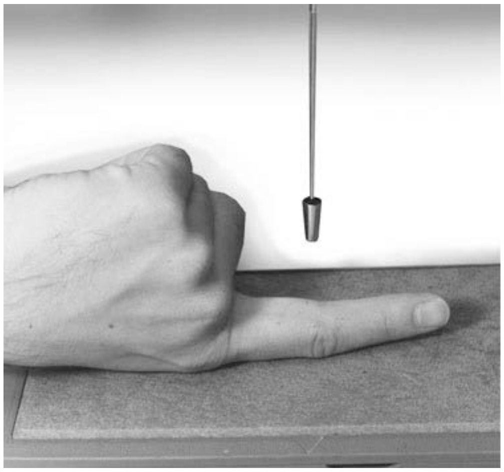


Figure 5–3. Patient positioned for a lateral second digit (finger).

Figure 5–4. Patient positioned for a lateral fifth digit (finger).

Anatomy demonstrated

The three phalanges, interphalangeal, and metacarpophalangeal articulations, and the distal portion of the related metacarpal should be visualized for each finger. The articulations should appear open on all views—pay special attention to the oblique and lateral.

432. Radiographic projections of the hand

Standard projections of the hand include PA, PA oblique, and lateral. An additional view often ordered to assess for rheumatoid arthritis is the AP oblique projection (Norgaard method). Let’s proceed with our discussion of the routine projections of the hand.

Image receptor

Use a 10x12 inch cassette. Expose one projection per cassette table top. For additional guidance, reference your departments’ standard operating procedures or imaging protocols.

Position

The patient should be seated at the end of the radiographic table for all views and all overlying jewelry should be removed. As always, use gonadal shielding and proper collimation to minimize patient exposure. The PA, PA oblique, lateral, and AP medial oblique (Norgaard) are the acceptable positions of use.

Posterior anterior

The PA projection presents an anterior view of the hand and, because it serves as the general survey film for the hand, should include all digits and the wrist. Therefore, proper centering on the cassette is important.

With the forearm extended and its volar surface resting on the table top, the hand is placed so that the palm is on the cassette. Ensure fingers are flat and only slightly spread apart. Direct the CR perpendicular to the head of the third metacarpal.

You should use the reverse the projection and perform an AP projection if the hand and fingers cannot be fully extended and the metacarpals or metacarpophalangeal joints are the primary area of interest.

Posterior anterior oblique

Center the hand on the cassette and from the PA position; rotate the hand into a 45° oblique with the ulnar side down. Fingers should be extended and parallel to the cassette for maximum visualization of interphalangeal joint spaces. If the metacarpals are of primary interest, slightly flexing the fingers to place their tips on the cassette will place the metacarpals more parallel to the cassette and minimize foreshortening. Regardless of which method you perform, ensure the CR is projected perpendicular to the head of the third metacarpal.

Lateral

The lateral projection of the hand is usually done as a lateromedial projection. That is, with the ulnar side of the hand against the cassette. From the oblique projection, simply rotate the hand into a true lateral position with the fingers together and the thumb in its natural, partially opposed state (fig. 5–5). Center the lateral hand to the cassette and direct the CR perpendicular to the second MP joint.

An alternative method that many radiologists prefer is called a fan lateral. For this projection, the hand is still placed in true lateral, but the fingers are spread apart to eliminate superimposition of the phalanges (fig. 5–6). This position is most easily accomplished with the use of a “stepwedge” positioning sponge.

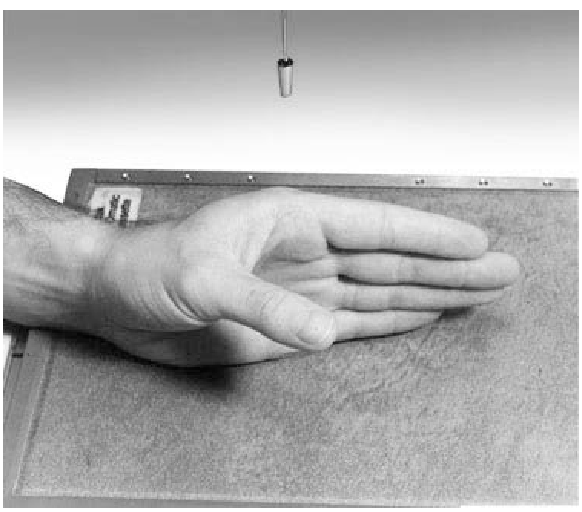


Figure 5–5. Patient positioned for a lateral hand.

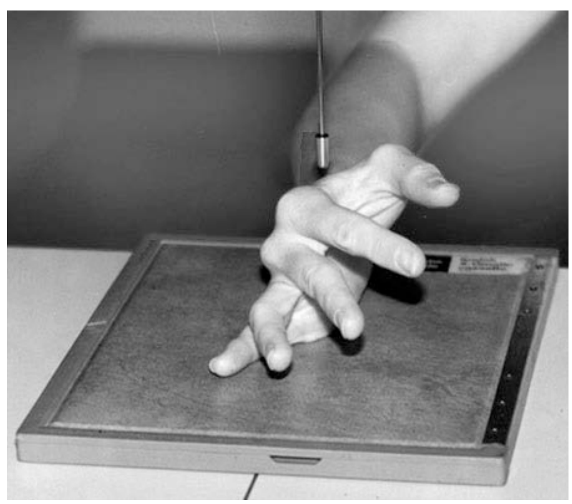


Figure 5–6. Patient positioned for a fan lateral projection of the hand.

AP medial oblique (Norgaard)

The AP medial oblique (Norgaard) is often ordered to detect early arthritic changes that may lead to rheumatoid arthritis. It is sometimes referred to as the "ball-catcher's" position because the positioning of the hands is similar to holding a ball. In order to obtain the contrast and detail necessary to detect early arthritic changes, it is especially important to use a low kVp setting.

Place both hands together in the true lateral position in the center of a 10×12 inch cassette oriented crosswise. Supinate the hands until they are in a 45° medial oblique. It is acceptable for the fingers to be slightly bent (fig. 5–7). Direct the CR perpendicular to a point midway between the hands at the level of the MP joints. Adjust collimation to include both hands, including all digits and carpals.

Figure 5–8 is an example of a properly positioned ball-catcher's radiograph.

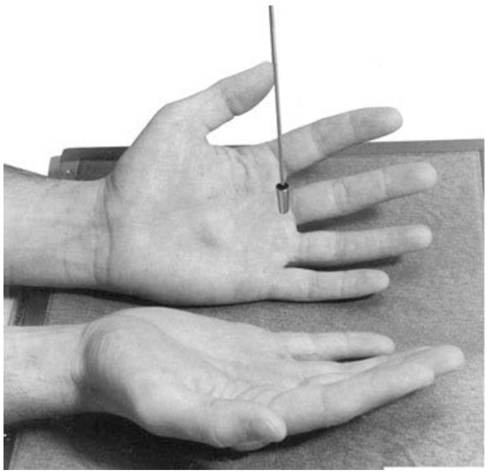


Figure 5–7. Patient positioned for an AP medial oblique hands projection.

Figure 5–8. AP medial oblique hands radiograph.

Anatomy demonstrated

All views of the hand should show phalanges, metacarpals, carpals, and related joint structures. The Norgaard method is especially sensitive for early arthritic changes in the joint spaces.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

431. Routine radiographic projections of the thumb and fingers

1. Explain why it is especially important to use gonadal shielding when you have a patient seated at the end of the table for an X-ray.

2. Name the routine projections of the thumb.

3. In what position is the arm placed for an AP projection of the thumb?

4. Positioning for the oblique projection of the thumb is very similar to what projection of the hand?

5. What is the centering point for a lateral thumb?

6. Which joints should be visible on thumb radiographs?

7. What is the centering point for radiographs of the fingers?

8. How can you keep the patient's fingers parallel with the film when performing a PA oblique projection?

9. Which lateral should you perform when accomplishing a finger series?

10. List three devices you can use to help immobilize a finger for the lateral position.

432. Radiographic projections of the hand

1. List the routine projections for the hand.

2. What is the centering point for the PA projection of the hand?

3. In what instance should you consider using the AP projection for the hand?

4. How many degrees should the hand be obliqued for the PA oblique projection?

5. When performing the PA oblique hand projection, when should you consider having the patient flex his or her fingers slightly to place the tips on the cassette?

6. What variation of the lateral hand radiograph can be performed to eliminate superimposition of the phalanges?

7. Which additional position of the hand is used to detect early arthritic changes?

8. Briefly describe the positioning for the view mentioned in question number 7.

5–2. The Wrist, Forearm, and Elbow

We continue our discussion of positioning of the upper extremity with the wrist, forearm, and elbow. We group these positions together because in cases of trauma to the forearm it is critical to include one or both joints on the radiograph. In many cases, the wrist and elbow are ordered as separate series in conjunction with the initial forearm examination. **NOTE**: All SIDs are assumed to be 40 inches unless otherwise indicated.

433. Radiographic projections of the wrist

Most radiology departments require at least three projections for a standard wrist series—PA, PA oblique, and lateral.

Image receptor

Use an 8x10 inch cassette. Expose one projection per cassette table top. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

Seat the patient at the end of the radiographic table for all views. Remove all watches or bracelets and roll up the sleeve of any shirt, if necessary, to remove all objects from superimposition of the distal forearm and wrist. Gonadal shielding is again important. Collimation should be adjusted to include the entire carpal region, as well as the distal radius and ulna, and the proximal portion of the metacarpals.

Posterior anterior

Usually, the first projection accomplished is the PA. For this position, the patient's forearm is extended with the hand placed palm down on the cassette. Center the wrist to the cassette and partially flex the fingers to form a loose fist. This will reduce the normal curvature of the wrist and lessens object-image distance for the carpals. Direct the CR perpendicular to the midcarpal area.

NOTE: An AP projection of the wrist may be requested instead of the PA if better visualization of the carpal interspaces is desired, or the wrist is casted in such a way to prohibit proper positioning for the PA projection. Positioning considerations are the same for this view, except the patient's hand is supinated (palm up) and the fingers are fully extended.

Posterior anterior oblique

The oblique projection routinely performed for the wrist is the PA oblique (lateral rotation). From the PA position, rotate the radial side up until the wrist forms a 45° angle with the cassette. Direct the CR perpendicular through the midcarpal region.

Lateral

The lateromedial projection, with the ulnar surface of the wrist in contact with the cassette, is the common lateral performed for the wrist. Place the forearm on the table with the wrist joint centered to the cassette. The wrist is in the true lateral position when the radial styloid process is directly superimposed over the ulnar styloid process. Supinating the hand five degrees will place the wrist in a true lateral position. The CR is directed perpendicular to the carpals.

Anatomy demonstrated

All routine views of the wrist should demonstrate the carpals, distal radius and ulna, proximal metacarpals, and articulations. The PA oblique projection demonstrates the carpals on the lateral side of the wrist, particularly the navicular, which is superimposed upon itself in the PA projection.

Additional projections of the wrist

There are many additional projections of the wrist. Each is useful for demonstrating slightly different aspects of the anatomy of the wrist; we will discuss three of the most common. Your department may include one or more of the following projections as part of its routine series: radial deviation, AP medial oblique, and carpal canal.

Ulnar deviation

This additional PA projection is used primarily to demonstrate the carpal scaphoid (navicular). The ulnar deviation view begins as a routine PA hand with the carpals centered to the cassette. At this point, have the patient hold the affected wrist and forearm with the opposite hand and then instruct them to move/rotate the affected hand outward (towards the 5th digit). The CR is directed perpendicular to the scaphoid. Figures 5–9 and 5–10 demonstrate proper positioning and the actual radiograph, respectively. Notice how clearly the navicular is seen.

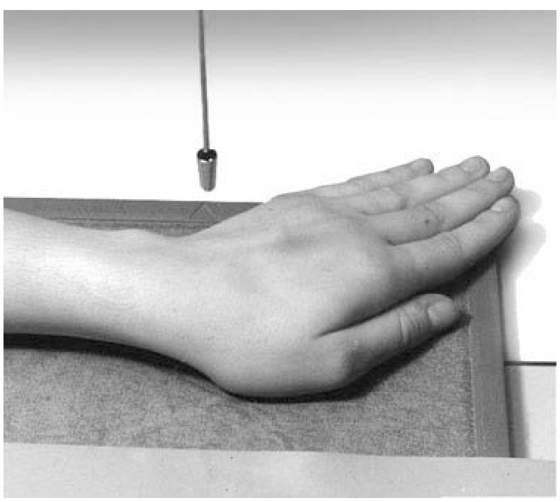


Figure 5–9. Patient positioned for radial deviation view of the wrist.

Figure 5–10. Radial deviation radiograph.

A similar, but opposite projection is the Radial deviation view. This position is used to demonstrate the pisiform and, like ulnar deviation, the carpal interspaces of the deviated side. To position for this view, all factors remain the same except the patient moves the hand towards the 1st digit (the thumb).

Anterior position oblique

As you recall, the PA oblique shows adequate visualization of the navicular. There are times when trauma to the medial aspect of the wrist may require a different view. The AP oblique (medial rotation), sometimes called a semisupination oblique, demonstrates the pisiform and related structures on the medial aspect of the wrist.

From the AP position, rotate the hand medially (internally) until the interstyloid line forms a 45° angle with the cassette. This maneuver projects the pisiform free of superimposition from the rest of the carpals. Direct the CR perpendicular through the midcarpal area to the center of the cassette.

Gaynor-Hart method (carpal canal)

The Gaynor-Hart method is also referred to by other names—carpal canal, carpal tunnel, or inferosuperior projection. Regardless of which terminology you use, this position shows an axial projection of the anterior surface of the wrist—the carpal canal. Extend the arm, placing the volar surface of the forearm on the table and cassette. Have the patient grasp the fingers of the affected hand with the opposite hand and hyperextend the wrist until the palmar surface of the hand is as vertical as possible to the cassette. Rotate the hand slightly toward the radial side of the wrist to separate the hamulus process and pisiform. Direct the CR through the carpal canal at an angle of 25° to 30° from vertical toward the forearm. Figures 5–11 and 5–12 demonstrate this position and a radiograph of the carpal canal, respectively. Notice in the radiograph how well the pisiform and hamular processes are visualized.

Figure 5–11. Patient positioned for a carpal canal view.

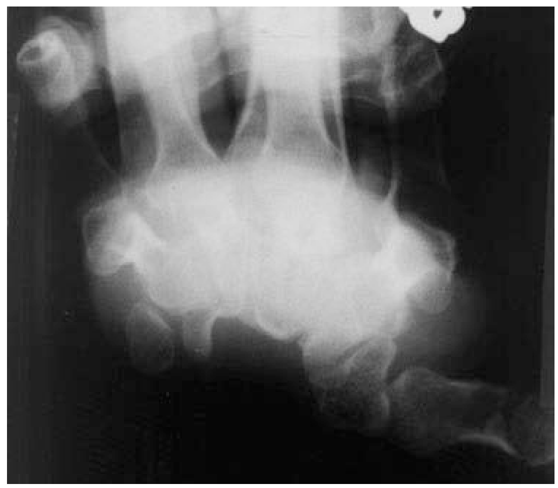


Figure 5–12. Carpal canal radiograph.

434. Routine radiographic projections of the forearm

Standard projections for the forearm are AP and lateral. Most radiologists prefer to have both joints (wrist and elbow) included on the film. Some departments, however, require that you include only the joint nearest the area of injury on the film. Since the only variation between these two methods is cassette size, we will only discuss the more common method—both joints included.

Image receptor

In most instances, you will have no problem fitting a projection of the forearm on an 11×14 inch (aligned diagonally) however, if the patient's forearm is too long where as both the wrist and elbow cannot be visualized, use a 14×17 inch cassette. Expose one projection per cassette. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

Seat the patient at the end of the radiographic table. Remove all watches or bracelets that may interfere with the examination and roll up the shirt sleeve to a point above the elbow, if necessary. Gonadal shielding and proper collimation to include only the forearm and both joints are again important radiation safety procedures to follow.

Anterior posterior

In order to place the forearm in true AP position, fully extend the arm so that there is only a minimal bend at the elbow. Rest the posterior surface of the forearm and hand on the cassette ensuring both the interstyloid line and the humeral epicondylar plane are parallel to the cassette. You may need to weight the thumb side of the hand with a sandbag to maintain the true AP position. The sandbag prevents pronation of the hand, which would cause the upper third of the radius to crossover the ulna. Direct the CR perpendicular to the middle of the forearm. We do not perform the PA because of radius-ulnar crossover.

Lateral

The lateral projection of the forearm is accomplished by having the patient flex the affected elbow 90 degrees. The whole extremity is then placed so that the medial surface of the forearm is resting on the casssette with the upper arm on the tabletop. When properly positioned the humerus, shoulder joint, and elbow should all be on the same level/plane. Rotate the wrist into the lateral position. This places the interstyloid line and the epicondylar plane of the humerus perpendicular to the film for a true lateral of the forearm. Direct the CR perpendicular to the middle of the forearm.

Anatomy demonstrated

Both projections demonstrate the wrist, radius, ulna, and elbow. Because the CR is directed to the middle of the forearm, the divergence of the beam causes slight distortion of the structures of the elbow and wrist.

435. Radiographic projections of the elbow

All radiology departments include, at a minimum, two projections as part of a routine elbow series—AP and lateral. Many departments include additional views as part of a standard series. These will be discussed at the end of the objective.

Image receptor

Use an 8x10 inch cassette exposing one projection per cassette. Always reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

The patient should be seated low enough to be able to rest the upper arm on the end of the radiographic table. Ideally the humerus should lie on the same plane as the elbow however patient condition may prevent this at times. Shield the gonads.

Anterior posterior

The AP projection is performed by fully extending the arm and placing the posterior surface of the arm and forearm on the table. Center the elbow to the cassette. As with the AP forearm position, you must ensure true AP by placing the line drawn through the epicondyles of the humerus parallel with the film. Also, the hand must be supinated to prevent rotation of the radial head. Direct the CR perpendicular to the center of the elbow joint.

Lateral

Positioning for the lateral elbow is similar to a lateral forearm. Extend the arm, placing the medial surface of the upper arm in contact with the table. The elbow is flexed 90° and the humeral epicondylar plane and interstyloid line are both perpendicular to the film. Direct the CR perpendicular to the elbow, ensuring that the elbow is centered to the cassette.

Anatomy demonstrated

The AP projection demonstrates a posterior view of the structures of the elbow joint with the proximal portion of the radius partially superimposed over the ulna. A properly positioned lateral view will show the elbow joint, distal arm, and proximal forearm. In addition, the humeral epicondyles are superimposed and the olecranon process is seen in profile.

Additional projections of the elbow

There are, of course, situations in which you will be required to demonstrate specific parts of the elbow, such as the olecranon process or the radial head. In such cases, various additional projections are used. Additionally, in some trauma situations you may be unable to obtain the standard projections. You may need to use certain modifications that will yield equivalent views. In this section, we cover some of the common additional views of the elbow.

Jones method

This is also called the acute flexion position because the elbow is in extreme (acute) flexion. It is used specifically to demonstrate the olecranon process.The posterior aspect of the humerus is placed flat on the table so that its distal end is centered on the film. The elbow is hyperflexed so that the forearm is brought as near to the upper arm as possible. The hand and wrist should be rotated until the thumb is on the lateral side and the palm rests on the shoulder. Position the epicondylar plane parallel to the film and direct the CR perpendicular to the olecranon process. Figures 5–13 and 5–14 demonstrate proper positioning and the actual radiograph, respectively.

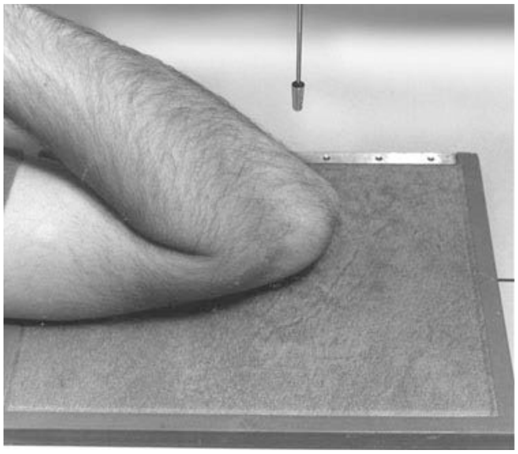


Figure 5–13. Patient positioned for acute flexion view of the elbow.

Figure 5–14. Acute flexion elbow radiograph.

Anterior posterior medial oblique

This position could be classified as either a routine or an additional view, depending upon your radiologist's preference. It is easy to obtain if you begin as you did for the AP elbow—extend the elbow in true AP and center the epicondyles to the cassette. Pronate the hand and adjust the elbow until its anterior surface forms a 40° to 45° angle with the cassette as shown in figure 5–15. This position frees the coronoid process from superimposition of the radial head. Figure 5–16 is an example of an AP medial oblique elbow radiograph.

Anterior posterior lateral oblique

The lateral oblique position is used to demonstrate the radial head, capitulum, and radio-ulnar articulation free from superimposition of the ulna. For a lateral oblique, begin as you would position for an AP elbow and rotate both forearm and upper arm laterally until the elbow forms a 40° angle with the film. Direct the CR perpendicular to the elbow joint. The following figures (figs. 5–17 and 5–18) show the proper positioning and actual radiograph, respectively.

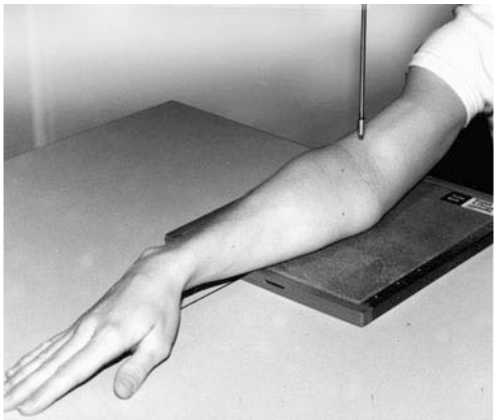


Figure 5–15. Patient positioned for an AP medial oblique elbow.

Figure 5–16. AP medial oblique elbow radiograph.

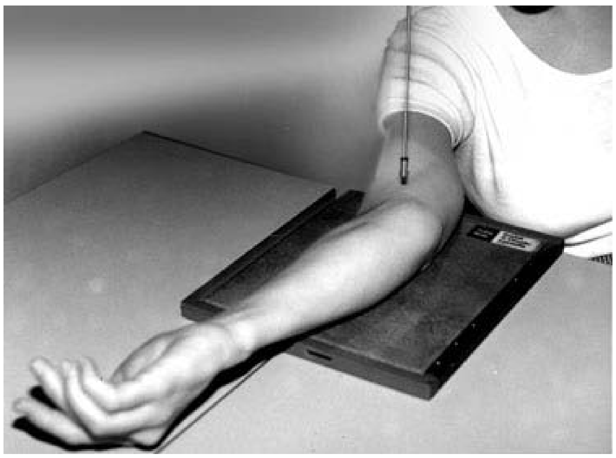


Figure 5–17. Patient positioned for an AP lateral oblique elbow.

Figure 5–18. AP lateral oblique elbow radiograph.

Anterior posterior elbow with partial flexion

Injuries involving the elbow are usually serious, painful, and totally incapacitating as far as the affected arm is concerned. Generally, when you see a patient with an elbow injury, the injured arm is in a sling and the elbow is partially flexed. Your patient may not be able to extend or hyperflex the arm. This situation prevents you from obtaining the standard AP projection, but there is a variation you can do.

When the patient is unable to extend the elbow completely it is necessary to make at least two exposures of the elbow joint. One is to demonstrate the distal humerus and one to demonstrate the proximal forearm.

With the patient seated low enough to place the entire humerus on the table, center the elbow to the cassette and support the elevated forearm with sandbags or sponges. Try to supinate the hand to rotate the radial head into true AP. Direct the perpendicular CR through the epicondylar plane. Figure 5–19 demonstrates proper positioning.

Figure 5–20 shows the position of AP elbow with partial flexion for the upper forearm, the second necessary projection. You will note that the forearm is placed on the cassette and the humerus is elevated. The CR is perpendicular to the film, directed through the center of the elbow.

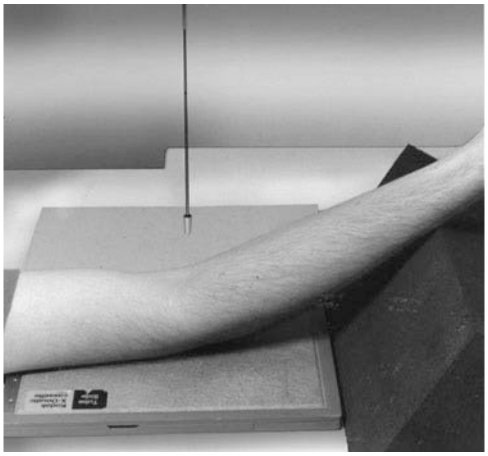


Figure 5–19. Patient positioned for a partial flexion view of the elbow to demonstrate the distal humerus.

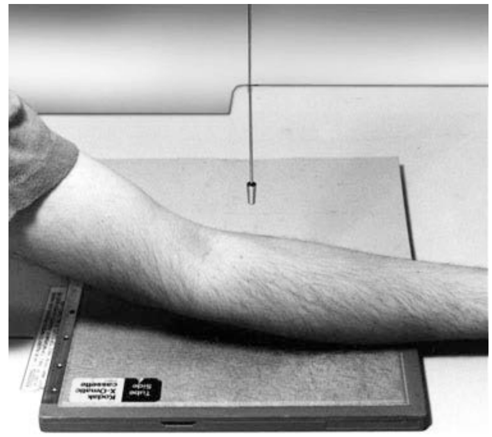


Figure 5–20. Patient positioned for a partial flexion view of the elbow to demonstrate the proximal forearm.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

433. Radiographic projections of the wrist

1. Name the three routine projections for the wrist.

2. What should be done to reduce the normal curvature of the wrist and lessen OID when accomplishing the PA projection of the wrist?

3. How should the wrist be positioned for the PA oblique wrist?

4. What should be done to the hand to place the wrist in true lateral position?

5. Which additional projection of the wrist described in this text may be used to demonstrate the carpal scaphoid?

6. Which carpal bone is particularly well visualized on the AP oblique projection of the wrist?

7. Which additional projection of the wrist is used to demonstrate the carpal canal?

8. Describe the path of the CR for the carpal canal view.

434. Routine radiographic projections of the forearm

1. What radiographic positioning line and plane are used when radiographing the forearm?

2. What positioning error causes radial crossover on the AP forearm?

3. How is the elbow positioned for the lateral projection of the forearm?

4. Describe the orientation of the line and plane from question 1 for a properly positioned lateral forearm.

435. Radiographic projections of the elbow

1. When seating the patient to perform an elbow series, you should ensure the stool is low enough to permit what?

2. What is the position of the humeral epicondylar plane for an AP elbow projection?

3. What is the position of the interstyloid line for a lateral elbow projection?

4. What additional view of the elbow is used to demonstrate the olecranon process?

5. What is the position of the elbow in the view mentioned in question 4?

6. What structure is demonstrated free from superimposition of the radial head on the AP medial oblique projection of the elbow?

7. The AP lateral oblique elbow is used to demonstrate what structures?

8. To what degree is the elbow rotated for the lateral oblique position?

9. Which views may be used in place of the AP when the patient cannot fully extend the elbow?

10. At least how many views are necessary when performing the method in question 9? Why?

5–3. The Humerus and Shoulder Girdle

We conclude our unit on positioning of the upper extremities with a discussion of the routine and nonstandard radiographic projections of the humerus and shoulder girdle. Specifically we will discuss positioning of the humerus, shoulder joint, clavicle, and scapula. **NOTE:** All SIDs are assumed to be 40 inches unless otherwise indicated.

436. Radiographic projections of the humerus

The standard projections of the humerus are AP and lateral. These are relatively easy positions to obtain providing the patient has not suffered serious trauma to the arm or shoulder. In the case of immobilizing trauma, there are nonstandard projections we can use to obtain the necessary views of the humerus. These will be discussed later, but first we need to be familiar with the standard projections.

Image receptor

For most patients, an 11×14 inch cassette aligned diagonally is sufficient to cover the entire humerus. In rare instances, you may need to use a longer film (14×17 in.). The humerus may be radiographed with or without a grid depending on the size of the patient's arm and shoulder. A good rule of thumb is to use a grid for parts measuring greater than 10 centimeters.Expose one projection per cassette. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

Radiographs of the humerus may be done erect or recumbent. No matter which position you chose, consider the fact that many patients with upper arm and shoulder injuries find it difficult and painful to assume the recumbent position. Since the positioning of the part is the same for each method, we will only describe the erect method. Make sure to use gonadal shielding when appropriate.

Anterior posterior

Have the patient stand with his or her back against the vertical cassette holder or upright bucky. Position the cassette so that its upper border is 1½ inches above the humeral head. Abduct the arm slightly to place the long axis of the humerus in line with the diagonal axis of the cassette. Supinate the hand until a line drawn through the humeral epicondyles is parallel to the film. Direct the CR perpendicular to the cassette, centered on the midshaft of the humerus. Collimate to include the bony and soft tissue structures of the upper arm from shoulder to elbow. Figure 5–21 demonstrates proper positioning.

Lateral

With the patient's back still against the vertical cassette holder or upright bucky, abduct the arm and bend the elbow, placing the palmer surface of the hand on the hip. The epicondylar line should be perpendicular to the film. Position the cassette so that its upper border is 1½ inches above the humeral head. Direct the CR perpendicular to the midshaft of the humerus. Collimate to include the bony and soft tissue structures of the upper arm from shoulder to elbow. Figure 5–22 demonstrates proper positioning.

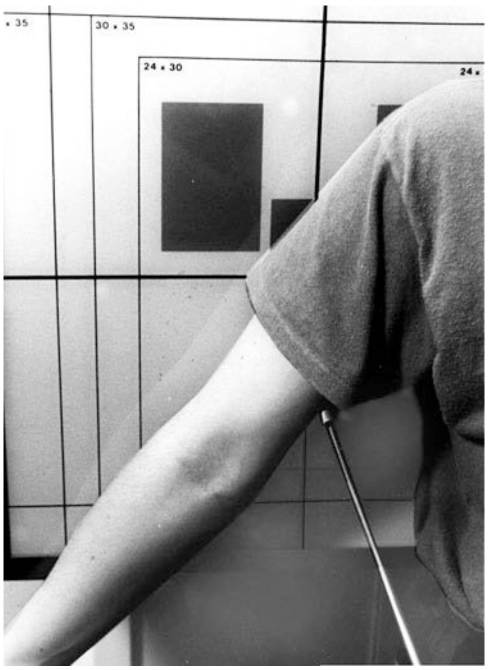


Figure 5–21. Patient positioned for an AP projection of the humerus.

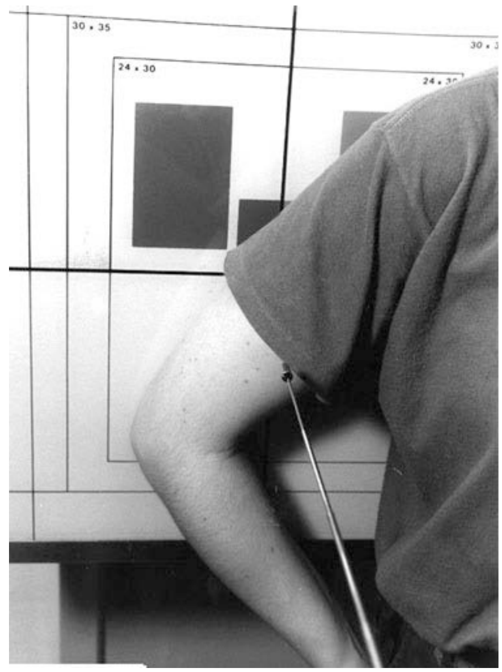


Figure 5–22. Patient positioned for a lateral humerus.

Anatomy demonstrated

Both projections demonstrate the entire length of the humerus to include shoulder and elbow joints.

Nonstandard radiographic projections of the humerus

Radiographic demonstration of the injured upper arm—especially fractures of the humerus—is complicated by two limiting factors. First, because of its attachment and close proximity to the rib cage, the humerus is not easily demonstrated in cross-table projections as are the more distal parts of the extremity. Second, fractures of the humerus, like those of the femur, are quite serious in nature. Therefore, the upper arm must not be moved to any great degree while it is being positioned for traumatic radiographic examinations.

Despite those limiting factors, we are still committed to produce two projections at right angles to each other, and in so doing, we are required to direct the CR at right angles to the long axis of the part and to its center. This procedure shows most fractures and any displacement of fractured bone. For instance, an AP radiograph may show any lateral displacement of bone at the fracture site, whereas a lateral view may show anterior or posterior displacement.

To obtain necessary views and because of positioning limitations due to trauma, certain variations of standard positions become necessary.

Positioning variation for anterior posterior humerus

Normal positioning for the AP humerus requires that the upper extremity be fully extended alongside the body. Severe pain or the arm being in a sling prevents full extension. You can still perform the AP projection using a slight variation.

Have the patient stand or sit on a stool with the back of the upper arm barely touching an upright bucky. By rotating the patient into a posterior oblique towards the affected arm, you can move the humerus into a position that very closely approximates true AP. Direct the beam perpendicular to the midshaft of the humerus.

Once you obtain the AP projection and before positioning for the lateral, the radiograph should be checked for severity and location of the fracture.

Positioning variations for lateral humerus

After viewing the AP image, you can see the fracture location. Its location determines which lateral variation you should do. For instance, if the fracture is in the lower half of the humerus, you can get a good lateral by placing the film between the arm and ribs (fig. 5–23). With the epicondylar plane and CR perpendicular to the film, anterior or posterior displacement of bone fragments can be seen on the radiograph.

If the fracture is in the upper half of the humerus, you may not be able to place the cassette high enough in the axilla to show the fracture. Therefore, a transthoracic lateral is needed.

In this position (fig. 5–24), the lateral side of the upper arm is gently placed against the surface of the upright bucky. The patient’s trunk is in true lateral and the opposite arm should be raised to place the forearm on top of the head. Because, as its name implies, the CR is directed through the chest, the exposure should be made on full inspiration. Having the lungs full of air improves the contrast and also decreases the exposure necessary to penetrate the body.

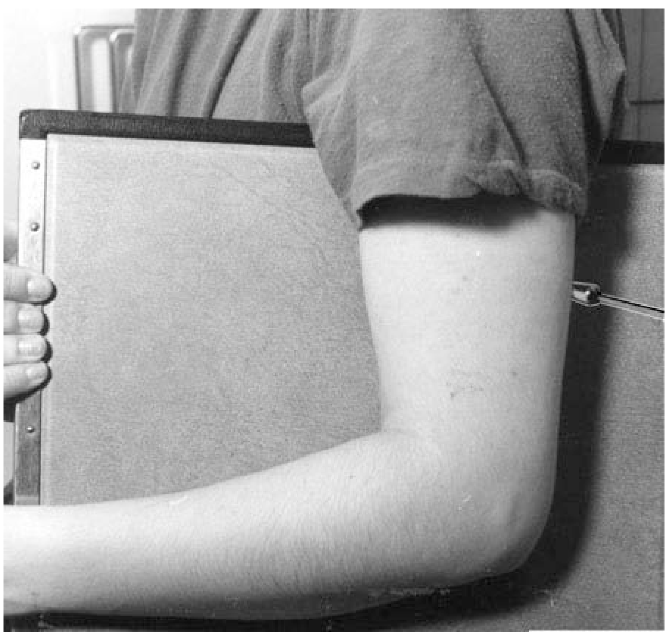


Figure 5–23. Patient positioned for a lateral view of the lower humerus (trauma variation).

Figure 5–24. Patient positioned for a transthoracic lateral humerus.

If the patient can be immobilized to prevent movement of the injured arm, a breathing technique may be used. In this case, instruct your patient to practice slow, deep breathing. (Rapid breathing may cause part motion.) An exposure time of 5 to 10 seconds can give excellent results by allowing this breathing motion to blur out the superimposed lung markings. As you can see, positioning variations of the humerus affected by trauma are used to keep part movement to a minimum. It is important that you do not add to the patient's injury. Unnecessary or excessive movement of the injured arm may cause additional complications. This can be avoided through your use of these positioning variations.

437. Radiographic projections of the shoulder

There are almost as many "routine" shoulder series as there are radiology departments in the Air Force. The specific views accomplished as part of a routine series are determined by the radiologists in a given department. Some of the common views taken for routine shoulder examinations are: AP, internal rotation; AP, external rotation; and AP, neutral rotation.

NOTE: The shoulder should never be rotated if you suspect there is a fracture or dislocation.

Image receptor

Each of the common shoulder view requires a 10×12 inch cassette positioned crosswise. Refer to the standard operating procedures or imaging protocols for more detailed guidance regarding which images are required for a shoulder series in your department.

Positioning

Projections of the shoulder may be accomplished upright or recumbent however as with the humerus, consider using the upright method for patient comfort in cases of suspected fracture or dislocation. Since positioning for the body part is the same for both methods, we will only discuss the recumbent method. For each projection, begin by placing the patient in the supine position on the radiographic table. Provide gonadal shielding when appropriate.

Anterior posterior, internal rotation

Rotate the patient toward the affected side enough to place the plane of the body of the scapula parallel to the film. You may need to support the elevated side of the body with a positioning sponge. Internally rotate the affected arm to place the back of the hand on the hip. Adjust the arm so that a line drawn through the humeral epicondyles is perpendicular to the film.

Direct the CR perpendicular to the cassette, centering on a point 1 inch medial and 1 inch inferior to the coracoid process. The exposure should be made on suspended respiration. Figure 5–25 is an example of an internal rotation shoulder radiograph.

Anterior posterior, external rotation

For the external rotation view, the patient is placed in the same position as for the internal rotation view except the hand is supinated (rotated away from the body). The arm is properly positioned when the epicondylar plane is parallel to the film, placing the humerus in true AP. Direct the CR perpendicular to the cassette, centering on a point 1 inch medial and 1 inch inferior to the coracoid process; center the film. The exposure should be made on suspended respiration.

Figure 5–26 is an example of an external rotation shoulder radiograph.

Anterior posterior, neutral rotation

In this position, the palm of the hand is placed against the thigh. This rolls the humeral head into a neutral position, placing the epicondylar plane 45 degrees to the film (medial oblique). All other factors are the same as for the previous two shoulder views.

Figure 5–25. AP, internal rotation shoulder radiograph.

Figure 5–26. AP, external rotation shoulder radiograph.

Anatomy demonstrated

Classifying the rotation radiographs of the shoulder is simply a matter of recognizing the position of the proximal humerus. When the arm is in internal rotation, only the superior portion of the humeral head is well visualized, since the rotation moves most of the head behind the other structures. The lesser tuberosity is shown in profile on the medial side of the humerus. The greater tuberosity is superimposed over other structures in the approximate center of the humerus.

When the humerus is in external rotation, the greater tuberosity is seen in profile laterally with the humeral head in profile medially. You can also see the depression of the anatomical neck between the greater tuberosity and head. The lesser tuberosity is superimposed over the lateral portion of the humerus.

When the arm is in neutral position, the lesser tuberosity is superimposed over the humerus a little toward the medial side. Because the humeral head extends posteromedially from the humerus, it is seen in the oblique position. The greater tuberosity is shown on the lateral side, although not so prominently as in the external rotation position.

Additional radiographic projections of the shoulder

Depending on your department standard operating procedures (SOP), you may include one or more of the following additional projections as part of your routine series, or you may only include them when specifically requested by the clinician. There are literally dozens of projections for the shoulder joint; however, we have tried to include only the most common.

Grashey position

The Grashey position is especially useful for demonstrating the joint space between the humeral head and the glenoid fossa with the glenoid fossa in profile. This projection can be made with the patient in either the supine or the erect position. The latter is more comfortable for the patient and is usually easier for accurate adjustment of body rotation.

With the cassette centered to the shoulder joint, rotate the body 35 degrees to 45 degrees toward the affected side. Adjust the degree of rotation to place the scapula parallel with the cassette and the posterior deltoid in contact with the table. Abduct the arm slightly in internal rotation and place the hand against the side of the body. Direct the CR perpendicular to the cassette through the joint space. Figures 5–27 and 5–28 show the Grashey position and the actual radiograph, respectively.

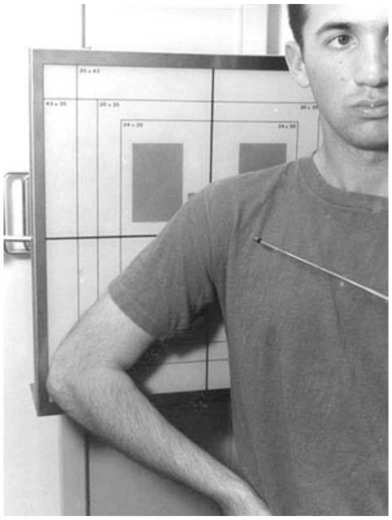


Figure 5–27. Patient positioned for Grashey view.

Figure 5–28. Grashey view radiograph.

Lawrence position

The Lawrence position is an inferosuperior axial projection sometimes called an axillary lateral because the CR enters through the axilla. It is an additional view added to the routine projections for the shoulder in many departments. It shows an axial view of the glenohumeral joint,lateral aspect of the scapula and clavicle, and the proximal humerus.

Although this can be done with the patient sitting, you will find it easier to do if your patient is supine. As you can see in figure 5–29, the arm of the affected side is abducted and placed at right angles to the long axis of the body. Rotate the arm externally.

With the patient's head turned away from the affected side, place a vertical cassette on edge with its tube side against the top of the shoulder as close to the neck as possible. Support the cassette in this position with sandbags. Direct the CR horizontally through the axilla to the region of the acromioclavicular joint. The degree of medial angulation of the CR depends upon the degree of abduction of the arm, but be careful not to angle so far medially that you project the joint space off the film. Figure 5–30 is an example of a Lawrence view radiograph.

Figure 5–29. Patient positioned for Lawrence view.

Figure 5–30. Lawrence view radiograph.

Supraspinatus outlet view

This view is used to demonstrate the arch formed between the coracoid and acromion processes through which the supraspinatus muscle passes to attach to the greater tuberosity of the humerus.

The positioning (fig. 5–31) is very similar to that of the lateral scapula view. The patient is upright, facing the vertical cassette holder. Center the affected shoulder to the film and oblique the patient 45 degrees to 60 degrees from the plane of the cassette until the scapula is perpendicular to the film. Direct the CR 10 degrees to 15 degrees caudal, centered to the humeral head. Figure 5–32 is an example of a properly positioned supraspinatus outlet view. On the radiograph, the scapula should be in the true lateral position, and the humeral head is projected in the “Y” of the scapula.

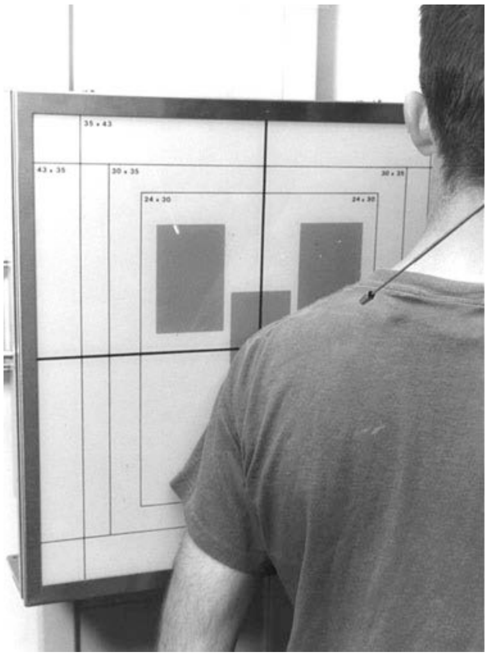


Figure 5–31. Patient positioned for a supraspinatus outlet view.

Figure 5–32. Supraspinatus outlet radiograph.

438. Routine radiographic projections of the shoulder girdle

As you will recall from our discussion of osteology, the shoulder girdle is comprised of two bones—the scapula and the clavicle. We will discuss positioning for both of these bones in this lesson, as well as the articulations between them—the acromioclavicular joints.

Scapula

Routine radiographic projections for the scapula are AP and lateral. The AP projection is very similar to the AP shoulder and is relatively simple to obtain. The lateral, however, is often repeated due to over or under rotation of the body.

Image receptor

As with the shoulder, both views of the scapula should be obtained on separate 10×12 inch cassettes positioned lengthwise. Reference your departments’ standard operating procedures or imaging protocols for further guidance.

Positioning

The AP projection may be accomplished either upright or recumbent yet once again, the upright position is recommended for patient comfort in trauma cases. The lateral projection is most easily accomplished in the upright position because this offers greater ease in adjusting body rotation.

Anterior posterior

Position the patient supine on the radiographic table. Abduct the arm 90 degrees to bring the scapula away from the midline structures of the spine and mediastinum. Bend the elbow and rest the back of the forearm on the table.

Direct the CR perpendicular to the cassette to a point 2 inches inferior to the coracoid process; center the film. The exposure should be made on suspended respiration.

Lateral

Position the patient facing the vertical cassette holder or upright bucky. Have your patient place the affected arm across the chest and grasp the opposite shoulder. Rotate the patient's body into an anterior oblique position until the body of the scapula is perpendicular to the film. The average patient will be rotated between 45 degrees and 60 degrees from PA.

Place the top border of the cassette 2 inches above the top of the shoulder. Direct the CR perpendicular to the film centered on the vertebral border of the scapula. The exposure should be made on suspended respiration.

Anatomy demonstrated

The AP projection will demonstrate the entire scapula with the lateral border free from superimposition of thoracic structures. The lateral projection will demonstrate the entire scapula free from superimposition of the rib cage. The vertebral and axillary borders of the scapular body should be completely superimposed.

Clavicle

Since a lateral view of the clavicle would be nearly impossible to obtain, routine projections for the clavicle are AP and AP axial. This is as close as we can come to providing two views at right angles to each other.

Image receptor

Each projection should be made on a separate 10×12 inch cassette crosswise with a grid.

Positioning

Both projection of the clavicle may be accomplished either upright or supine. We will describe the supine methods.

Anterior posterior

Position the patient supine on the radiographic table with arms at sides. With the tube centered to the film and the collimator light on, adjust the patient so that the clavicle is centered to the film. The exposure should be made on suspended expiration.

Anterior posterior axial

The axial view is used to project the clavicle free from superimposition of the bony thorax and to provide a slightly different angle for fracture identification. With the patient in the same position for the AP projection; angle the CR 25 degrees to 30 degrees cephalad passing through the midpoint of the clavicle to the center of the film. Again, make the exposure on suspended expiration.

Anatomy demonstrated

Both views should demonstrate the entire clavicle. The axial view is helpful in that it will demonstrate most of the clavicle free from superimposition of the bony thorax.

Acromioclavicular joints

The AC joints are usually demonstrated bilaterally on the same film (14×17 inch crosswise). If the patient is too large, use two 8×10 inch cassettes as needed due to patient size. Use a 72-inch SID to reduce magnification.

Position the patient with his or her back against the vertical cassette holder. Direct the CR perpendicular to the film centered to the midline of the body at the level of the AC joints. Adjust collimation to include only the structures immediately surrounding the joints.

Two AP views are the routine, one with the patient holding a 10 pound weight in each hand, and one taken without the weights. With and without weight views are necessary to evaluate for separation of the AC joints. If an injury exists, the image taken with the use of weights will show an increased gap in the AC joint as compared to the image taken without the weights.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

436. Radiographic projections of the humerus

1. What is the determining factor when deciding whether or not to use a grid for radiographs of the humerus?

2. Where is the film positioned for the AP humerus?

3. How are the humeral epicondyles positioned for the AP humerus?

4. Briefly describe the patient position for the lateral humerus.

5. When radiographing a patient with a suspected humerus fracture, which view should you do first? Why?

6. When radiographing a patient with a fracture in the upper half of the humerus, what type of lateral should you perform?

7. What are two benefits of performing a transthoracic lateral humerus on suspended inspiration?

8. What is the purpose of using a breathing technique?

437. Radiographic projections of the shoulder

1. How much and in what direction should the patient be rotated for any of the rotation views of the shoulder?
2. How are the hand and humeral epicondylar line positioned for the internal rotation view of the shoulder?
3. What is the centering point for the rotation views of the shoulder?
4. How are the hand and epicondylar plane positioned for the external rotation view of the shoulder?
5. How are the hand and epicondylar plane positioned for the neutral rotation view of the shoulder?
6. Where is the lesser tuberosity seen on an internal rotation view of the shoulder?
7. Where is the greater tuberosity seen on an external rotation view of the shoulder?
8. What does the Grashey position demonstrate?
9. How many degrees and in what direction is the body rotated for the Grashey position?
10. What type of a projection is the Lawrence view?
11. What type of view does the Lawrence position provide of the shoulder joint?
12. Describe the supraspinatus outlet view position and path of the CR.

438. Routine radiographic projections of the shoulder girdle

1. Why is the arm abducted for the AP projection of the scapula?

2. What is the centering point for the AP scapula?

3. Where is the film placed for the lateral scapula?

4. What are the routine views of the clavicle?

5. How many degrees and in what direction is the CR angled for the axial view of the clavicle?

6. What does the axial view of the clavicle demonstrate?

7. Why should you use a 72-inch SID when radiographing the AC joints?

8. What are the routine views for the AC joints?

9. What condition will radiographs of the AC joints demonstrate?

10. How can you tell if the condition from question 9 is present?

Answers to Self-Test Questions

431

1. The divergent beam will pass very close to the gonads.
2. AP, oblique, and lateral.
3. Fully extended and in extreme internal rotation.
4. PA
5. The metacarpophalangeal joint.
6. The interphalangeal joint, first metacarpophalangeal joint, and first carpometacarpal joint.
7. The proximal interphalangeal joint of the affected digit.
8. Use a 45° positioning sponge.
9. The lateral that places the affected finger closest to the film.
10. A foam block, a wooden tongue depressor, tape, or similar object.

432

1. PA, PA oblique, and lateral.
2. The head of the third metacarpal.
3. When the hand and fingers cannot be fully extended and the metacarpals or metacarpophalangeal joints are the primary area of interest.
4. 45°.
5. When the metacarpals are of primary interest.
6. The fan lateral.
7. The AP medial oblique (Norgaard).
8. From the lateral position, supinate the hands until they form a 45° medial oblique. Direct the CR perpendicular to a point midway between the hands at the level of the MP joints.

433

1. PA, PA oblique, and lateral.
2. Partially flex the fingers to form a loose fist.
3. From the PA position, rotate the radial side up until the wrist forms a 45° angle with the cassette.
4. Supinate the hand 5°.
5. The ulnar deviation view.
6. The pisiform.
7. The Gaynor-Hart.
8. Direct the CR through the carpal canal at an angle of 25° to 30° from vertical toward the forearm.

434

1. The interstyloid line and the humeral epicondylar plane.
2. Pronation of the hand.
3. Flexed 90°.
4. Both the interstyloid line and the epicondylar plane are perpendicular to the film.

435

1. The patient to rest the upper arm on the end of the radiographic table.
2. Parallel to the film.
3. Perpendicular to the film.
4. The Jones method.
5. The elbow is hyperflexed.
6. The coronoid process.
7. The radial head, capitulum, and radio-ulnar articulation.
8. 40°.
9. AP projections with partial flexion.
10. At least two views are necessary: one to demonstrate the distal humerus and one to demonstrate the proximal forearm.

436

1. The size of the patient’s arm.
2. 1½ inches above the humeral head.
3. Parallel to the film.
4. Abduct the arm, bend the elbow and placing the palm of the hand on the hip. The epicondylar line should be perpendicular to the film.
5. The AP; because the location of the fracture will determine what type of lateral you obtain.
6. A transthoracic lateral.

7. It improves contrast and decreases radiation exposure.
8. To blur out the superimposed lung markings.

437

1. Rotate the patient toward the affected side enough to place the plane of the body of the scapula parallel to the film
2. Internally rotate the affected arm to place the back of the hand on the hip. Adjust the arm so that a line drawn through the humeral epicondyles is perpendicular to the film.
3. One inch medial and 1 inch inferior to the coracoid process.
4. The hand is supinated and the epicondylar plane is parallel to the film.
5. Place the palm of the hand on the thigh, this rolls the humeral head into a neutral position, placing the epicondylar plane is 45° to the film.
6. In profile on the medial side of the humerus.
7. In profile on the lateral side of the humerus.
8. The joint space between the humeral head and the glenoid fossa with the glenoid fossa in profile.
9. 35° to 45° toward the affected side.
10. Inferosuperior axial projection.
11. An axial view.
12. With the patient upright, facing the vertical cassette holder, center the affected shoulder to the film and oblique the patient 45° to 60° from the plane of the cassette until the scapula is perpendicular to the film. Direct the CR 10° to 15° caudad, centered to the humeral head.

438

1. To move the scapula away from the midline thoracic structures.
2. Two inches inferior to the coracoid process.
3. Place the upper border of the cassette 2 inches above the top of the shoulder.
4. AP and AP axial.
5. 25° to 30° cephalad.
6. Most of the clavicle free from superimposition of the bony thorax.
7. To reduce magnification.
8. AP, with and without weights.
9. Separation of the joint.
10. The image taken with the use of weights will show an increased gap in the AC joint as compared to the image taken without the weights.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

46. (431) The centering point for the central ray (CR) on radiographic projections of the thumb is the
    a. interphalangeal joint.
    b. carpometacarpal joint.
    c. metacarpophalangeal joint.
    d. proximal interphalangeal joint.

47. (431) "With the hand and fingers extended palm down, center the thumb on the unmasked portion of the film" is a description of which thumb projection?
    a. Anterior posterior (AP).
    b. Posterior anterior (PA).
    c. Lateral.
    d. Oblique.

48. (432) When imaging the hand, if the fingers cannot be fully extended for the posterior anterior (PA) projection and the metacarpals are of primary interest, what should you do?
    a. Tape the distal metacarpal joints to the cassette.
    b. Perform an anterior posterior (AP) projection of the hand.
    c. Angle the central ray until it is perpendicular to the metacarpals.
    d. Perform the PA and notify the radiologist the fingers could not be extended.

49. (432) The projection used to detect early arthritic changes of the hands is the
    a. Grashey.
    b. Settegast.
    c. Norgaard.
    d. Gaynor-Hart.

50. (433) Which radiographic position of the wrist involves a 5 degree supination of the hand?
    a. Lateral.
    b. Radial deviation.
    c. PA medial oblique.
    d. AP medial oblique.

51. (433) If the scaphoid bone is of primary interest, which wrist projection is performed?
    a. Posterior anterior oblique.
    b. posterior anterior.
    c. Radial deviation.
    d. Ulnar deviation.

52. (434) Which positioning error causes radial crossover on an anterior posterior (AP) forearm radiograph?
    a. Interstyloid line perpendicular to the film.
    b. Improper tube-part film alignment.
    c. Supination of the hand.
    d. Pronation of the hand.

53. (434) When positioning for a *true* lateral of the forearm, the interstyloid line
    a. and epicondylar plane are is parallel to film.
    b. and epicondylar plane are perpendicular to film.
    c. is parallel to film and the epicondylar plane is perpendicular to film.
    d. line is perpendicular to film and the epicondylar plane is parallel to film.

54. (435) When imaging the elbow, which projection specially demonstrates the olecranon process?
    a. Jones method.
    b. Partial flexion views.
    c. Anterior posterior lateral oblique.
    d. Anterior posterior medial oblique.

55. (435) Which radiographic projection of the elbow is used to demonstrate the coronoid process free of superimposition?
    a. Jones method.
    b. Partial flexion views.
    c. Anterior posterior lateral oblique.
    d. Anterior posterior medial oblique.

56. (436) If a fracture of the humerus is suspected, what do you do after imaging the anterior posterior (AP) but prior to imaging the lateral?
    a. Perform an axillary view.
    b. Perform a transthoracic projection.
    c. Check the AP image for the fracture location.
    d. Get approval from a radiologist to move the arm.

57. (437) Which structures are demonstrated in profile on an external rotation radiograph of the shoulder?
    a. Lesser tuberosity and humeral head.
    b. Humeral head and greater tuberosity.
    c. Bicipital groove and lesser tuberosity.
    d. Greater tuberosity and bicipital groove.

58. (437) How is the central ray (CR) projected when performing the Lawrence position of the shoulder?
    a. Anteroposterior.
    b. Posteroanterior.
    c. Inferosuperior.
    d. Superoinferior.

59. (438) What is the purpose of performing erect anterior posterior (AP) acromioclavicular joint views with and without weights?
    a. To demonstrate joint separation.
    b. To evaluate for joint trabeculation.
    c. To evaluate the strength of the joint.
    d. To demonstrate the joint free of superimposition.

Please read the unit menu for unit 6 and continue ➔

Unit 6. Positioning of the Lower Extremity

THE RADIOGRAPHIC POSITIONING DISCUSSION continues in this unit with the positioning with the lower extremity. Like the upper extremity, the lower extremity is often a common site of injury. No doubt, much of your work in clinical radiography will involve imaging these structures. In this unit, we will cover many of the standard projections and a few additional projections that you will use when radiographing traumatic injuries to the lower extremities.

NOTE: As in the previous units, any reference to film, cassette, and/or image receptor is meant to be synonymous with each other. As well, always expose each image with the appropriate right or left lead anatomical marker. Using stickers, sharpie permanent markers, or computer aided text is neither authorized nor legal in a court of law to mark human radiographic images.

6–1. The Toes, Foot, and Heel

Injury, disease, and bony malformations such as bunions and heel spurs are common reasons for radiographing the foot. You will recall that the foot consists of 26 bones—seven tarsals, five metatarsals, and 14 phalanges. For purposes of radiography, we divide the foot into three sections—the toes, entire foot, and heel. Each section has specific positioning requirements that we will discuss. (**NOTE:** All SIDs are assumed to be 40 inches unless otherwise indicated.)

439. Routine radiographic projections of the toes

Routine radiographic projections of the toes are AP, AP oblique, and lateral.

Image receptor

Expose one projection per 8x10 inch cassette table top. Always reference your departments’ standard operating procedures or imaging protocols for further guidance.

Position

For all projections, have the patient seated on the radiographic table with the feet resting on the table.

Anterior posterior

Perhaps the easiest projection to position a patient for when radiographing the toes is the AP. This is also referred to as a dorsal plantar (DP) dorsal plantarprojection and is used to show a general study of all toes. The procedure requires the plantar surface of the foot be placed on the cassette and a perpendicular central ray (CR) directed to the film through the metatarsal-phalangeal joint of the affected toe. This simple method will show slight foreshortening of the phalanges and only partial opening of interphalangeal joints.

Because of the natural curvature of toes, to show open interphalangeal joints and phalanges without foreshortening, you need to position the foot for a PA (plantodorsal; sole of foot to upper surface) projection with a perpendicular CR or angle the CR 15 degrees cephalic (toward the ankle) for an AP (dorsal plantar; upper surface to sole of foot) projection. The dorsal plantar projection is done with the patient prone, and the film and toes elevated on one or two small sandbags/foam positioning sponges. When the toes are supported horizontally this way, the long axes of the phalanges are parallel to the film. Therefore, when you direct a perpendicular CR to the film, the ray will pass through open joint spaces. Because radiologists readily accept the AP projection for toes, the PA (plantodorsal) projection is considered to be an additional projection that is only done upon request.

Anterior posterior oblique

The AP oblique (medial rotation) is the oblique routinely performed for the toes. Begin by positioning the foot as for AP toes. Rotate the foot medially so the great toe is closest to the film and the sole of the foot forms a 30 degree angle with the film. Direct the CR perpendicular to the MP joint of the affected toe.

Lateral

When the foot is placed in the lateral position the toes are superimposed on top of each other; this results in a poor demonstration of them. It is best to do a lateral for the individual toe. The affected toe is the determining factor when deciding how the lateral is best done. For example, if the great toe (hallux) is injured, a lateromedial projection places it nearest the film (fig. 6–1). Conversely, if the fifth toe is injured, it is better to use a mediolateral projection (fig. 6–2). As you can see, you should perform the lateral projection that puts the affected toe as close to the film as possible.

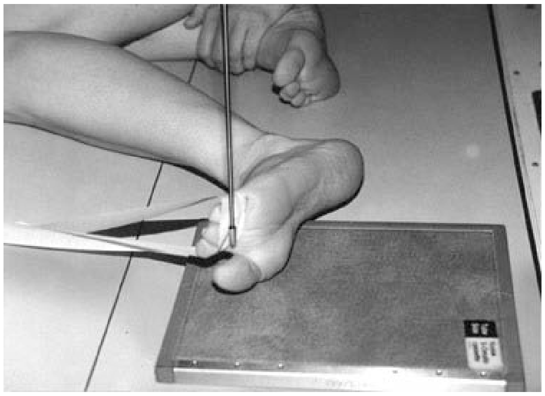


Figure 6–1. Patient positioned for a lateral first.

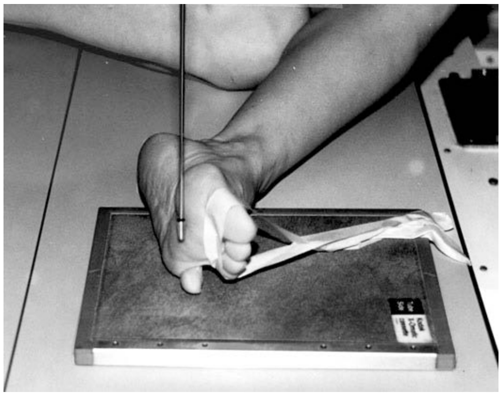


Figure 6–2. Patient positioned for a lateral fifth toe.

You will have to separate the affected toe from the others by using a tongue depressor or tape. Direct the CR perpendicular to the film through the metatarsophalangeal joint of the great toe or proximal interphalangeal joint of the lesser toes.

Anatomy demonstrated

Each projection must show the phalanges, distal metatarsal, and joint spaces of the affected toe. Make sure the ungual tufts point in the same direction for all projections. For example, do not reverse the film holder after making one exposure. Doing so will produce two or three projections pointing in different directions. This forces radiologists to turn the film and disrupts their continuity of thought and anatomical orientation.

440. Radiographic projections of the foot

Generally, the foot is demonstrated with three radiographic projections—AP, AP medial oblique, and lateral. However, there are many additional projections of the foot. We will discuss some of the most common.

Image receptor

Expose one projection per 8x10 or 10x12 inch cassette table top. The actual size will depend on the size of the foot being radiographed. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

Position the patient as you would for toe radiographs—seated on the radiographic table with the feet resting on the table.

Anterior posterior

Like many other radiographs, the AP (or AP Axial) projection of the foot can be done more than one way. The method selected is usually determined by your radiologist. One AP projection positions the plantar surface of the foot on the cassette so that its long axis parallels the midline of the film. The third toe, foot, ankle, and knee should form a straight line. The CR is angled 10 degrees cephalad (toward the ankle), entering the dorsal surface of the foot at the base of the third metatarsal.

The CR angulation compensates for the natural curvature of the longitudinal arch formed by the long axis of the metatarsals and tarsals. With this method, the CR enters the metatarsals at a right angle to the longitudinal arch. Therefore, the metatarsals are projected on the film without foreshortening.

Another way to perform an AP projection of the foot is to direct the CR perpendicular to the film while leaving all other positioning factors the same as just described. In this manner, because the CR is not perpendicular to the longitudinal arch, you project the metatarsals onto the film in a foreshortened image.

Although both methods produce adequate AP projections of the foot, the perpendicular CR should be used when a foreign body in the foot is suspected. This enables you to present the radiologist two films at true right angles to each other—true AP and lateral.

Neither AP method, however, demonstrates all the bones of the foot (fig. 6–3). The talus (astragulus) and calcaneus (os calcis) are not visualized on an AP projection adequately; the phalanges, metatarsals, and tarsals anterior to the talus are satisfactorily demonstrated.

Figure 6–3. AP Axial foot radiograph.

Figure 6–4. AP medial oblique foot radiograph.

Anterior posterior medial oblique

In most instances the routine oblique of the foot is the AP medial oblique projection. As with the AP position, the patient is supine. Flex the knee enough to place the plantar surface of the foot on the cassette. Rotate the foot medially until the sole forms a 30 degree angle with the film. Direct the CR perpendicular to the base of the third metatarsal.

The medial oblique shows the lateral articulations of the tarsals. In figure 6–4 you can see joint spaces between the cuboid and calcaneus, between the cuboid and fourth and fifth metatarsals, between the cuboid and third cuneiform, and between the talus and navicular. Also, the metatarsals and phalanges are shown in an oblique view. If the medial aspect of the foot and its articulations—between the first and second metatarsals, and between the first and second cuneiforms—are to be demonstrated, your radiologist may request an additional view, the AP lateral oblique.

Lateral

The lateral view can be either a lateromedial projection or mediolateral projection. Usually, it doesn't make any difference which method is done because both projections produce virtually identical radiographic images. We will describe the mediolateral projection because it is the more comfortable position for the patient.

Begin as you would for the AP projection. Rotate the foot, leg, and body (if necessary) until the foot and ankle are in true lateral position. Ensure the plantar surface of the foot is perpendicular to the film. Direct the CR perpendicular to the level of the base of the third metatarsal.

An additional consideration of foot radiography is technique. Some texts recommend the kilovoltage used should be in the 80 kVp range to reduce subject contrast. This is recommended because of the great difference in part thickness from the tarsals to the toes, especially in the AP and oblique views. This higher kVp technique provides a more uniform radiographic contrast over the range of foot thickness. A wedge filter may also be used to compensate for the varying thickness of the foot.

Additional projections of the foot

You have learned that AP (or AP axial), AP medial oblique, and lateral are the standard projections for the foot. In some instances, these standard views do not adequately demonstrate specific anatomy or pathology. Additional views may add to the standard series, or these supplemental films may be substituted in place of the routine.

Calcaneus positions

Standard projections of the calcaneus are the axial (plantodorsal) and lateral. The axial projection requires the patient to be seated on the radiographic table with the legs fully extended and the ankle centered to the film in the AP position. Flex the foot to place the plantar surface perpendicular to the film. Angle the CR 40 degree cephalic (directed toward the ankle). It should enter the plantar surface at the the base of the third metatarsal and exit at the center of the film (fig. 6–5).

The plantodorsal projection presents an axial view of the calcaneus (fig. 6–6); however, two views are still needed therefore that is why it is necessary to include a lateral view as well.The lateral calcaneus projection is similar to the mediolateral foot projection. The only difference is the centering point. Direct the CR perpendicular to the cassette, 1 inch distal to the medial malleolus.

Weight-bearing views

Weight-bearing projections of the feet are taken to show the relationships between the bones of the feet with the patient standing. They are almost always accomplished bilaterally. The laterals are taken specifically for the longitudinal arch to demonstrate *pes cavus* (exaggerated height of the arch) and *pes planus* (lowering of the arch, or flat feet).

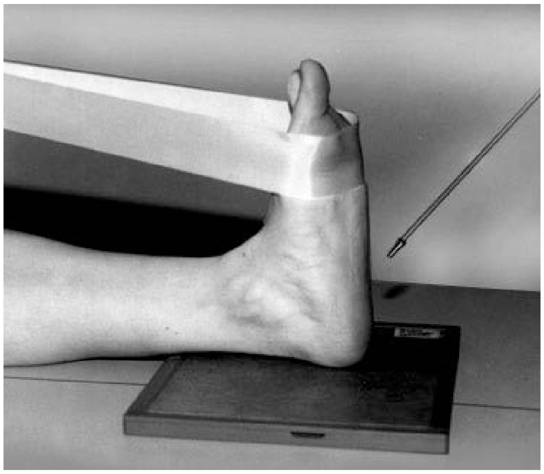


Figure 6–5. Patient positioned for an axial (plantodorsal) calcaneus.

Figure 6–6. Axial calcaneus radiograph.

Your radiologist evaluates these radiographs under the assumption that the patient's weight is evenly distributed on the feet. Consequently, you should keep even weight distribution in mind when you perform the radiographs. One way to help ensure equal weight distribution is to stress its importance to the patient. In addition, have the patient remain in the same position for both comparison radiographs.

This is generally not a problem for the APs because you can radiograph both feet simultaneously. For the laterals, if you have no commercial or "homemade" bench for this purpose, simply have the patient stand on two items of equal height (books, blocks of wood, etc.). Place the film vertically between the support items and feet. Using a horizontal CR, expose one foot; swing the tube around, change the film, and expose the other.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

439. Routine radiographic projections of the toes

1. What is the centering point for the AP projection of the toe?

2. Name two methods for radiographing the toes that show open interphalangeal joints and phalanges without foreshortening.

3. How many degrees and in what direction should the CR be angled for the AP medial oblique toe projection?

4. Which lateral should be done for the great toe? The fifth toe?

5. Name two ways to separate the affected toe from the others for the lateral projection.

440. Radiographic projections of the foot

1. What is the purpose of angling the CR 10° cephalad for an AP projection of the foot?

2. If you are performing a foot series to rule out foreign body, how should you perform the AP projection?

3. What type of oblique is part of the routine foot series?

4. If you wanted to see the articulation between the first and second cuneiforms, which oblique would you perform?

5. What is the relation of the plantar surface of the foot to the film on a lateral foot projection?

6. What are the standard projections for the calcaneus?

7. Briefly describe the axial (plantodorsal) projection of the calcaneus.

8. Name two conditions which may be demonstrated by weight-bearing lateral views of the feet.

6–2. The Ankle, Lower Leg, and Knee

Our coverage of positioning of the lower extremity continues with the ankle, leg, and knee. These are sites of frequent injury, sometimes quite serious. This can hinder you in positioning the part for the routine views therefore in this section we will deal with both standard positioning and some alternate ways to produce necessary radiographs. **(NOTE:** All SIDs are assumed to be 40 inches unless otherwise indicated.)

441. Radiographic projections of the ankle

Since injuries to the ankle may affect the weight-bearing and mobility of the patient, it is imperative that prompt and adequate treatment be given to them. One of the very first steps in treating the ankle is obtaining radiographs to determine the extent of injury. To satisfy this requirement, we generally employ the AP, AP medial oblique, and lateral projections.

Image receptor

Expose one projection per 8x10 or 10x12 inch cassette table top. The actual size will depend on the size of the part being radiographed. Reference your departments’ standard operating procedures or imaging protocols for further guidance.

Position

Seat the patient on the radiographic table with the legs extended and resting on the table.

Anterior posterior

Place the cassette on the table so that the long axis of the cassette coincides with the long axis of the leg. Position the ankle so that the midpoint of a line between the malleoli is centered to the film. Flex the foot until the sole forms an angle of 90 degrees with the surface of the cassette. Adjust the foot so that its long axis is vertical (straight up and down). Direct the CR perpendicular to the midpoint of the intermalleolar line. Figure 6–7 is an example of an AP ankle radiograph.

Anterior posterior medial oblique

The AP medial oblique projection usually follows the AP in the series. Begin by centering the ankle to the cassette as you did with the AP projection. In order to demonstrate the ankle mortise, rotate the leg medially 15 to 20 degrees until a line drawn between the malleoli is parallel with the film. Do not rotate the foot alone, but the entire leg, ankle, and foot. Direct the CR through the ankle joint, perpendicular to the center of the film. Figure 6–8 shows the AP oblique ankle radiograph. You can see how well this position demonstrates the mortise between the lateral malleolus and the talus.

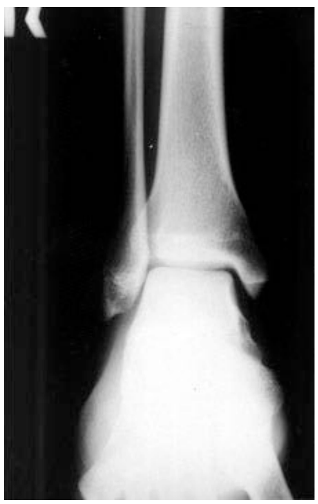


Figure 6–7. AP ankle radiograph.

Figure 6–8. AP medial oblique ankle radiograph.

Another method of performing the AP medial oblique projection of the ankle involves rotating the leg 45 degrees medially. This projection best demonstrates the tibiofibular joint since it closes the ankle mortise and superimposes the distal portions of the tibia and fibula over the talus. The first method is the most commonly accepted routine oblique view.

Lateral

Though the lateromedial projection of the ankle puts the mortise closer to the film, the mediolateral projection is the projection of choice because it is a much easier position for the patient to assume. Therefore the standard lateral ankle projection in most departments is the mediolateral projection.

For the mediolateral ankle projection, the patient is placed in the lateral recumbent position with the affected side down. The ankle is positioned so that the malleoli are superimposed and centered to the film. Placing the malleoli perpendicular to the film will require the toes and distal portion of the foot to be raised slightly off the cassette. The patient’s foot should be flexed but if an injury prevents dorsiflexion, instruct the patient to do the best they can. Direct the CR perpendicular to the film, centered on the medial malleolus. Figure 6–9 demonstrates this position.

The lateral projection of the ankle is generally made last, and on a separate film. Although a puts the, which minimally improves detail of the joint,

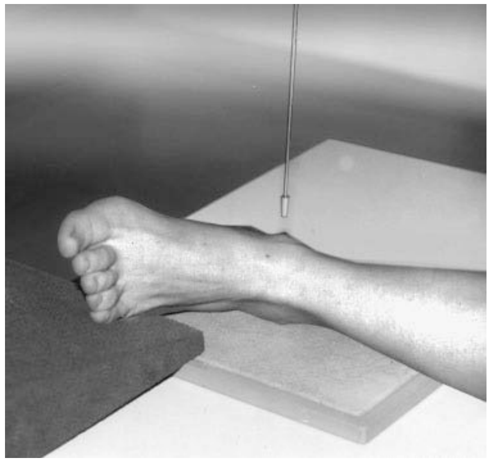


Figure 6–9. Patient positioned for a lateral ankle.

Anatomy demonstrated

The AP projection demonstrates the horizontal and medial aspects of the ankle mortise. The lateral malleolus usually overlies the lateral aspect of the talus, thereby inhibiting visualization of the lateral aspect of the mortise. Notice, however, how well the entire mortise is visualized in the medial oblique position of the ankle (fig. 6–8).

When correctly positioned, the lateral view demonstrates the articular surfaces of the talus and tibia—the tibiotalar joint space. Since the superior surface of the talus is somewhat condyloid, it is imperative that both superolateral eminences be superimposed. If they are not, one or the other will be superimposed over the joint space. This fault renders diagnosis of joint pathology or trauma exceedingly difficult. This is why the leg and ankle must be placed in the true lateral position prior to exposure.

Also, observe that the talus is extremely well visualized in these projections. Because of its superior location, the talus is not seen at all in the AP projection of the foot and is distorted in the medial oblique view. Its lateral aspect is shown in the lateral projection of the foot, but because of the entrance point of the CR, this view is also somewhat distorted. Thus, whenever you are dealing with an injury involving the talus, always include routine views of the ankle. This need of accurate projections accounts for the classic “foot-n-ankle” series.

Perhaps the most common error made in positioning the ankle for both the AP and the medial oblique is failure to flex the ankle until the plantar surface of the foot is perpendicular to the film. If the joint is extended (the normal relaxed position of the ankle when the patient is sitting or lying on the table), the calcaneus may superimpose the joint space. The resulting superimposition makes interpretation difficult.

Special considerations for the injured ankle

Injuries of the ankle include sprains, strains, dislocations, fractures, and worst of all, fracture dislocations. Strains involve over-stretching of some part of the musculature, and sprains are joint injuries in which some supporting ligament fibers are ruptured. They are relatively easy to deal with from the radiographic point of view; whereas, the others are not.

Ankle injuries can be extremely painful and debilitating. For this reason, you must exercise extreme care when positioning a patient with an obviously swollen or deformed ankle. In some instances, the patient will be unable to move the injured leg at all and you will be forced to improvise in order to obtain necessary positions. Consider using cross-table techniques to obtain the necessary views. Remember, the most important thing is to obtain views at right angles to each other, even if they are not true AP and lateral projections.

While these injuries may require you to do variations of the routine positions, some injuries indicate the need for special stress positions of the ankle.

Stress views

AP projections of the ankle joint with induced stress are made to diagnose a tear of the medial or lateral ligament by showing a widening of the joint space of the side in question. The complete stress series consists of the following projections: standard AP, AP with forced inversion, and AP with forced eversion. The ankle must remain in the AP position for the stress studies, and the foot is forcibly turned medially for one projection and laterally for the other.

If the ankle is acutely sensitive due to a recent injury, a physician or orthopedic surgeon may choose to inject a local anesthetic into the sinus tarsi just prior to the stress view exams. The patient is the best person to provide the "stress" to the ankle using a long strip of bandage or tape wrapped around the ball of the foot just beneath the toes. If the patient cannot perform or hold the stress sufficiently, then call upon only trained orthopedic personnel to perform the stress on the ankle. Improperly stressing the ankle can aggravate an existing injury or in other cases, cause an injury. Radiology personnel instruct the patient on how to properly stress the ankle to obtain the required images but should never be the one actually stressing the joint.

442. Routine radiographic projections of the lower leg

The tibia provides half the articular surfaces for two major joints and is second only to the femur in length. Neither it nor the fibula gives rise to any special radiographic problems. Both bones are routinely demonstrated in two projections: AP and lateral.

Image receptor

Expose one projection per 14x17 inch cassette table top. For longer lower legs, position the cassette diagonally, so that both joints may be visualized on one film. However, if you turn the cassette diagonally, you may need to increase your SID slightly in order for the beam to cover the diagonal length of the film. In turn, if you increase the SID, remember to adjust your technique accordingly. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

Position the patient either supine or sitting on the radiographic table with the legs extended and resting on the table. (In the case of severe trauma, you can just as easily perform the projections on a stretcher.)

Anterior posterior

Adjust the leg so that a line drawn between the femoral condyles is parallel with the film. Adjust the cassette to include both joints. Direct the CR perpendicular to the middle of the leg.

Lateral

Routine positioning for the lateral view involves rolling the patient into the lateral recumbent position with the affected side down. Adjust the leg so the femoral condyles are perpendicular to the film. Direct the CR perpendicular to the middle of the leg.

Additional considerations for severe injury

In cases of obvious fracture, you will not be able to roll the patient into the lateral recumbent position. Instead, use the cross-table technique to obtain the lateral. Gently raise the leg, supporting both above and below the site of injury and place a radiolucent pad underneath the leg. Position the cassette between both legs and direct the CR horizontally, entering from the lateral aspect of the leg.

Once again, by using the diagonal length of the film, both joints will be included. Remember, however, that they are projected by divergent beams and, therefore, are somewhat distorted. We include them as a general survey only. When a fracture invades either joint, the problem of effecting therapeutic treatment is complicated. Fractures of or into these joint spaces are quite serious because they:

1. Interrupt the smooth continuity of the articular surface.
2. May rupture the synovial membrane of the articulation.
3. Must be treated in such a way as to ensure healing that will not leave a roughened articular surface.
4. May very well prove to be sites of future osteogenic pathology such as osteoarthritis.

For these and other reasons, you must demonstrate the joint spaces as accurately as possible. If the fracture of the leg (as seen in the AP and lateral projections of the leg) appears to invade either of the joint spaces, then you must provide at least AP and lateral projections of the affected joint. This will enable accurate visualization of the joint space without distortion because the CR will pass directly through the joint.

443. Radiographic projections of the knee

The routine knee series differs widely from department to department. Often times a single department will have more than one “routine” knee series depending on the patient history. For this reason, we will not attempt to describe a routine series, but instead, we will discuss several of the most common views (projections) taken of the knee. Chances are, wherever you work, the routine knee series will consist of some combination of these projections.

Image receptor

Expose one projection per 10x12 inch cassette, typically with the use of a grid whether stationary or in the bucky. The actual cassette size will depend on the size of the part being radiographed. Reference your departments’ standard operating procedures or imaging protocols for further guidance.

Position

Place the patient supine on the radiographic table. Once again, we stress the importance of gonadal shielding because the beam is directed in close proximity to the gonads.

Anterior posterior

Most radiologists prefer the AP projection, rather than the PA. Even though the PA offers essentially identical radiographic representation of the knee, the AP is most often the projection of choice because of patient comfort and ease of positioning.

To position the knee for the AP projection properly, ensure the long axis of the leg is centered to the midline of the table and rotate the entire extremity medially until a line through the epicondyles of the femur is parallel with the film. The CR should enter at a point one-half inch inferior to the apex of the patella. Whether the CR is perpendicular or angled is dependent upon the measurement of the patient between the ASIS and the top of the table. Follow this guidance for CR angulation:

- Equal to or less than 18 centimeters (cm), angle the CR 5 degrees caudal.
- 19 to 24 cm, direct the CR perpendicular to the film.
- Equal to or greater than 25 cm, angle the CR 5 degrees cephalic.

Lateral

The lateral projection is accomplished by having the patient assume a lateral recumbent position with the affected side down. It is very important to have the femoral epicondylar plane perpendicular to the film and the knee flexed. Flexing the knee 20 to 30 degrees allows the thigh muscles to relax and shows maximum volume of the joint cavity. To prevent the joint space from being obscured by the magnified shadow of the medial femoral condyle, angle the CR 5-7 degrees cephalic entering at a point 1 inch distal to the medial epicondyle (fig. 6–10).

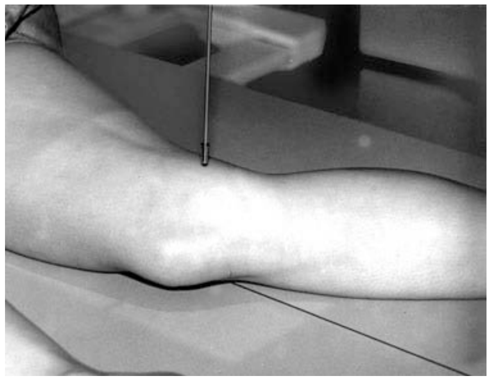


Figure 6–10. Patient positioned for a lateral knee.

Sometimes, especially with a severe trauma patient, you will be unable to accomplish the routine lateral position. When you can't place your patient lateral recumbent, you can still get a good lateral view cross-table.

With the cross-table lateral, the cassette is placed vertically against the medial condyle. The lower extremity may be supported on a radiolucent pad to center the knee to the film. Direct the CR horizontally to the center of the film through the joint.

The cross-table lateral has a distinct advantage. Since you are using a horizontal CR, you are able to demonstrate any fluid levels that may be present. For example, let's say you have a patient who experienced trauma to the knee and swelling is visualized. The AP and lateral projections may appear normal however performing a cross-table lateral projection should be suggested to the radiologist to demonstrate any fluid levels. This could indicate a very small fracture of the tibia plateau, which allows fat cells and blood to escape from the bone marrow.

Oblique

Oblique views are sometimes added to a series at the request of the radiologist. These can be done with the patient supine (AP oblique) or prone (PA oblique). Neither method presents any positioning problems as long as you center the knee, use a perpendicular CR, and rotate the entire extremity until the femoral epicondylar plane is 45 degrees to the film surface.

Homblad's position

The Homblad position is an additional position of the knee that demonstrates the intercondyloid fossa of the femur and the tibial spines. It is sometimes called the *tunnel view*.

Place the patient on the table in a kneeling position with the affected knee centered to the film. Have your patient lean forward placing hands on the radiographic table for support until the femur forms a 70 degree angle with the table surface (20 degrees from vertical) as shown in Figure 6–11. Direct the perpendicular CR through the intercondyloid fossa to the center of the film.

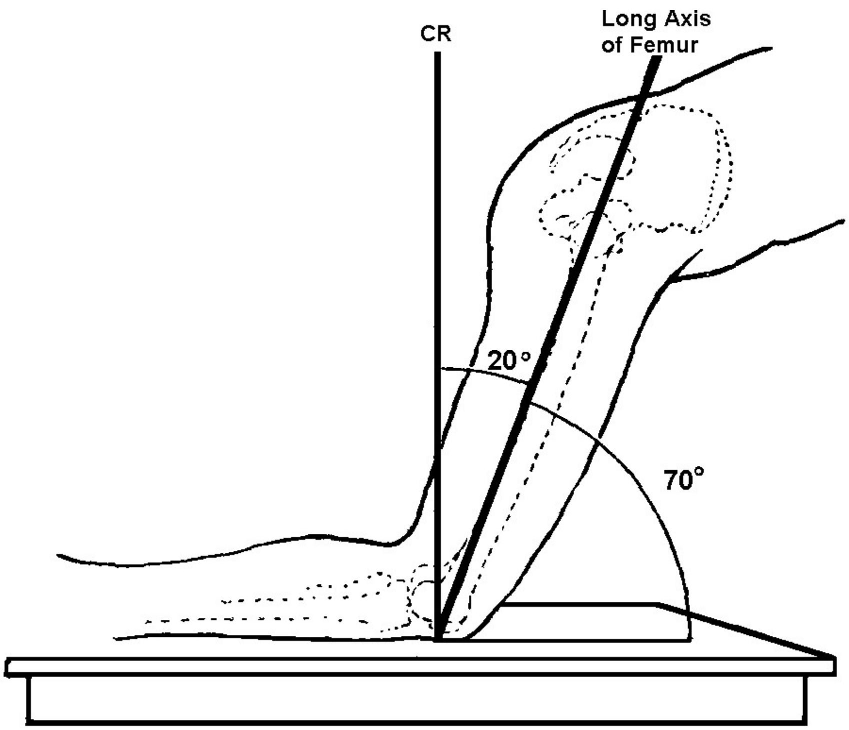


Figure 6–11. Positioning of the Homblad method (illustration).

Figure 6–12 shows a radiograph of the Homblad position. Several structures are demonstrated on a properly positioned Homblad. Notice that the tibial plateau is well visualized. The intercondylar eminence consisting of two bony prominences (tibial spines) project superiorly from the middle of the tibial plateau are also well visualized. The rounded intercondyloid fossa should also be clearly seen.

Figure 6–12. Homblad view radiograph.

Beclere's position

When the patient is unable to assume the Homblad position, you can demonstrate the intercondyloid fossa and tibial eminence using the Beclere position.

Place the patient in the supine position. Flex the knee, placing the long axis of the femur at an angle of 120 degrees with the long axis of the tibia. Notice in Figure 6–13 that the femur and leg form an angle similar to the Homblad position. The film is supported with sandbags or sponges to put it in contact with the posterior aspect of the flexed knee. The CR is directed at right angles to the long axis of the tibia and through the knee joint.

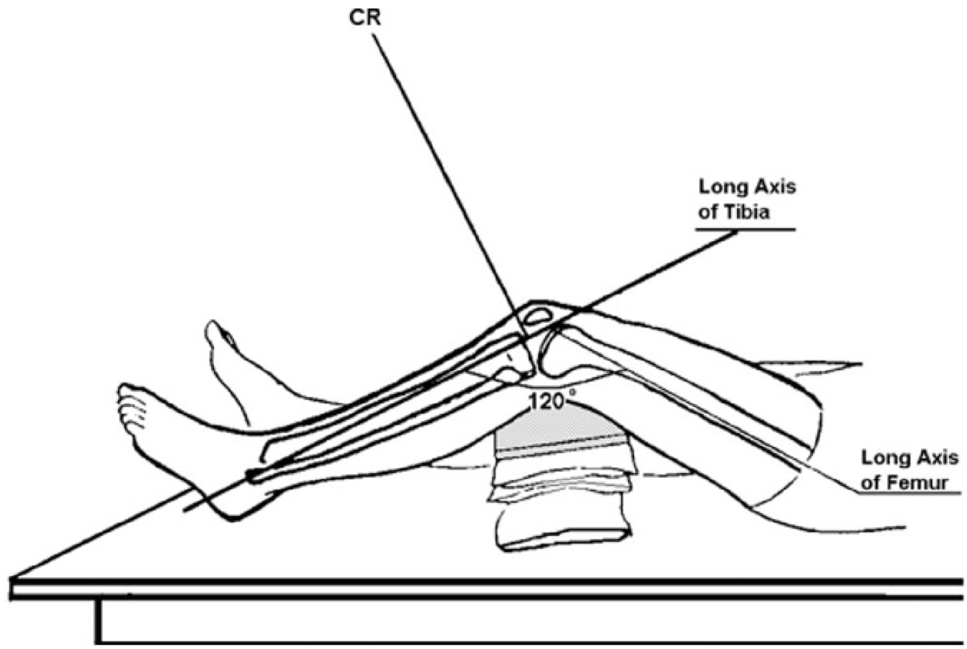


Figure 6–13. Positioning of the Beclere method (illustration).

Weight-bearing views

Weight-bearing views of the knees are often requested to aid in diagnosing arthritic changes of the lower extremities. These projections—usually AP and lateral only—are done with the patient and radiographic table in the upright position, and may be accomplished unilaterally or bilaterally. These erect projections will demonstrate narrowing of the joint spaces that would otherwise appear normal if the patient were supine. When only one knee is under examination, ensure the patient shifts his or her body weight to that extremity. Positioning considerations for the upright views are the same as those for the supine projections.

Projections of the patella

In addition to the standard knee views, there are a few projections designed specifically to give optimal detail of the patella. Again, these views may or may not be part of the "routine" series in your department. The patella usually is demonstrated in three positions—PA, lateral, and tangential.

Posterior anterior

This projection, as oppose to the AP, is preferred because it places the patella closer to the film. The reduction in OID will result in better detail. On the other hand, the PA projection may cause a great deal of pain for the patient, especially in cases of severe trauma. Careful positioning will reduce discomfort for your patient and allow you to obtain maximum detail.

The PA projection of the patella begins with the patient prone on the table with the affected patella centered to the film. Because the weight of the leg overlies the injured patella, you may be subjecting your patient to excruciating pain. You can reduce this pressure by placing sandbags under the thigh and the leg. Ensure the patella is parallel with the film by rotating the heel of the affected leg outward a few degrees. Finally, direct the CR perpendicular to the film, exiting the patella.

Lateral

For the lateral position of the patella, the leg is placed in the same position as for the lateral knee. The main difference is that the CR is not angled, but directed perpendicular to the film, centered on the patella. Also, if the PA projection demonstrates a fractured patella, only flex the knee about 10° instead of the 20 to 30 degrees required for the lateral knee. This will help prevent separation of the fracture.

Because the patella is in profile and the CR is perpendicular to the film, the subpatellar space should be well visualized. If this space is obscured by the femoral condyles, then the leg is probably obliqued. This condition could prevent an accurate diagnosis of a fracture.

Tangential view

There are a number of ways to demonstrate a tangential view of the patella. We will discuss two of the most common.

Settegast position

The Settegast position, commonly called the sunrise view, produces a tangential view of the patella. It is an inferior-superior projection useful for showing vertical fractures of the patella. In addition, the articulating surfaces of the femoropatellar articulation and the subpatellar space should be well visualized. Although this view can be obtained with the patient sitting or lateral recumbent, we will cover only the prone position.

With your patient prone on the table, center the patella to the film and slowly flex the knee. If the patient permits, ideally, flex the knee until the patella is perpendicular to the film. If not, flex the knee as much as possible. Angle the CR to pass through the joint space (fig. 6–14). The specific degree of angulation will depend on the amount of flexion of the knee.

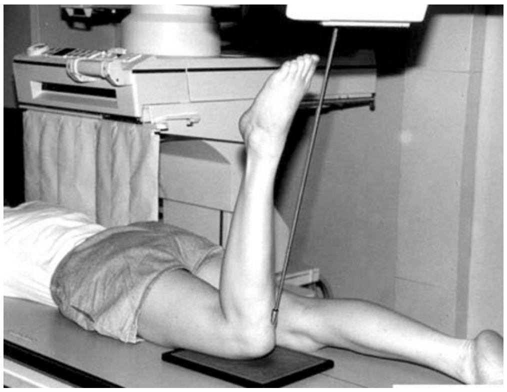


Figure 6–14. Patient positioned for the Settegast method.

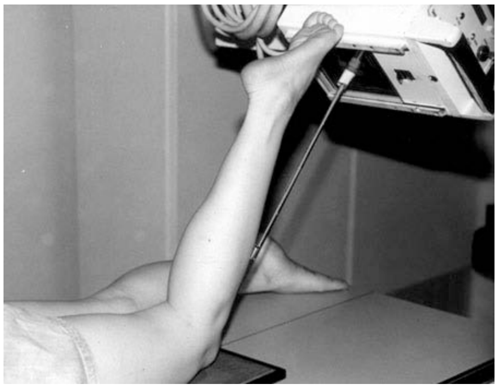


Figure 6–15. Patient positioned for the Hughston method.

Hughston position

Another view that may be used to demonstrate a tangential view of the patella and subpatellar space is the Hughston position. You may find this method easier to perform in trauma situations because it requires less flexion of the knee.

Place the patient in the prone position on the radiographic table. Flex the knee until the tibia forms a 50° to 60° angle with the table. Angle the CR 45 degrees cephalad centered on the joint space, and rest the patient's toes on the collimator (fig. 6–15).

Either of these methods will produce adequate visualization of the desired anatomy. In fact, there are many other methods described in various texts for demonstrating equivalent views. The specific method employed is generally a matter of the technologist's preference. Figure 6–16 is an example of a tangential projection of the patella.

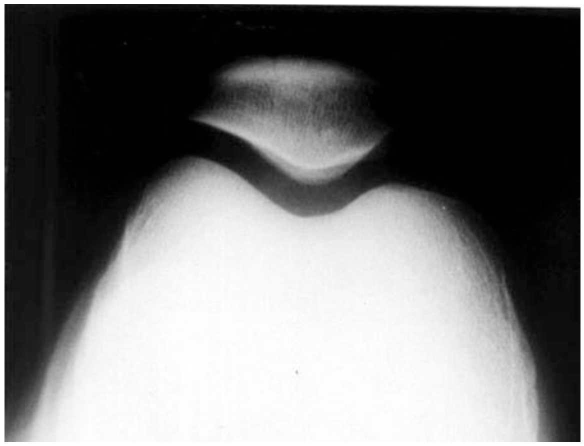


Figure 6–16. Tangential radiograph of patella.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

441. Radiographic projections of the ankle

1. What are the standard projections for an ankle series?

2. How is the foot positioned for the AP projection of the ankle?

3. How should the ankle be positioned to demonstrate the entire ankle mortise?

4. Why is the mediolateral projection of the foot usually performed instead of the lateromedial?

5. Why should the foot be flexed for an AP projection of the ankle?

6. Why are stress views of the ankle sometimes obtained?

7. Which views are usually taken as part of a stress series?

442. Routine radiographic projections of the lower leg

1. When radiographing the lower leg, how can you fit both joints on a single film if the leg is exceptionally long?

2. What bony landmarks should be parallel to the film on an AP projection of the lower leg?

3. How is the patient normally positioned for a lateral projection of the lower leg?

4. Identify four reasons why fractures of the lower leg, which involve the joints, are considered quite serious.

5. What should you do if you see a fracture on the routine views of the lower leg that appears to invade either of the joints? Why?

443. Radiographic projections of the knee

1. For the AP projection of the knee, describe where the CR is directed and when and how is the CR angled?

2. How much is the knee flexed for the lateral projection? Why?

3. Why is the CR angled for the lateral knee projection?

4. What is the distinct advantage of performing the lateral knee cross-table?

5. How many degrees is the epicondylar plane rotated for oblique views of the knee?

6. What specific anatomy is demonstrated by the Homblad position?

7. What angle should the femur form with the table on a properly positioned Homblad?

8. Where is the film placed for Beclere’s position?

9. Weight-bearing views of the knee are helpful in demonstrating what condition?

10. Name three standard positions used to demonstrate the patella.

11. How can you increase patient comfort when performing the PA projection on an injured patella?

12. What is the main difference between a lateral projection of the knee and a lateral projection of the patella?

13. Name two methods for producing a tangential view of the patella.

14. If the patient permits, ideally, how much is the knee flexed for the Settegast view?

15. How is the CR directed for the Hughston view of the patella?

6–3. The Femur, Hips, and Pelvis

We continue our coverage of the lower extremity with radiography of the femur, hips, and pelvis. Since these structures are in close proximity with one another, a fracture involving one usually requires radiographs of the adjoining osteology. For instance, a fracture of the proximal femur may invade the hip joint and require radiographs of both the femur and hip, or even the pelvis. For this reason, we include these structures together in this section.

444. Routine radiographic projections of the femur

Routine projections for the femur are AP and lateral however, since the adult femur is usually too long to fit on a 17-inch cassette, generally two exposures are made for each view.

Image receptor

Expose one projection per cassette. In most instances, you will need a 14×17-inch cassette and a 10×12-inch cassette for each view of the femur typically using a grid. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

Since most departments require that you include the entire length of the femur on both projections, you will need to make two exposures for each view. The first exposure should be made on a 14×17 inch cassette and include the distal femur and knee joint. The second exposure should be made on a 10×12 inch cassette and include the hip. Since the next objective covers radiography of the hip, we will only discuss the distal femur projections now.

Anterior posterior femur

Place the patient in the supine position on the radiographic table. Adjust the pelvis to eliminate any rotation. Turn the entire extremity inward (medially) until the femoral epicondylar plane is parallel with the surface of the film. Even though your attention is directed at the distal end of the femur, this medial rotation also puts the hip joint in true AP.

NOTE: Do not attempt to rotate a femur suspected of being fractured. The femoral artery lies close to the femur and could be lacerated by jagged ends of broken bone. If this happens, the patient can bleed to death in a matter of minutes.

Position the cassette in the bucky so that the lower margin is low enough to include the knee joint. Direct the CR perpendicular to the center of the film. Because of the varying thickness of the part, you can improve the overall quality of the image by positioning the tube so the cathode is over the upper thigh and the anode is toward the knee end of the femur. This will use the "anode-heel effect" to your advantage and direct more of the primary radiation to the thickest part.

Lateral femur

Place the patient in the lateral recumbent position with the affected side down. Center the femur on the midline of the table and draw the other leg forward, as shown in figure 6–17, to minimize superimposition over the superior portion of the affected leg. This obscures the uppermost portion of the affected femur but presents the distal two-thirds without superimposition. The affected femur is lateral when the epicondylar plane is perpendicular to the film. Flex the knee slightly and position the cassette so that its lower margin is low enough to include the knee joint 2 inches below the apex of the patella. Direct the CR perpendicular to the center of the film.

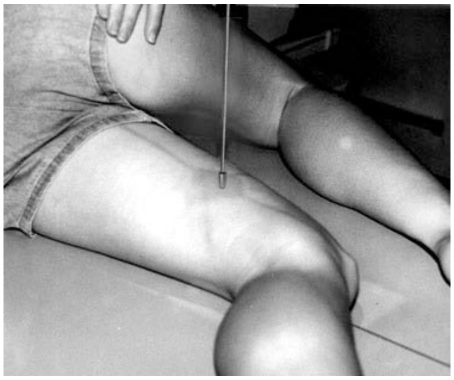


Figure 6–17. Patient positioned for a lateral distal femur.

There are times that you cannot use the lateral recumbent position. When there is a fracture demonstrated on the AP projection or obvious deformity of the limb, do not attempt to use the routine lateral position. Take all precautions to prevent additional injury to your patient. Leave the patient in the supine position and place a cassette vertically along the medial side of the thigh and direct a horizontal CR to the center of the film. This cross-table lateral is useful for demonstrating the lower two-thirds of the femur.

445. Radiographic projections of the hip and pelvis

Routine projections to demonstrate the hip are AP and lateral. Some departments include an AP pelvis as part of the routine hip series instead of the AP hip. Also, many departments use the modified Cleaves position or "frogleg" lateral when radiographing the hips bilaterally.

Image receptor

Expose one projection per cassette. If imaging bilateral hips, use a 14x17 inch cassette however, if only imaging one hip, 10x12 inch cassette is adequate to display the desired anatomy. Due to the part size, use of a grid or bucky is necessary however reference your departments' standard operating procedures or imaging protocols for further guidance.

Position

Place the patient supine on the radiographic table. Adjust the pelvis to eliminate any rotation. Gonadal shielding is extremely important for both male and female patients as the CR will pass in close proximity to the gonads. Shielding the gonads though should not obsure any of the desired anatomy.

Anterior posterior hip

While the AP projection of the hip joint is generally not difficult to perform, projecting the joint into a small field can be a problem if you cannot locate it exactly. The hip joint lies at the level of the uppermost portion of the greater trochanter in a plane 2 inches medial to the ASIS. By using these two bony landmarks, you can easily find the center of the hip joint as seen in Figure 6–18.

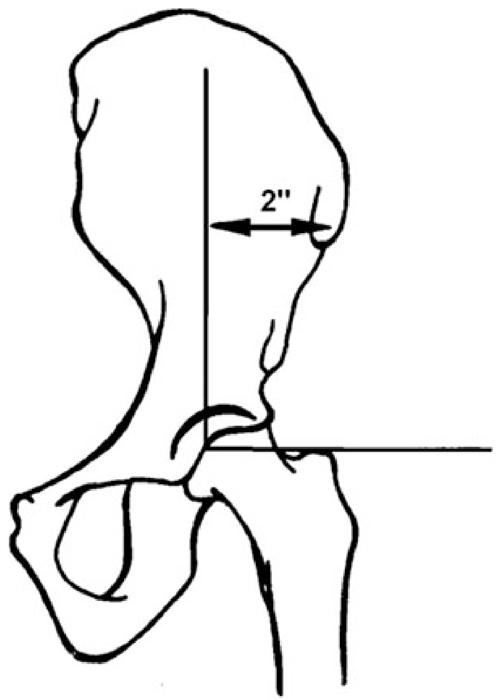


Figure 6–18. Location of the hip joint.

With the patient supine and the affected hip joint centered to the film and bucky, place the hip in true AP by rotating the leg medially until the femoral epicondylar plane is parallel with the film. When the epicondylar plane is parallel to the film, this also places the femoral necks parallel with the film Avoid any movement of the femur if a fracture is suspected. Using the method described above to locate the hip, direct the CR perpendicular to the hip joint and to the center of the film.

Lateral hip

With the patient still supine on the table from the AP projection, bend the leg at the hip and knee slightly and rotate the leg outward into the lateral position. In figure 6–19, notice the lateral side of the affected extremity is placed on the table and the hip is centered to the film. It may be necessary to roll the unaffected side of the pelvis a few inches off the surface of the table to place the lateral side of the affected thigh on the table. The CR is perpendicular to the film centered midway between the ASIS and the symphysis pubis. Figure 6–20 is an example of a lateral hip radiograph.

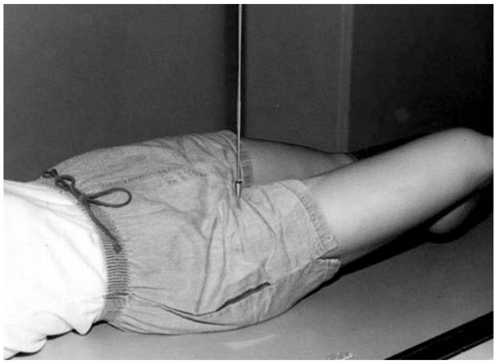


Figure 6–19. Patient positioned for a lateral hip.

Figure 6–20. Lateral hip radiograph.

Modified Cleaves method

When radiographing the hips bilaterally, many departments prefer to use the modified Cleaves method or "*frogleg*," lateral instead of performing two separate laterals as shown in figure 6-21. The *frogleg position* shows an AP oblique projection of the femoral heads, necks, and trochanters. This position begins with the patient supine and centered to the midline of the table. The hips & knees are flexed up approximately 90 degrees and the thighs are abducted at least 45 degrees from vertical.

NOTE: Be careful to abduct the thighs equally. To support them self in this position, have the patient turn their feet inward and place the soles of the feet together. The CR is directed perpendicular to the film and centered to a point midway between the femoral heads.

Though the modified Cleaves method is more routinely performed, sometimes the original Cleaves method is requested as an additional view to demonstrate the femoral heads, necks, and trochanters bilaterally in an axiolateral view. Positioning for the original Cleaves method is exactly the sameas with the modified Cleaves method however this time the CR is angled 25-40 degrees cephalic so that the CR is parallel with the femoral shafts.

Figure 6-21 is an example of the modified Cleaves or "frogleg" lateral.

Figure 6–21. Modified Cleaves view radiograph.

Danelius-Miller position

In instances of suspected fracture to the hip or proximal femur, you will be unable to position the patient for the routine lateral hip. In these cases it is best to perform a modified version of the lateral hip projection named after its inventors—Danelius and Miller. This position produces an axial lateral view of the femoral head, neck, and trochanters. It is often referred to as a surgical lateral because of its frequent use in the operating room.

Begin by placing the patient in the supine position. The unaffected lower extremity is flexed and raised to remove it from the path of the CR. Place a gridded cassette vertically with its upper border in contact with the patient at the level of the iliac crest on the affected side. Angle the lower border away from the patient until the film forms about a 45 degree angle with the body, thereby placing it parallel with the femoral neck. Support the cassette with sandbags. If possible, rotate the patient's leg medially 15 degrees. Direct the CR horizontally through the femoral neck so that the CR is perpendicular to the film, as shown in figure 6–22.

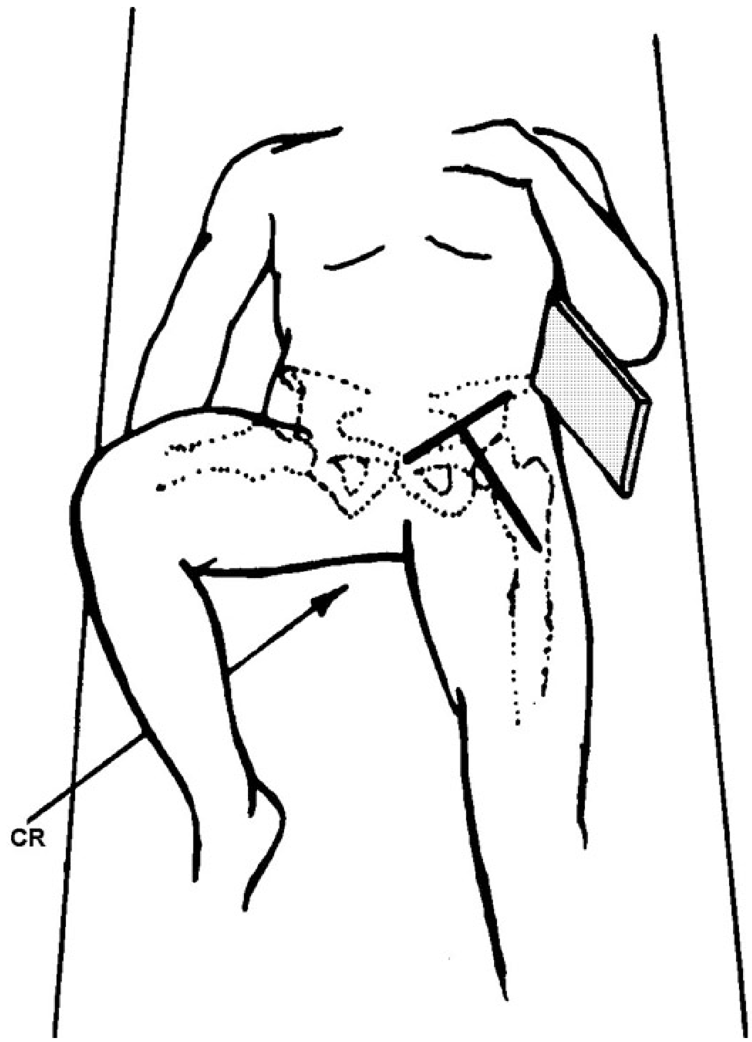


Figure 6–22. Positioning for a Danelius-Miller lateral hip (illustration).

Positioning of the pelvis

Unless your radiologist requests an additional film, a general survey study of the pelvis requires only an AP projection. The patient is positioned supine. Ensure that there is no rotation of the pelvis. Center the pelvis to the film by placing the upper border of the cassette about 1 – 1 ½ inches above the iliac crest. If the hips are of primary interest, position the heels about 8-10 inches apart and rotate the legs medially until the both great toes are touching. This technique places the feet in approximately a 15-20 degree angle from vertical but more importantly, places the femoral necks parallel to the film. Direct the CR perpendicular to the midpoint of the film.

Gonadal shielding is not recommended as it will obscure some of the anatomy that you are attempting to demonstrate.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

444. Routine radiographic projections of the femur

1. How is the femur positioned for the AP projection of the femur?

2. Why should you *not* attempt to rotate a femur that may be fractured?

3. How can you help to compensate for the varying part thickness when radiographing the femur?

4. When should you *not* attempt to place the patient in the lateral recumbent position for the lateral femur projection?

445. Radiographic projections of the hip and pelvis

1. Describe the location of the hip joint.

2. What two structures are parallel to the film for the AP projection of the hip?

3. Which views can be used to obtain a lateral view of both hips simultaneously?

4. How are the legs positioned for the view mentioned in question 3?

5. How is the CR directed for the modified Cleaves view?

6. Which view of the hip is sometimes called the surgical lateral?

7. How should the film be positioned for the surgical lateral hip view?

8. Why should the legs be rotated medially when performing an AP pelvis?

Answers to Self-Test Questions

439

1. The metatarsal-phalangeal joint of the affected toe.
2. PA (plantodorsal) with a perpendicular CR, or an AP (dorsal plantar) with 15 degree cephalic angulation.
3. 30° medially.
4. Great toe–lateromedial; fifth toe–mediolateral.
5. By using a tongue depressor or tape.

440

1. To compensate for the natural curvature of the longitudinal arch formed by the long axis of the metatarsals and tarsals
2. With a perpendicular CR.
3. AP medial oblique.
4. AP lateral oblique.
5. Perpendicular.
6. Axial (plantodorsal) and lateral.
7. Flex the foot to place the plantar surface perpendicular to the film. Angle the CR 40 degree cephalad entering the plantar surface at the base of the third metatarsal.
8. Pes cavus and pes planus.

441

1. AP, AP medial oblique, and lateral.
2. The foot should be flexed to form a 90 degree angle with the film and adjusted so that its long axis is vertical.
3. Oblique the ankle 15 to 20 degrees medially until the malleoli are parallel to the film.
4. It is easier for the patient to assume the mediolateral position.
5. If it is not, the calcaneus may superimpose the joint space.
6. To demonstrate tears in the medial or lateral ligaments.
7. AP, AP with forced inversion, and AP with forced eversion.

442

1. By turning the cassette diagonally.
2. The femoral condyles.
3. In the lateral recumbent position with the affected side down.
4. They interrupt the smooth continuity of the articular surface; they may rupture the synovial membrane of the articulation; they must be treated in such a way as to ensure healing that will not leave a roughened articular surface; and, they may prove to be sights of future osteogenic pathology such as osteoarthritis.
5. Perform AP and lateral projections of the affected joint; so that the joint will be projected without distortion on the films.

443

1. Direct the CR to a point one-half inch inferior to the apex of the patella. Measure the distance between the patient’s ASIS and the top of the table. If equal to or less than 18 cm, angle the CR 5 degrees caudal; if 19 to 24 cm, direct the CR perpendicular to the film. If equal to or greater than 25 cm, angle the CR 5 degrees cephalic.

2. Twenty to 30 degrees; to allow the thigh muscles to relax and show the maximum volume of the joint.
3. To prevent the joint space from being obscured by the magnified shadow of the medial femoral condyle.
4. The cross-table technique will demonstrate any fluid levels.
5. 45 degrees.
6. The intercondyloid fossa of the femur and the tibial spines.
7. 70 degrees.
8. In contact with the posterior aspect of the flexed knee.
9. Arthritic changes.
10. PA, lateral, and tangential.
11. Support the leg by placing sandbags under the thigh and leg.
12. When radiographing the patella, the CR is not angled but directed perpendicular to the film centered on the patella.
13. Settegast and Hughston.
14. Until the patella is perpendicular to the film.
15. 45 degrees cephalad, centered on the joint space.

444

1. With the epicondylar plane parallel to the film.
2. Because the femoral artery lies in close proximity to the femur and could be lacerated by jagged ends of bone fragments.
3. By placing the cathode side of the tube over the upper thigh. (using the anode-heel effect)
4. When there is a fracture demonstrated on the AP projection or obvious deformity of the limb.

445

1. The hip joint lies at the level of the uppermost portion of the greater trochanter in a plane 2 inches medial to the ASIS.
2. The femoral epicondylar plane and the femoral neck.
3. Modified Cleaves “frog leg” and original Cleaves.
4. The knees are flexed approximately 90 degrees and the thighs are abducted at least 45 degrees from vertical.
5. Perpendicular to the film centered to a point midway between the femoral heads.
6. Danelius-Miller.
7. Place the upper border at the level of the iliac crest and angle the lower border away from the patient until it forms a 45 degree angle with the body.
8. To place the femoral necks parallel to the film.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

60. (439) Which radiographic projection of the toes shows the interphalangeal joint space and demonstrates the phalanges without foreshortening?
    a. Dorsal plantar (DP) with perpendicular central ray (CR).
    b. DP with CR angled 15 degrees cephalic.
    c. Anterior posterior (AP) medial oblique.
    d. AP lateral oblique.

61. (440) Which tarsal bones are *not* adequately demonstrated on the anterior posterior (AP) projection of the foot?
    a. Talus and navicular.
    b. Talus and calcaneus.
    c. Navicular and calcaneus.
    d. Third cuneiform and calcaneus.

62. (440) For the routine foot series, the foot should be obliqued
    a. 30 degrees medial.
    b. 30 degrees lateral.
    c. 45 degrees medial.
    d. 45 degrees lateral.

63. (440) How should the central ray (CR) be directed for the plantodorsal projection of the calcaneus?
    a. 30 degrees cephalic to the level of the base of the fifth metatarsal.
    b. 30 degrees cephalic to the level of the base of the third metatarsal.
    c. 40 degrees cephalic to the level of the base of the fifth metatarsal.
    d. 40 degrees cephalic to the level of the base of the third metatarsal.

64. (441) Which radiographic projection of the ankle involves adjusting the leg until the malleoli are parallel with the film?
    a. Anterior posterior (AP).
    b. AP medial oblique.
    c. AP lateral oblique.
    d. Lateral.

65. (441) Stress views of the ankle demonstrate
    a. nondisplaced malleolar fractures.
    b. tears in the medial and lateral menisci.
    c. tears in the medial and lateral ligaments.
    d. narrowing of the affected side of the ankle joint.

66. (442) How is the part positioned for the anterior posterior (AP) projection of the leg (tib-fib)?
    a. With the malleoli parallel to the film.
    b. With the femoral condyles parallel to the film.
    c. With the femoral condyles perpendicular to the film.
    d. With the tibial condylar plane perpendicular to the film.

67. (443) Which projection of the knee will demonstrate a fluid level?
    a. Beclere.
    b. Oblique.
    c. Mediolateral.
    d. Cross-table lateral.

68. (443) How should the femur be positioned when performing the Homblad view of the knee?
    a. Perpendicular to the table.
    b. At an angle 70 degrees to the table.
    c. At an angel 120 degrees to the tibia.
    d. At an angle 70 degrees from vertical.

69. (443) Which projection of the knee demonstrates the intercondyloid fossa?
    a. Beclere.
    b. Settegast.
    c. Hughston.
    d. Anterior posterior (AP) medial oblique.

70. (444) The femur is properly positioned for the anterior posterior (AP) projection when the
    a. trochanters are parallel to the film.
    b. epicondyles are parallel to the film.
    c. trochanters are perpendicular to the film.
    d. epicondyles are perpendicular to the film.

71. (445) If you suspect a fracture to the hip or proximal femur, which method should be used to accomplish the lateral view?
    a. Cleaves.
    b. Danelius-Miller.
    c. Lateral recumbent.
    d. Modified Cleaves.

72. (445) How is the cassette positioned for the Danelius-Miller view?
    a. Upper boarder at the iliac crest, parallel with the femoral neck.
    b. Upper boarder at the iliac crest, at a 45 degree angle to the femoral neck.
    c. Upper boarder 2 inches superior to the iliac crest, parallel with the femoral neck.
    d. Upper boarder 2 inches superior to the iliac crest, at a 45 degree angle to the femoral neck.

73. (445) Where is the film placed for the anterior posterior (AP) projection of the pelvis?
    a. Upper border 1–1 ½ inches above the anterior superior iliac spine (ASIS).
    b. Upper border 1–1 ½ inches above the iliac crest.
    c. Centered 5 inches inferior to the symphysis pubis.
    d. Centered 5 inches superior to the iliac crest.

Please read the unit menu for unit 7 and continue ➔

Unit 7. Positioning of the Chest and Abdomen

RADIOGRAPHY OF THE CHEST AND ABDOMEN represents probably the greatest percentage of the workload done in most radiology departments across the world. In many instances, these projections are accomplished as scout films for special studies, or even pre-operatively as general survey films. We include them together in this unit because they are often accomplished in conjunction with one another. Also in this unit, we will cover positions for the bony thorax because it is closely associated with the chest.

NOTE: As in the previous units, any reference to film, a cassette, and/or image receptor is meant to be synonymous with each other. As well, always expose each image with the appropriate right or left lead anatomical marker. Using stickers, sharpie permanent markers, or computer aided text is neither authorized nor legal in a court of law to mark human radiographic images.

7–1. The Chest and Abdomen

The chest is unquestionably the most commonly radiographed portion of the body. By this point in your career, you are no doubt aware of the proper procedures for positioning the routine views of the chest. We will briefly review these procedures while also discussing the additional projections and aspects of chest X-ray quality control. Finally, we will cover the frequently performed abdominal examinations. As in the previous units, any reference to film, a cassette, and/or image receptor is meant to be synonymous with each other. (**NOTE:** All SID for chest radiography are assumed to be 72 inches unless otherwise indicated.)

446. Routine radiographic projections of the chest

As you know, the routine radiographic projections of the chest are PA and lateral. While relatively simple, proper positioning is vital to ensure good quality films and an accurate diagnosis are obtained.

Image receptor

Expose one projection per 14x17 inch cassette typically lengthwise for most adults. Some broad-chested patients (especially males) may require the film positioned crosswise for the PA. For younger or smaller patients, a 10x12 or 11x14 inch cassette may be used. Always reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

All routine chest radiography performed in the radiology department should be done upright, in a bucky, and at 72 inches SID. Performing the views upright will help the patient to attain full inspiration, and it will also demonstrate any fluid levels that may be present in the lungs. Other advantages of the upright position are that it prevents widening of the mediastinal structures which occurs when the patient is recumbent, and it permits use of a 72-inch SID. Use of a 72-inch SID is important because it reduces the magnification of mediastinal structures that can indicate disease processes such as cardiomegaly (enlarged heart).

Other important technical considerations for chest radiography are the use of high kilovoltage peak (kVp) techniques and automatic exposure control (AEC) systems. It is generally accepted that chest radiography performed with a grid at higher kVp settings (typically 120 kVp) to achieve a longer scale of contrast while showing adequate detail, contrast, and density for both the air-filled lungs and the much denser mediastinal structures. With that said, radiography of the chest requires more exposure latitude than any other part of the body. Another tool we can use to achieve consistent high quality chest radiographs is the use of AEC systems. The reliability of AEC systems have increased over the years and in most departments, have become an important part of chest radiography because the proper use of AEC helps ensure consistent quality films when follow-up studies are obtained weeks or months after the initial examination. Another benefit of AEC is automatic technique compensation for disease processes such as emphysema (less technique needed) or pulmonary infiltration (more technique needed) that often is not apparent until the initial exposure turns out over- or under-exposed. In addition to AEC, the computer software behind computed radiography and/or direct capture radiography also helps to provide the exposure latitude required for reducing technique related repeats.

Posterior anterior

The PA chest is performed more often than any other single radiograph because it is performed not only on ill patients, but on many patients who are well but have this radiograph as part of a routine physical. Because you perform so many, you may become complacent when doing this examination. To be able to produce high-quality radiographs consistently, it is necessary for you to pay attention to several important steps in positioning.

Position the patient upright and facing the vertical cassette holder. The patient's chest should be in contact with the holder. Adjust the film so that its upper border is approximately 2 inches above the shoulders. Have the patient place his or her chin on top of the vertical cassette holder, if possible. With the patient centered to the cassette, place the hands on the hips (low enough so they will not to be included in the collimated light field) and roll the shoulders forward and down.

It is important to have the patient place both shoulders against the cassette holder, if possible, to ensure there is no rotation. By rolling the shoulders forward, you move the scapulae laterally and almost entirely out of the lung fields. Keeping the shoulders down will ensure you do not accidentally center too high and clip the costophrenic angles.

Breathing instructions

Most chest X-rays are made at the end of full inspiration to allow maximum visualization of the lung tissue. Rather than having your patient inhale to the point of straining, it is best to utilize the two breath techniques with the exposure made at the end of the second inspiration. An example of the two breath technique style instructions are as follows:

1. Take in a deep breath (pause for a second), blow it out.
2. Take in another deep breath and this time hold it in!
3. After the exposure, breathe and relax.

This method of given breathing instructions is more effective for routine and obese patients because it allows more air into the lungs without causing the patient to strain.

The number of ribs visualized above the diaphragm indicates the sufficiency of inspiration by the patient. Some radiologists like to count the anterior aspects of the ribs, while others count the posterior aspects. Whichever method is used, ribs should be counted in the right hemithorax to avoid the heart shadow.

For the purpose of this discussion and for what seems to be more routinely recognized, we are going to count the posterior ribs. When counting posterior ribs, be careful where you begin the count. The tendency is to miss the first rib because it runs more vertical than the rest of the ribs. Also, the aspect of the rib must be entirely above the diaphragm in order to be counted. A good inspiration chest X-ray should demonstrate ***ten*** posterior ribs above the diaphragm. Figure 7–1 shows a PA chest film.

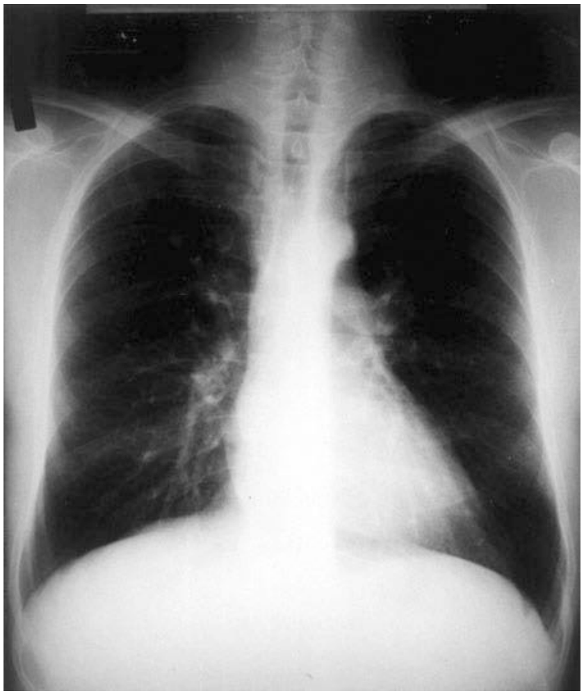


Figure 7–1. PA chest radiograph.

If you have a patient with a suspected pneumothorax, you should take two PA chest films—one taken upon full inspiration and the second taken upon complete expiration. When counting the posterior ribs for an expiration film, there should be at least one less rib in the lung field to know that a sufficient expiration image was obtained. The reason for the expiration film is that it may demonstrate small amounts of free air that might be obscured on the inspiration film.

Exposures for heart size should be made at the end of normal inspiration. Strained inhalation may force the diaphragm downward too much and result in an elongated heart image.

Special precautions

A common cause for repeated films is the presence of foreign objects such as chains, necklaces, or bras showing up on the finished radiographs. Since most of your patients will already be dressed for the exam when entering the exposure room however, you should still ask if they have removed everything from the waist up. This last minute check will reduce your overall repeat rate, which saves time, effort, and resources, as well as reducing radiation exposure to your patients.

Position of the shoulders

One of the most common errors made in performing the PA chest is failure to roll the patient's shoulders far enough forward. To obtain maximum rotation, the back of the patient's hands should be placed on the waist. Try this experiment: place the palms of your hands on your waist and roll your shoulders forward as far as possible, then simply turn your hands over so the backs of your hands are on your waist. Notice how much more your shoulders roll. By doing the exam in this manner, the scapulae are almost totally removed from the lung fields.

Some technologists feel if an AP projection is made of the chest, as during a portable examination, it is not necessary to consider the scapulae. This is not true. If the patient's condition permits, the shoulders should be rolled forward just as on the PA projection.

Rotation

Another common error is failure to position the patient with both shoulders against the film. If the patient is rotated, the true relationship between structures is not maintained because some structures are hidden and some are distorted.

To check for rotation on a PA chest radiograph, look at the sternoclavicular joints. They should appear the same and equally distant from the midline. Rotation usually produces an asymmetrical appearance with one joint farther from the midline than the other. One of the joints may even be obscured by the spine. When this occurs, it is easy to determine the direction of rotation. If the right joint is obscured, the patient's left side is rotated away from the film and vice versa. To reduce the likelihood of this occurring, both shoulders should touch the vertical cassette holder and the hips should not be rotated.

Lateral

The routine lateral for a chest series is the left lateral because this position places the heart closer to the film, thereby reducing magnification. Occasionally, a right lateral will be ordered because of pathology in the right hemithorax however, if the side is not specified, always do the left.

Begin by placing the patient in front of the vertical cassette holder with the left side against the holder. The film should be in the same position as for the PA, about 2 inches above the shoulders. Have the patient raise both arms above the head and grab both elbows with the opposite hand. Ensure the patient is standing straight, and is not leaning to the right, left, front, or back.

Center the chest to the film. Facing the patient from the same direction as the tube, place your hand along the patient's back and adjust the body until the back is perpendicular to the film. The exposure should be made with a 72 inch SID and on suspended inspiration.

A common problem associated with the lateral chest film is an apparent underexposure of the upper lung fields. This underexposure is generally not caused by radiographic technique; it usually results from failure to raise the patient's arms high enough. The proper height can be attained by folding the raised arms over the head. This not only raises the shoulders to a maximum, but also tends to steady the patient, reducing the possibility of motion. Figure 7–2 is an example of a lateral chest radiograph.

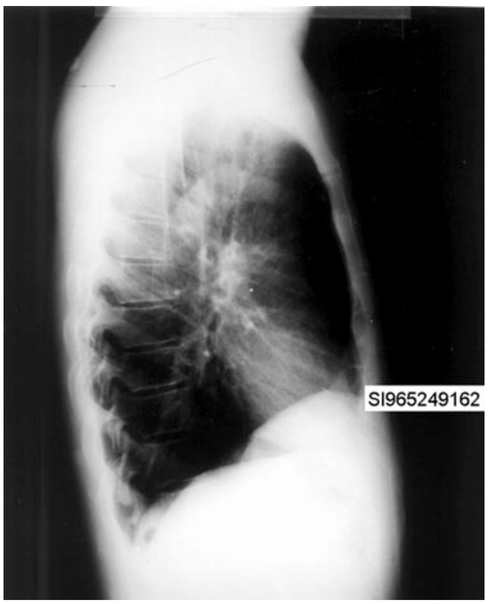


Figure 7–2. Lateral chest radiograph.

447. Additional radiographic projections of the chest

In addition to the standard projections of the chest, there are many additional projections that are requested from time to time when the standard projections are inadequate to demonstrate known or suspected pathology. We will discuss obliques, decubitus films, the apical lordotic projection, and finally, portable chest radiography.

Oblique views of the chest

Oblique views of the chest are usually ordered after evaluation of the initial PA and lateral films have revealed pathology or suspected pathology. The radiologist will sometimes order obliques to evaluate the area in question from different angles.

Standard oblique films of the chest are 45 degrees right anterior and left anterior obliques. As with all other chest films, obliques should be done erect at 72 inches SID when possible. All oblique exposures should be made on full inspiration.

Have the patient stand facing the vertical cassette holder. Adjust the film so that its upper border is approximately 2 inches above the shoulders. Place the hand of the side that is to be against the film on the corresponding hip. For instance, if you are doing a right anterior oblique (RAO), place the patient's right hand on the right hip. Place the opposite hand on the head or resting on the upper surface of the vertical cassette holder. Rotate this side away from the film until the body forms a 45degree angle with the film. Center the patient to the film.

If you are performing obliques specifically to demonstrate the heart, the amount of obliquity for the left anterior oblique (LAO) should be increased to 60° however, the RAO stays at 45°. Since most of the heart lies in the left half of the thoracic cage, the LAO requires more obliquity to free the heart from superimposition of the spine.

Lateral decubitus

The lateral decubitus position of the chest is used in cases of free fluid or free air in the chest cavity. By using a horizontal beam, we are able to demonstrate any air-fluid levels that may be present. In cases where a significant fluid collection is seen on the PA projection, the lateral decubitus produces a change in fluid position and reveals previously obscured lung areas. Whether done as a right or left lateral decubitus, the basic procedure is the same.

The suspected pathology will determine the specific decubitus film required. In cases of free fluid (i.e., pleural effusion), perform the lateral that will place the affected side down so that the fluid will collect in the dependent portion of the thorax and away from the mediastinum. For example, if the patient has a suspected left sided pleural effusion, perform a left lateral decubitus (patient positioned with left side down). For free air (i.e., pneumothorax), position the patient with the affected side up so that the air will rise to the highest point in the thorax and away from the mediastinum. Again in example, if a right side pneumothorax is suspected; perform a left lateral decubitus once again so that any free air rises to the top (right side) of the body.

To position the patient, place him or her in a lateral recumbent position and facing the cassette. The cassette is placed vertically against the chest (fig. 7–3). Adjust the cassette so that its upper border is approximately 2 inches superior to the shoulders. If the side down is of interest, raise the body off the table by placing a radiolucent pad under the thorax. This important step ensures demonstration of the entire costophrenic angle of the affected side. The CR is directed horizontally approximately through the level of the seventh thoracic vertebra to the center of the film. No matter what though, make certain that the elapsed time from when you initially place the patient in the lateral recumbent position to when you take the exposure is at least 5 minutes. This allows the pathology of interest, air or fluid, to rise or settle appropriately inside the chest cavity.

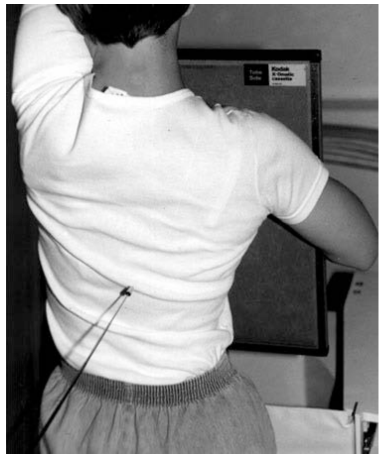


Figure 7–3. Patient positioned for a left lateral decubitus.

Keep certain points in mind when performing a lateral decubitus position. The lateral decubitus position is referred to (named) by the side that is down (i.e., the side of the thorax that is closest to the table). For example, a *right lateral decubitus* position (fig. 7–4) requires the patient to lie on the right side. The film should be clearly marked as a decubitus with arrows or some other method established by your department. Properly marking the film aids the radiologist in establishing orientation and enables proper viewing of the radiograph.

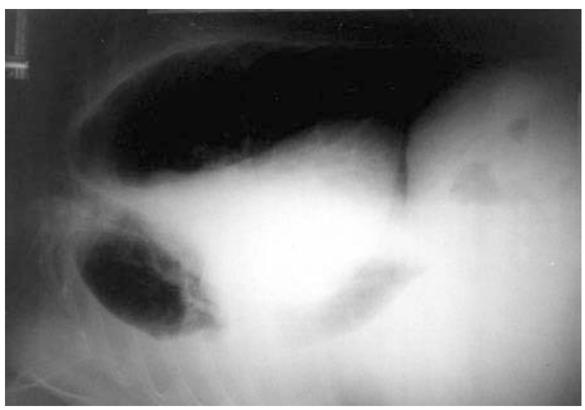


Figure 7–4. Lateral decubitus chest radiograph.

Anteror posterior lordotic chest projection

This position demonstrates a specific portion of the lungs—the apices—and is commonly called the *apical lordotic position*.

Begin by having your patient stand with the back against a vertical cassette holder. Have the patient step forward about 12 inches, flex the knees, and lean back against the vertical bucky, arching the lumbar spine into acute lordosis until the coronal plane forms approximately a 45 degree angle with the plane of the film (fig. 7–5). With the neck, shoulders, and scapulae against the film, have the patient place their hands on the waist and roll their shoulders and elbows forward. This pulls the scapulae laterally, removing them from superimposition of the apices. Direct the CR perpendicular to the center of the film. With the body positioned in this manner, the clavicles are projected above lung fields, thereby providing an unobstructed view of the apices (fig. 7–6).

Figure 7–5. Patient positioned for an AP lordotic projection of the lungs.

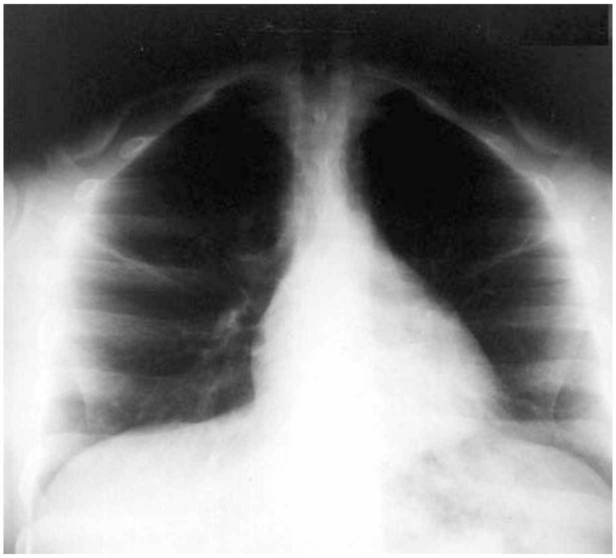


Figure 7–6. AP lordotic chest radiograph.

448. Radiographic projections of the abdomen

Abdomen radiographs are requested for a variety of reasons, such as to demonstrate free air or fluid in the peritoneal cavity, gaseous distension of any part of the alimentary canal, or evidence of intra-abdominal masses or foreign bodies. It is not difficult to produce a good quality abdomen radiograph if you follow a few simple procedures.

Image receptor

Abdominal radiography of the adult requires 14×17 inch cassette positioned lengthwise. Occasionally, on morbidly obese patients you may need to use two 14×17 inch cassettes crosswise to demonstrate the entire abdomen. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

Radiography of the abdomen requires precise technique selection. The need for delineation of the soft tissue structures of the abdomen coupled with the often widely varying thickness of the abdomen makes kVp selection critical. Most sources agree that a range of 70 to 80 kVp (depending on patient size) will produce the desired contrast range for abdominal radiography.

Anterior posterior supine abdomen

Often referred to as a "flatplate" or KUB (kidneys, ureters, and bladder), the AP supine abdomen is the most frequently performed abdominal radiograph.

Begin by placing the patient in the supine position on the radiographic table. Center the patient to the midline of the table and adjust the shoulders and pelvis to ensure there is no rotation. It is acceptable to place a small pad under the patient's knees for added comfort, if necessary. Center the film to the level of the iliac crests but make sure the symphysis pubis is included. Direct the CR perpendicular to the film and make the exposure on suspended expiration.

Foreign bodies in the abdomen

Another common abdominal exam is performed on patients who swallow a foreign object. Typically when this happens, you will be imaging a toddler therefore depending upon the size of the patient, cassette size will vary. Radiographs are performed to locate the object and make sure it is not obstructing or perforating. Usually, a flat plate of the abdomen is all that is necessary; however, some physicians want the entire alimentary tract demonstrated on the initial film. "Entire alimentary tract" means from the mouth to the anus. If it is necessary (because of patient size) to use two films, the films must overlap so you do not miss any structures. Follow-up films need only include from the last known location of the object to the anus.

Acute abdomen series

An acute abdomen series usually consists of three radiographs—an erect PA chest, an erect abdomen, and a supine abdomen —preferably taken in the order listed. It is sometimes called an obstruction series because of its frequent use on patients with intestinal obstruction. Since we have already discussed procedures for performing the PA chest and the supine abdomen, we will only discuss the erect, or upright, abdomen radiograph here.

Upright films are taken for many reasons. One reason is to demonstrate abnormal air or fluid levels in the abdominal cavity or within a structure such as the small intestine. In order to demonstrate this, the air or fluid needs time to settle therefore, the patient should remain in an upright position for 5 to 10 minutes prior to taking the radiographs. Remember, if the patient is ambulatory or in a wheel chair, he or she is already in an upright position. By doing the erect films first, you will shorten the time necessary for the examination, thereby rendering better care to the patient.

To perform the upright abdomen, begin by having the patient stand with his or her back against the vertical cassette holder. Adjust the cassette so that it is centered 2 to 3 inches above the level of the iliac crests so the diaphragm will be included on the film. Direct the horizontal CR perpendicular to the film and make the exposure on suspended expiration.

If the patient is too ill to maintain an upright position, a left lateral decubitus abdomen radiograph is recommended. With the left side down, free air will rise over the lateral surface of the liver. This tends to avoid confusing shadows caused by air in the stomach.

Anatomy demonstrated

A properly exposed and positioned abdominal radiograph (fig. 7–7) will demonstrate five structures—the outline of the psoas major muscles, lower margin of the liver, kidneys, transverse processes of the L-spine, and the symphysis pubis on the lower margin of the film. Note that even though it is sometimes called a KUB, the ureters will not be visualized on an abdominal radiograph unless appropriate radiographic contrast medium has been administered.

Figure 7–7. AP supine abdomen radiograph.

Additional radiographic projections of the abdomen

There are several additional projections of the abdomen that, while not frequently performed, may be requested under specific circumstances. We will discuss two of the most common—the lateral and left lateral decubitus.

Lateral

In small clinics or areas where computed tomography (CT) is not readily available, the lateral abdomen can be performed to visualize the abdominal aorta, which is obscured by the spine on the AP projections. Abdominal aortic aneurism (AAA) is a serious medical condition in which the walls of the aorta become weakened and "balloon" outward. If the vessel walls become weak enough, the aneurism can rupture and the patient will bleed to death in a matter of seconds.

Atherosclerotic disease (i.e., hardening of the arteries) frequently accompanies aortic aneurism and may be seen radiographically because of the calcification of the vessel wall. For this reason, a lateral abdomen is sometimes requested on patients exhibiting symptoms of AAA. Although either lateral may be performed, the left is the accepted norm.

Left lateral decubitus

The left lateral decubitus abdomen is performed on patients who cannot stand for the upright abdomen position. The left lateral decubitus is preferred over the right for two reasons—it places the liver on the side up, which provides an adequate background density for visualizing small pockets of free air in the abdomen; and it places the stomach away from the area where free air will accumulate. The stomach frequently contains air that could be mistaken for free air in the abdomen if the right lateral decubitus were taken.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

446. Routine radiographic projections of the chest

1. List four reasons why chest X-rays should be performed upright.

2. Why is it important to use a 72-inch SID for chest X-rays?

3. Why must you use high kVp for chest X-rays?

4. Where is the film placed for the PA chest?

5. What can you do to ensure good inspiration when performing a chest X-ray on obese patients?

6. When evaluating a PA chest for adequate inspiration, in which part of the chest should the ribs be counted? Why?

7. How many posterior ribs should be seen above the diaphragm as evidence of adequate inspiration?

8. In what instance would you take two PA chest radiographs with one exposure made on inspiration and the other on expiration?

9. What should you look for when checking a PA chest for rotation?

10. Why do we routinely perform the left lateral for chest radiography?

11. In what instance would you perform a right lateral chest X-ray?

12. What is the likely result on a lateral chest X-ray if the arms are not raised high enough?

447. Additional radiographic projections of the chest

1. What are the standard oblique views of the chest?

2. If the heart is of interest, what obliques of the chest should be performed?

3. Why are decubitus films of the chest performed?

4. When performing a right lateral decubitus chest X-ray to evaluate for pleural effusion, which costophrenic angle must be included on the film?

5. Which decubitus film should be performed to evaluate for a left sided pneumothorax?

6. How is the coronal plane positioned for the apical lordotic view of the chest?

448. Radiographic projections of the abdomen

1. What kVp range should be used for abdominal radiography?

2. Where is the film placed for an AP supine abdomen?

3. What is meant by the phrase “entire alimentary tract”?

4. What films are included as part of a standard acute abdomen series?

5. How long should the patient remain in an upright position before performing an upright abdomen radiograph? Why?

6. If the patient cannot stand for the upright abdomen radiograph, what alternate view may be taken?

7. List five structures that should be visualized on a properly exposed and positioned KUB?

8. Which additional view of the abdomen is sometimes performed to rule out abdominal aortic aneurism?

9. Why is the left lateral decubitus abdomen preferred over the right?

7–2. The Bony Thorax

The bony thorax consists of the sternum and ribs. These bones protect the thoracic viscera, primarily the heart and lungs. Occasionally, pathogenic changes or trauma will require radiographic examination of these bones. Trauma to these structures can be particularly dangerous because of the possibility of pneumothorax (i.e., collapsed lung) which is why you must be able to produce high quality films quickly. In this section, we will discuss projections for ribs, the sternum, and related joint structures.

449. Radiographic projections of the ribs

Fractures are the chief reason for radiographing the ribs. In some cases, fracture fragments may protrude into the pleura and lungs, causing severe complications. Also, the ribs may be the site of tumors, osteomyelitis, tuberculosis, and other conditions. Regardless of the reason for the X-ray request, certain considerations should be kept in mind.

Technical considerations

In cases of trauma to the ribs, most departments include a standard PA chest radiograph as part of the routine rib series. This film is performed to help rule out pneumothorax, the most dangerous potential complication of rib injury. Once the PA chest has been obtained; the remaining projections in the series are largely dependent on the location of the injury or pathologic condition.

Ribs in relation to the diaphragm

The diaphragm plays an important part in rib positioning. The lower ribs partly surround the diaphragm and upper abdominal contents, while the upper ribs surround the heart and lungs. Because of the markedly different densities of these two areas, ribs are classified into two groups for purposes of positioning—those that are projected above the diaphragm (pairs 1–8), and those that are projected below the diaphragm (pairs 9–12).

Three factors affect the position of the diaphragm—body habitus, patient position, and phase of respiration. The diaphragm sits relatively low in thin patients, and higher in hypersthenic or obese patients. Also, if the patient is standing, the diaphragm is lower than if the patient is supine. Finally, deep inspiration forces the diaphragm to its lowest point.

Therefore, ribs above the diaphragm are examined with the patient upright, whenever possible, and the exposure is made on suspended inspiration. These two procedures will place the diaphragm as low as possible, allowing a more uniform background density for the upper ribs.

Ribs below the diaphragm are examined with the patient recumbent on the X-ray table, whenever possible, and the exposure is made on suspended expiration. These steps release pressure on the diaphragm, allowing it to rise to a higher level. This makes it possible for the lower ribs to be radiographed against a uniform background of abdominal contents.

Radiographic technique

Because of the difference in background densities between upper and lower ribs, radiographic technique selection is somewhat determined by the area of interest. Ribs are relatively thin and flat, therefore low kVp (60 to 80 depending on patient size) should be used to prevent over penetration of the ribs. A technique of low kVp-high milliamperage seconds (mAs) produces the desirable short-scale contrast that is necessary for optimum visualization of ribs. Since tissue density is increased below the diaphragm, an increase in kVp (as compared to ribs above the diaphragm) is sometimes necessary for adequate penetration.

Positioning

As you already know, the diaphragm plays an important part in rib positioning because of its effect on background density, radiographic technique, and breathing instructions. Furthermore, the location of the affected rib, with respect to the diaphragm, determines the combination of radiographs that should be made.

Most departments vary the routine positions based on whether the area of interest is anterior or posterior, and above or below the diaphragm. For example, if anterior ribs above the diaphragm are injured, you should do a PA rib projection and an anterior oblique (PA oblique) of the affected side with the patient erect and the exposure made on suspended inspiration. If the posterior ribs above the diaphragm are injured or affected by pathology, take an AP rib projection and a posterior oblique (AP oblique) of the affected side with the patient erect and the exposure made on suspended inspiration.

When ribs below the diaphragm are the area of interest, always take an AP rib and a posterior oblique of the affected side. Remember, for ribs below the diaphragm, the patient should be recumbent and the exposure taken on suspended expiration.

The AP and PA rib films offer no difficulty for the technologist. On the other hand, deciding which oblique to perform can be fairly confusing at times. The thing to remember is to attempt to get the affected ribs nearest to the film without superimposition of the vertebral column. Use this rule of thumb: *anterior obliques for anterior injuries, posterior obliques for posterior injuries*.

To help prevent superimposition of the vertebral column over the affected ribs, always try to imagine how you are positioning the vertebral column when you rotate the patient into an oblique. For anterior ribs above the diaphragm, the affected side should be away from the film. For example, an LAO projects the vertebral column over the left ribs, allowing the right side (the side away from the film) to be free from vertebral superimposition.

Posterior obliques should always be positioned with the affected side closest to the film. For instance, a left posterior oblique (LPO) projects the vertebral column on the right side of the chest, this allows the left side, to be viewed free from superimposition. You may notice that not only does the oblique demonstrate the affected ribs free from vertebral superimposition, but it also attempts to place the affected area parallel with the film.

45degree oblique projections, whether anterior or posterior, are the best way to demonstrate the axillary portions of the ribs. Lateral projections superimpose the axillary portions of the unaffected ribs over the affected ones, and AP or PA projections cause self-superimposition of the ribs. Therefore, you should oblique the patient 45 degrees to place the axillary portions of the ribs parallel with the film.

Posterior obliques

Assuming that the patient is upright, positioning for posterior obliques begins with the patient placing their back against the vertical bucky. For ribs above the diaphragm, place the upper border of the film 1 ½ inches above the shoulders; for ribs below the diaphragm, place the lower border of the film at the level of the iliac crest. Have the patient raise both arms, placing the hands on the back of the head. Oblique the patient, keeping the affected side in contact with the film and raising the unaffected side until the coronal plane forms a 45 degree angle with the film (fig. 7–8). Center the affected side to the cassette and direct the CR perpendicular to the film using a 72-inch SID, if possible.

Figure 7–8. Patient positioned for a posterior oblique of the right ribs (below the diaphragm).

Anterior obliques

Again, assuming that the patient is upright, positioning for the anterior obliques begin by having the patient face the vertical bucky. Adjust the position of the cassette as described in the previous paragraph. Place the hand on the unaffected side on the hip, and place the hand of the affected side on the back of the patient's head. Oblique the patient, keeping the unaffected side in contact with the film and raising the affected side until the coronal plane forms a 45 degree angle with the film (fig. 7–9). Center the affected side to the cassette. Direct the CR perpendicular to the film using a 72- inch SID, if possible.

Figure 7–9. Patient positioned for an anterior oblique of the right ribs (above the diaphragm).

450. Radiographic projections of the sternum

The location of the sternum makes it one of the more difficult bones to demonstrate radiographically. Because of its location directly anterior to the thoracic spine, a direct AP or PA projection without bony superimposition is not feasible. The RAO and lateral positions are accepted as the standard images used to demonstrate the sternum.

Image receptor

Expose one projection per 10x12 inch cassette for each view of the sternum. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

Both views of the sternum may be done either erect or recumbent. Consider your patients condition when deciding how best to accomplish the series. If there is trauma to the sternum, but the patient comes to the department walking or seated in a wheelchair, consider performing both projections upright. Serious injury to the sternum may make it extremely uncomfortable for the patient to assume the recumbent position.

If the patient comes to the department on a stretcher, you may need to perform the series with the patient as is (i.e., supine). In this instance, you will need to perform an LPO and a cross-table lateral.

Right anterior oblique

The RAO is the oblique of choice because it places the sternum relatively close to the film and enables the sternum to be overshadowed by the heart which provides a uniform background density making it easier to visualize. The LAO projects the sternum to the right side of the thorax and vertebrae, causing an increase in superimposed pulmonary markings. These markings cast confusing shadows, especially with elderly patients and heavy smokers that can be misinterpreted as fractures or pathology affecting the sternum.

Positioning the RAO sternum is not difficult as long as you ensure the entire sternum is projected on the film and patient rotation is within proper limits. The average patient requires an obliquity of 15 to 20 degrees. Too little body rotation projects thoracic vertebrae over the sternum, and too much will project it away from the uniform background density of the heart. The proper amount of rotation is dependent on the depth of the patient’s chest from anterior to posterior. The deeper the chest, the less body rotation is necessary to clear the sternum from the vertebrae.

Pulmonary markings overlying the sternum can be a problem even in the RAO position. Therefore, some technologists prefer to use a breathing technique for this projection. By using a low mA station and a long exposure time, you can instruct the patient to take slow, shallow breaths to blur the pulmonary markings. If this method is undesirable or can’t be done because of the patient’s condition, make the exposure on suspended expiration to obtain a more uniform density. The resultant radiograph shows a slightly oblique view of the sternum in the shadow of the heart.

Lateral

Position the patient in the erect left lateral position with the left shoulder in contact with the cassette holder. Have the patient clasp hands behind the back and roll the shoulders posteriorly. Adjust the cassette so that its upper border is 1½ inches above the jugular notch and center the sternum to the cassette (fig. 7–10). Direct the CR perpendicular to the film using a 72-inch SID to reduce magnification caused by OID. The exposure should be made on suspended inspiration.

Figure 7–10. Patient positioned for a lateral sternum.

Sternoclavicular articulations

Most technologists do not have the chance to perform views of the sternoclavicular (SC) joints very often; therefore, you may not be aware of the standard projections used to demonstrate SC joints. SC joints may be demonstrated bilaterally with a PA projection; however, this method does not always produce a clear view of the joints due to the overlying spine. Therefore, bilateral anterior (PA) obliques are usually performed.

When performing anterior obliques of the SC joints, oblique the patient 10 to 15 degrees centering on the SC joints. The SC joint nearest the film will be clearly seen free from superimposition of the spine. Direct the CR perpendicular to the film and make the exposure on suspended respiration.

Another less common method maintains the patient in a prone position but angles the CR. The CR is angled medially 15 degrees from the side being examined. That is, the left sternoclavicular articulation is being demonstrated when the tube is located above the patient’s left shoulder, and vice versa. With this method though, you cannot use a grid because the direction of the tube angle would produce grid cut-off.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

449. Radiographic projections of the ribs

1. What is the most dangerous potential complication of rib injury?

2. Into what two groups are ribs classified for purposes of radiography?

3. What three factors affect the position of the diaphragm?

4. What patient position and phase of respiration should be used when radiographing ribs above the diaphragm? Why?

5. What is the rule of thumb when deciding which obliques to perform for rib injuries?

6. When performing anterior obliques for ribs, where is the affected side placed?

7. Where is the affected side placed for posterior obliques?

8. What is the best way to demonstrate the axillary portions of the ribs?

450. Radiographic projections of the sternum

1. What are the standard projections for the sternum?

2. Why is the RAO position preferred over the LAO for the sternum?

3. What determines the degree of obliquity for the RAO sternum?

4. What can be done to blur pulmonary markings on the RAO sternum?

5. Where is the film placed for the lateral sternum?

6. What SID should be used for the lateral sternum? Why?

7. What views are usually performed to demonstrate the SC joints?

8. How many degrees should the patient be obliqued for views of the SC joints?

Answers to Self-Test Questions

446

1. It helps the patient attain full inspiration, it will demonstrate any fluid levels in the lungs, it prevents widening of the mediastinal structures, and it permits the use of a 72-inch SID.
2. It reduces magnification of the mediastinal structures.
3. To achieve a longer scale of contrast while showing adequate detail, contrast, and density for both the air-filled lungs and the much denser mediastinal structures.
4. Upper border is approximately 2 inches above the shoulders.
5. Have the patient take two deep breaths and make the exposure at the end of the second inspiration.
6. In the right hemithorax; to avoid the heart shadow.
7. Ten posterior.
8. When evaluating for pneumothorax.
9. Check the sternoclavicular joints. They should appear the same and equally distant from the midline.
10. Because it places the heart closer to the film, thereby reducing magnification.
11. When evaluating pathology in the right hemithorax.
12. Underexposure of the upper lung fields.

447

1. 45 degrees RAO and 45 degrees LAO.
2. 45 degrees RAO and 60 degrees LAO.
3. To evaluate for free fluid or air in the chest cavity.
4. The right.
5. The right lateral decubitus.
6. At a 45 degree angle to the film.

448

1. 70 to 80 kVp.
2. Centered to the level of the iliac crest.
3. From the mouth to the anus.
4. PA chest, erect abdomen, and a supine abdomen.
5. 5 to 10 minutes; to allow any air or fluid levels to settle.
6. Left lateral decubitus abdomen.

7. Psoas major muscles, lower margin of the liver, kidneys, transverse processes of the L-spine, and the symphysis pubis.
8. The lateral abdomen.
9. Because it places the liver on the side up, which provides the liver as a uniform background density for detecting free air and it places the stomach away from the area where free air will accumulate.

449

1. Pneumothorax.
2. Ribs projected above the diaphragm, and ribs projected below the diaphragm.
3. Body habitus, patient position, and phase of respiration.
4. Patient erect and on suspended inspiration; this brings the diaphragm to its lowest point.
5. Anterior obliques for anterior injuries, posterior obliques for posterior injuries.
6. Away from the film.
7. Closest to the film.
8. 45 degrees anterior or posterior oblique projections.

450

1. RAO and lateral.
2. It places the sternum relatively close to the film and enables the sternum to be overshadowed by the heart which provides a uniform background density making it easier to visualize.
3. The depth of the patient’s chest.
4. Use a breathing technique.
5. Top border 1½ inches above the jugular notch.
6. 72 inches; to reduce magnification caused by OID.
7. Bilateral anterior obliques.
8. 10 to 15 degrees.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

74. (446) On a good inspiration posterior anterior (PA) chest radiograph, how many ribs should be demonstrated above the diaphragm in the right hemithorax?
    a. Nine anterior.
    b. Nine posterior.
    c. Ten anterior.
    d. Ten posterior.

75. (446) When evaluating for rotation on a posterior anterior (PA) chest radiograph, which structures should be checked?
    a. Apices.
    b. Costophrenic angles.
    c. Sternoclavicular joints.
    d. Acromioclavicular joints.

76. (447) When performing oblique views of the chest, how is the patient positioned if the heart is of particular interest?
    a. 45° right anterior oblique (RAO), 45° left anterior oblique (LAO).
    b. 45° RAO, 60° LAO.
    c. 60° RAO, 60° LAO.
    d. 60° RAO, 45° LAO.

77. (447) When performing a lateral decubitus radiograph of the chest, why would you place a radiolucent pad under the patient?
    a. For patient comfort.
    b. To keep the thoracic spine parallel with the table.
    c. To ensure visualization of the costophrenic angle of the side up.
    d. To ensure visualization of the costophrenic angle of the side down.

78. (448) Which structure *will not be seen* on a properly exposed abdominal radiograph?
    a. Ureters.
    b. Kidneys.
    c. Psoas major muscles.
    d. Lower margin of the liver.

79. (448) When performing an abdomen series on a patient that is unable to stand, what view may be used in place of the upright abdomen?
    a. A flat plate abdomen.
    b. Left lateral decubitus.
    c. Right lateral decubitus.
    d. 20° Trendelenburg kidneys, ureters, and bladder (KUB).

80. (449) Which conditions will place the diaphragm at its lowest point?
    a. Patient erect, full expiration.
    b. Patient erect, full inspiration.
    c. Patient supine, full expiration.
    d. Patient supine, full inspiration.

81. (449) Radiographs of ribs below the diaphragm should be made with the patient
    a. erect and on suspended expiration.
    b. erect and on suspended inspiration.
    c. recumbent and on suspended expiration.
    d. recumbent and on suspended inspiration.

82. (449) Which position would be *most* effective for demonstrating a right-sided injury to the anterior ribs above the diaphragm?
    a. Right anterior oblique (RAO).
    b. left posterior oblique (LAO).
    c. right anterior oblique (RPO).
    d. left posterior oblique (LPO).

83. (450) Where is the film placed for the lateral projection of the sternum?
    a. Centered to manubrium.
    b. Centered to manubriosternal joint.
    c. Upper border 1 ½ inches above the jugular notch.
    d. Upper border 1 ½ inches above the clavicular notch.

Please read the unit menu for unit 8 and continue ➔

Unit 8. Positioning of the Vertebral Column

WE CONTINUE OUR POSITIONING DISCUSSION in this unit by talking about the various projections of the spinal (vertebral) column. In this unit, we will cover many of the routine and additional projections for the cervical, thoracic, and lumbar vertebral column regions as well as projections for the sacrum and coccyx.

NOTE: As in the previous units, any reference to film, a cassette, and/or image receptor is meant to be synonymous with each other. Always expose each image with the appropriate right or left lead anatomical marker. Using stickers, sharpie permanent markers, or computer aided text is neither authorized nor legal in a court of law to mark human radiographic images.

8–1. The Cervical Spine

The cervical spine, commonly referred to as the C-spine, is a frequent subject of radiographic examination. Common reasons for C-spine radiography include: head and neck trauma, whiplash, osteoarthritic changes, and symptoms of cervical nerve impingement (i.e., pain or numbness radiating to the shoulders and arms). Many aspects of positioning of the cervical spine are quite challenging to the new technologist. Diligent attention to the techniques described in this section combined with supervised practice will aide you greatly in mastering cervical spine radiography.

451. Routine radiographic projections of the cervical spine

The “routine” cervical spine series differs from department to department. However, most departments use either the standard three view (AP, lateral, and open mouth) or five view series (to include obliques) as their routine. In this lessson, we discuss all five common C-spine projections from a non-trauma perspective. Radiography of the trauma C-spine requires a separate, detailed discussion because of the potential seriousness of C-spine injuries, and will be covered in the next lesson.

Image receptor

When radiographing the C-spine, most images can be performed on 8×10 inch cassette; however; one common exception is the lateral projection in which 10×12-inch cassette is utilized. Reference your department’s SOPs or imaging protocols for further guidance.

Positioning

All routine projections of the C-spine may be performed either upright or recumbent. As long as the patient's condition permits, it is largely a matter of technologist preference. Since the basic procedures are the same for each method, we will discuss only the upright.

Anterior posterior

When performing the AP projection, begin by positioning the patient with his or her back to the vertical cassette holder and with the median plane centered to the film. Raise the patient's chin slightly so the mandible does not superimpose the middle vertebrae. Angle the CR 15-20 degrees cephalad and center just inferior to the most prominent point of the thyroid cartlidge. The thyroid cartilage lies at approximately the level of the fifth cervical vertebra, but with the cephalic angulation, centering on this landmark will cause the CR to pass directly through C4. Figure 8–1 is an example of an AP C-spine radiograph.

Lateral

To accomplish the lateral, stand the patient in front of the vertical cassette holder and place the patient's left shoulder in contact with the film. Instruct the patient to stand straight, distributing his or her body weight evenly on both feet and adjust the patient until the coronal plane is perpendicular to the film. Raise the mandible until its rami no longer superimpose the spine. Direct the CR perpendicular to the film and center to the level of the fourth cervical vertebra. A 72-inch SID is needed to overcome the natural OID produced by the left shoulder. Instruct the patient to depress the shoulders as much as possible. Patients with broad shoulders may need to hold sandbags of equal weight in each hand to help depress the shoulders. Figure 8–2 is an example of a lateral C-spine radiograph.

Figure 8–1. AP cervical spine radiograph.

Figure 8–2. Lateral cervical spine radiograph.

AP open mouth

The AP open mouth projection demonstrates a posterior view of the atlas (C1) and axis (C2). Commonly called the odontoid projection, it requires precise positioning of the head in order to visualize the atlas and axis free from superimposition of surrounding bony structures.

When performing this projection, ask the patient to remove any dentures or other removable dental work. Begin by placing the patient's back to the vertical cassette holder. With the patient's mouth open as wide as possible, adjust the head so that a line through the inferior portion of the upper incisor and the mastoid tip is perpendicular to the film. Direct the CR perpendicular to the film, through the open mouth. Be sure to have the technique and tube-film placement ready so that you can make the exposure quickly.

The major difficulty in positioning this projection comes from aligning the incisor and mastoid tip. Failure to align these points exactly results in superimposition of the base of the skull or the teeth—depending upon the direction in which the line is tilted—over the structures of interest.

You can easily check positioning on the radiograph by observing the location of the teeth and the base of the skull. If the base of the skull is lower than the teeth and superimposing the odontoid, the head is tilted too far back. Likewise, if the teeth appear lower than the base of the skull and are superimposing the odontoid process, the head is tilted too far forward. In these instances, a subsequent radiograph with the head tilt adjustedfurther back should correct the problem. However, sometimes even when the head is positioned correctly, there is still some superimposition over the vertebrae. When this happens, you may need to try one of the additional projections for the odontoid process listed in the next objective. Figure 8–3 is an example of an AP open mouth radiograph.

Figure 8–3. AP open mouth radiograph.

Obliques

Oblique views of the C-spine are done primarily to demonstrate the intervertebral foramina. The foramina open 45 degrees anterolaterally from both sides of the posterior aspect of the C-spine and approximately 15-20 degrees downward from horizontal. Obliques may be performed either AP or PA and are always performed bilaterally. While obliques can be performed recumbent, you will probably find it easier to perform them upright.

For posterior (AP) obliques, the patient is positioned at a 45 degree angle to the vertical bucky. Both the RPO and LPO positions are performed. Be careful to turn the patient's entire body—not just his or her head—keeping the head and neck straight with the body. Direct the CR 15-20 degrees cephalic and at the level of C4 (fig. 8–4). Posterior obliques demonstrate the intervertebral foramina farthest from the film.

For anterior (PA) obliques, again position the patient at a 45 degree angle to the vertical bucky; both RAO and LAO positions are performed. Direct the CR 15-20 degrees caudal, again centering at the level of C4 (fig. 8–5). Anterior obliques demonstrate the intervertebral foramina closest to the film.

Figure 8–4. Patient positioned for an AP oblique cervical spine.

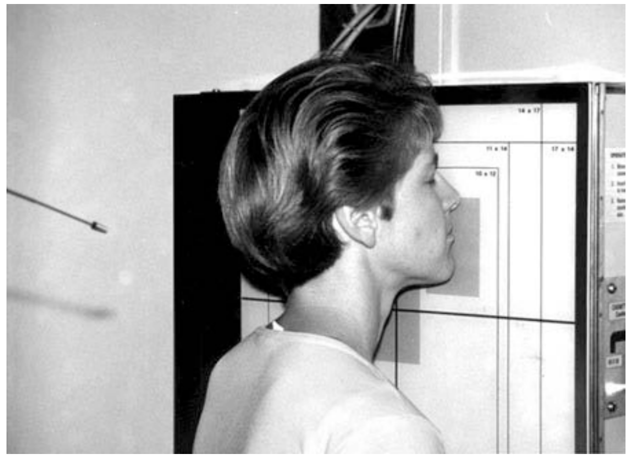


Figure 8–5. Patient positioned for a PA oblique cervical spine.

For either method, a slightly longer SID—between 60 and 72 inches—is recommended to overcome the OID inherent in both positions. Figure 8–6 is an example of an oblique cervical spine radiograph.

Figure 8–6. Oblique cervical spine radiograph.

Anatomy demonstrated

The anatomy demonstrated by AP, lateral, AP open mouth, and obliques radiographs are discussed in the following table:

Anatomy Demonstrated by Radiographs	
Projection	**Demonstrates**
AP	A posterior view of the lower five cervical vertebrae. C1 and C2 are obscured by the mandible and base of the skull.

Anatomy Demonstrated by Radiographs	
Projection	**Demonstrates**
Lateral	An excellent view of all seven cervical vertebrae. Is extremely helpful in checking alignment of the posterior aspects of the vertebral bodies to rule out fracture, subluxation, or dislocation. Best demonstrates the zygapophyseal joints of the C-spine.
AP open mouth	A posterior view of C1 and C2 free from superimposition of surrounding bony structures. On some patients, this view will be insufficient to demonstrate the odontoid process, and you will need to perform one of the additional views listed in the next objective.
Obliques	Demonstration of the intervertebral foramina open; posterior obliques display those farthest from the film and anterior obliques display those closest to the film.

452. Additional radiographic projections of the cervical spine

The most common additional radiographic projections of the cervical spine include: the cross-table lateral, flexion and extension views, and Judd and Fuchs projections of the odontoid.

Radiographing the trauma C-spine

Patients who experience serious trauma to the head and/or neck from motor vehicle accidents, falls, etc., are usually placed on a backboard with a C-spine collar until it can be determined radiographically if they have fractured or dislocated the C-spine. These types of injuries to the C-spine, as you know, can result in paralysis or even death if not immediately treated. For this reason, we are usually called on as soon as the patient is stable to perform C-spine radiographs.

When radiographing the trauma C-spine, always begin with a cross-table lateral to determine alignment of the vertebral bodies. C-spine collars and foam immobilization blocks are designed to be radiolucent for obvious reasons. *Never loosen or remove a C-spine immobilization device.* The patient's physician (or emergency room physician) is the only one authorized to make the decision as to when to remove or loosen the neck brace. Check for necklaces hiding under the C-spine collar to avoid having to repeat the film.

The principles behind the cross-table lateral are the same as for the routine lateral C-spine in terms of film placement and CR alignment. Pull the patient's arms down to prevent the shoulders from obscuring the lower cervical vertebrae. Make sure to explain this technique to the patient so he or she doesn't resist the individual that is pulling on the arms. Here are some steps to follow in order to successfully expose this image:

1. Position the patient; get the cassette in-place; and set the control panel with your exposure technique.
2. Have the person assisting grab on to the patient's hands/distal forearms (but don't pull yet).
3. Tell the patient to "take in a deep breath".
4. Tell the patient to "blow it out and relax their shoulders." When the patient relaxes the shoulders, the person assisting pulls the shoulders inferiorly. Make sure the person pulling also realizes not to pull so hard that they cause pain to the pain or moves the patient out of proper radiographic position for the cross-table image
5. Make the exposure and then allow the arms to relax.

Show the initial image to the radiologist or emergency room physician and then proceed with the remainder of the series only after being instructed to do so.

Lateral hyperflexion and hyperextension views

Lateral hyperflexion and hyperextension views of the cervical spine are performed to evaluate anterior and posterior mobility of the spine. The positions are very similar to the standard lateral C-spine projection. The differences are as follows:

1. For the hyperflexion view, tilt the patient’s head all the way forward so the chin rests on the chest.
2. For the hyperextension view, tilt the patient’s head all the way back.

Keep in mind, flexion views *should not be performed* unless fracture or dislocation has been ruled out.

Additional projections of the odontoid process

As mentioned previously, in some instances, due to patient anatomy, the AP open mouth projection does not adequately demonstrate the odontoid process of C2. When this happens, you may find it necessary to attempt one of the additional views of the odontoid process—the Judd or Fuchs methods. Whether in a trauma or routine scenario, typically a technologist is allowed to attempt the open mouth twice before moving on to either of these two additional methods. After two open-mouth attempts and no more than two attempts at one of the Judd or Fuchs methods, CT is definitely the next method of choice to clearly visualize the odontoid and surrounding anatomical structures.

Judd method

The Judd method is a PA projection of the odontoid in which the patient is positioned very similar to the Water’s view of the sinuses, which are described in the next unit. Position the patient facing the vertical cassette holder. Tilt the head back until the orbitomeatal line forms a 37 degree angle with the film. This will place the nose approximately 1 inch from the surface of the cassette holder. Adjust the head until the median plane is perpendicular to the film. Direct the CR perpendicular to the film and center on the external occipital protuberance (fig. 8–7).

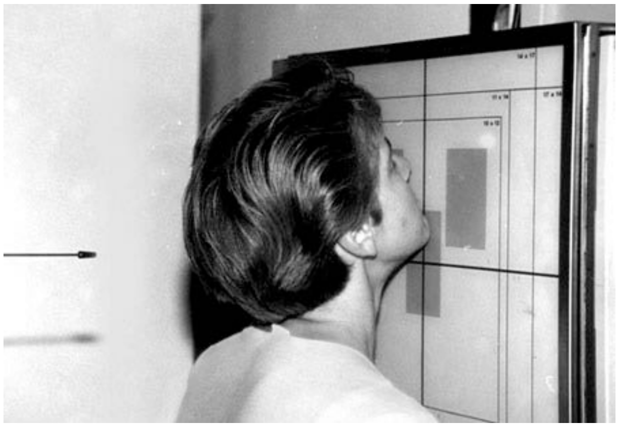


Figure 8–7. Patient positioned for the Judd method of odontoid radiography.

Fuchs method

The Fuchs method is basically a reverse Judd. The patient is supine and centered to the bucky. Palipate and center the cassette to the level of the tips of the mastoid processes. Extend the patients chin upward until the tip of the chin and the mastoid processes are in a line perpendicular to the film. Ensure the head is straight and not rotated in either direction. Direct the CR perpendicular to the cassette just below the chin. A properly positioned image projects the odontoid within the foramen magnum.

Both methods produce equivalent views of the odontoid process. The specific method performed is largely a matter of technologist preference.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

451. Routine radiographic projections of the cervical spine

1. How is the CR directed for the AP C-spine?

2. At what level does the thyroid cartilage lie?

3. Which plane of the body is perpendicular to the film for the lateral C-spine projection?

4. Why is a 72-inch SID required for the lateral C-spine projection?

5. What two bony landmarks should be used when positioning for the AP open mouth projection?

6. If the teeth appear lower than the base of the skull and are superimposing the odontoid process on an open mouth radiograph, what positioning problem is indicated?

7. How many degrees is the patient rotated for anterior or posterior oblique views of the C-spine?

8. How is the CR directed for AP obliques of the C-spine?

9. What structures are best demonstrated on anterior obliques of the C-spine?

10. Match the C-spine projection in column B with the description in column A. Each projection may be used more than once.

Column A	g. *Column B*
a. ____ 1. Provides best demonstration of the zygapophyseal articulations.	a. AP.
b. ____ 2. Demonstrate the intervertebral foramina farthest from the film.	b. Lateral.
c. ____ 3. Used to check alignment of the posterior aspects of the vertebral bodies.	c. Open mouth.
d. ____ 4. Provides a posterior view of C1 and C2.	d. Anterior obliques.
e. ____ 5. Demonstrate the intervertebral foramina closest to the film.	h. e. Posterior obliques.
f. ____ 6. C1 and C2 are obscured by the mandible and base of the skull.	
____ 7. Requires 15-20 degrees caudal angulation.	

452. Additional radiographic projections of the cervical spine

1. When a cross-table lateral C-spine radiograph is performed, what should be done to help prevent the shoulders from obscuring the lower cervical vertebrae?

2. Why are lateral hyperflexion and hyperextension views of the cervical spine performed?

3. How is the head tilted for the hyperflexion view?

4. What condition(s) should be ruled out prior to performing lateral hyperflexion and hyperextension views of the C-spine?

5. Name two additional views of the odontoid process.

6 How is the orbitomeatal line positioned for the Judd method?

7. 'Where should the odontoid process be projected for the Fuchs method?

8–2. The Thoracic Spine

The thoracic spine, commonly called the T-spine, consists of 12 vertebrae. It is the longest portion of the vertebral column. Common reasons for radiographing the T-spine include trauma, osteoarthritic changes, kyphosis, and other pathologic conditions. In this section, we will discuss the routine projections for the T-spine, as well as common additional projections.

453. Routine radiographic projections of the thoracic spine

Routine radiographic projections of the thoracic spine are AP and lateral.

Image receptor

Radiography of the adult T-spine requires 14×17 inch cassettes positioned lengthwise. Reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

Radiographs of the thoracic spine may be performed either upright or recumbent. The recumbent method is probably the more common of the two; however, in cases of severe arthritis or kyphosis, it may be easier for the patient to stand than to lie on his or her back. Appropriate radiation protection procedures are, as always, important. Close side to side collimation will help reduce breast exposure to the female patient.

Anterior posterior

Position the patient in the supine or upright position, facing the X-ray tube. Center the median plane to the film. Where there is gross deformity of the spine—kyphosis or scoliosis—position the patient as best you can. Imagine where the patient's midline is and center it to the table and film. Flex the knees and hips to reduce the normal kyphotic curvature and place the patient's arms at the sides of the body. Place the upper border of the film approximately 2 inches above the shoulders. This will put the seventh thoracic vertebra at the center of the film. Direct the CR perpendicular to the film and make the exposure on suspended expiration.

When dealing with patients suspected of having fractures of the T-spine, be just as careful and cautious as you would for C-spine trauma. Handle the patient in precisely the same manner with as little movement as possible.

One main point to remember is proper use of the anode-heel effect. With T-spine positioning, always place the cathode end of the tube toward the abdomen. This will allow the strongest portion of the beam to pass through the thickest part of the body overlying the T-spine.

Lateral

Begin by placing the patient in the left lateral position. Ensure you have the entire T-spine parallel to the table. Place a foam sponge or pillow under the patient's head to keep the spine parallel. You may also need to support the narrow portion of the waist with a foam cushion. If the narrow lumbar region is unsupported the lower thoracic spine will sag toward the table and distort the intervertebral spaces. Center the spine to the film and direct the CR perpendicular to the film at the level of T7 which is approximately 3 inches above the xiphoid process or at the level of the inferior angle of the scapulae.

In addition to tube-part-film alignment, breathing instructions are very important with the lateral. A breathing technique may be used to help blur pulmonary markings. If a breathing technique is not employed, the exposure should be made on suspended expiration.

Anatomy demonstrated

The AP projection demonstrates vertical alignment of the thoracic vertebrae. Therefore, any lateral displacement of vertebral bodies (e.g., scoliosis) is well visualized in the AP radiograph. It should be noted that not all lateral curvatures of the spine are abnormal. A slight curvature toward the dominant extremity is considered normal. For instance, a right-handed person tends to use the right arm more often than the left, which causes the muscles on the right side of the spine to be stronger. This can pull the vertebrae toward that side slightly.

The routine lateral T-spine radiograph demonstrates a lateral view of the third through 12th thoracic vertebrae. T1 and T2 are usually superimposed by the shoulders. The lateral is the best projection to demonstrate the intervertebral foramina of the T-spine, and will also demonstrate the amount of kyphotic curvature. In addition, the lateral projection is the only view in which the degree of compression of intervertebral disks may be accurately evaluated. Finally, compression fractures are also best demonstrated with the lateral.

454. Additional radiographic projections of the thoracic spine

In this lesson, we will discuss some common additional radiographic projections of the thoracic spine; specifically, the Twining position and oblique views.

Swimmer's method

The swimmer's method is a combination of the Twining (upright positioning) and Pawlow (lateral recumbent)views. The main difference between the two is that the Twining is performed upright while the Pawlow is performed lateral recumbent. The swimmer's method gives a lateral view of the cervicothoracic region; that is, the lower cervical and upper thoracic vertebrae. It is used as an additional film anytime C6, C7, T1, and T2 are not well visualized on a routine lateral C or T-spine radiograph.

The swimmer's view can be performed with the patient upright, supine, or in either lateral recumbent position. For the purposes of this text, the patient is placed in the lateral recumbent position with the vertebral column parallel to the film. The arm nearest the film should be raised above the head and the shoulder away from the film should be depressed and rotated slightly backward or forward to move the humeral head away from vertebral bodies. If the shoulder can be depressed sufficiently, direct the CR perpendicular to the film. If the shoulder cannot be depressed enough to clear the vertebrae, angle the CR 3-5 degrees caudad. Figure 8–8 and 8–9 are two examples of how the swimmer's (lateral cervicothoracic) method can be performed.

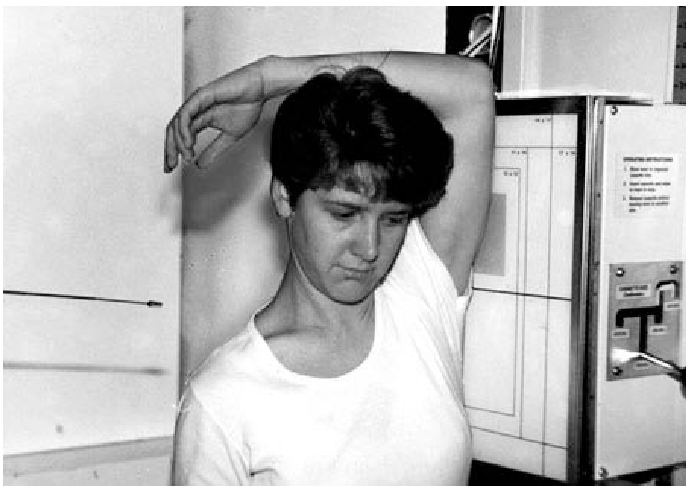


Figure 8–8. Patient positioned for a lateral cervicothoracic radiograph.

Figure 8–9. Lateral cervicothoracic radiograph.

Obliques

Oblique positions of the thoracic spine are primarily taken to demonstrate zygapophyseal articulations. These joint spaces are well visualized if they are seen at an angle of 20 degrees from the vertical with the patient in the lateral recumbent position. In other words, obliques of the T-spine are performed as 70 degrees anterior or posterior obliques.

With the patient in the lateral position, if the side away from the film is rotated 20 degrees forward (i.e., an anterior oblique), then joints nearest the film are demonstrated. If the elevated side is rotated backward 20 degrees (i.e., a posterior oblique), the joints farthest from the film are demonstrated. For example, if the patient is in the 70 degree RAO position, the joints of the right side are visualized; in the RPO position, the left zygapophyseal joints are seen. Be aware to elevate the lumbar and lower thoracic area when necessary to ensure the thoracic spine is parallel with the film.

Whether you use anterior or posterior obliques typically depends upon the preference of the radiologist reading the images. From the technical side of it though, it is important to know that there actually is a little difference in the object-image distance between PA and AP obliques so you should not mix them in the same series (i.e., perform one anterior and one posterior oblique). Comparing the sides is more difficult if the obliques are mixed.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

453. Routine radiographic projections of the thoracic spine

1. What can be done to help reduce the normal kyphotic curvature when performing an AP T-spine?

2. Where is the film placed for the AP T-spine?

3. What phase of respiration should be used when performing an AP T-spine?

4. How can the anode-heel effect be used to your advantage when performing an AP T-spine?

5. What can be done to keep the lower thoracic spine from sagging toward the table on the lateral projection?

6. What is the centering point for the lateral T-spine?

7. Which projection of the T-spine is most useful for demonstrating scoliosis? Kyphosis?

8. Which thoracic vertebrae are demonstrated on the routine lateral T-spine?

454. Additional radiographic projections of the thoracic spine

1. What is the main difference between the Twining method and the Pawlow method?

2. What anatomical region does swimmer’s method demonstrate?

3. Describe the positioning of the patient’s arms for the swimmer’s method.

4. How should you direct the CR if the shoulder cannot be depressed for the swimmer’s method?

5. Oblique T-spine radiographs are performed to demonstrate what structures?

6. What is the degree of obliquity for T-spine obliques?

7. Which joints are demonstrated on anterior oblique T-spine projections?

8. Why should you *not* mix anterior and posterior obliques on the same study?

8–3. The Lumbar Spine

Since this part of the vertebral column supports the majority of the weight of the body, even minor injuries may incapacitate the patient. Serious injuries, such as fractures, are extremely dangerous and may result in paralysis if the spinal cord is damaged. With that said, accurate diagnosis of the cause for “low back pain” includes radiographic examination of the lumbar spine. In this section, we will cover both standard and additional radiographic projections of the lumbar spine.

455. Routine radiographic projections of the lumbar spine

The routine radiographic projections of the lumbar spine are AP, lateral, and L5-S1 spot. We shall consider certain characteristics of each position, starting with the AP.

Image receptor

Cassette size varies for projections of the lumbar spine. Always use collimation. The L5-S1 spot projection may be performed on an 8×10 inch cassette without difficulty. Reference your department’s SOPs or imaging protocols for further guidance.

Positioning

Unless they are ordered as weight-bearing views, projections of the lumbar spine are normally accomplished recumbent. As with all examinations, a closely collimated beam is important in helping reduce patient exposure. Gonadal shielding is important on male patients due to the close proximity of the X-ray beam to the gonads. However, on female patients, shielding is contraindicated because it would obscure desired bony anatomy.

Anterior posterior

Position the patient supine on the radiographic table and center the median plane to the film. It is very important that the hips and shoulders lie in the same plane and that the patient is not rotated to prevent the appearance of an artificially induced curvature or rotation of the spine. Flex the hips and knees to reduce the natural lordotic curvature of the spine and open the intervertebral joint spaces. Move the arms out of the field of exposure. Direct the CR perpendicular to the film centered to the level of the iliac crests if a 14×17 inch film is used, or 1 ½ inches above the level of the iliac crests if an 11×14 inch film is used. Using a 48-inch SID is also recommended for the following reasons: 1) reduces distortion; 2) the intervertebral joint spaces are more completely opened; and 3) improves the overall quality of the AP L-spine exam. Finally, exposure should be made on suspended expiration.

Lateral

Begin by placing the patient in the lateral recumbent position on the radiographic table. Have the patient abduct his or her arms 90 degrees. Place the patient's hips and knees together, bending them slightly to help maintain a true lateral position. You may need to place a small pad between the knees to prevent over-rotation of the pelvis. Place a pillow under the patient's head, and adjust his or her spine into true lateral. Center the spine to the film and direct the CR perpendicular to the film, centering as you did for the AP projection—at the level of the crests for a 14×17 inch film, or 1 ½ inches above the crests for an 11×14 inch film. Make the exposure on suspended expiration to prevent the costophrenic angles from superimposing the upper lumbar vertebrae and causing them to be overpenetrated.

To produce good visualization of intervertebral disk spaces, you must prevent the lumbar spine from "sagging." When the patient is lateral recumbent, the lumbar spine tends to sag, especially in patients with a narrow waist and wide pelvis. Since it is necessary to have the vertebral column at right angles to the CR, you may need to place support cushions under the lower thorax if the hips are exceptionally wide. If the spine is not parallel to the table, the intervertebral disk spaces may appear closed.

L5-S1 spot lateral

This projection is particularly important in patients with wide hips and a narrow waist. These patients produce a wide difference in density between those two areas on the routine lateral due to the difference in thickness and tissue density. Also, because of the lumbar sag that was previously explained, the L5-S1 spot projection may be the only means of viewing that articulation with an open joint space.

The spot lateral is also performed in the lateral recumbent position, like the full lateral, therefore only a small adjustment to the full lateral position is necessary. To center the lumbosacral joint properly, direct the CR to a point 2 inches posterior to the ASIS and 1½ inches inferior to the iliac crest. If the spine is not parallel to the film, a vertical CR may not open the joint space. In this case, angle the CR 5 degrees caudal for males and 8 degrees caudal for females.

Anatomy demonstrated

The AP projection presents a posterior view of the five lumbar vertebrae and the majority of the sacrum and the sacroiliac joints. This projection is useful for demonstrating spinous and transverse processes, as well as open intervertebral joints.

The lateral projection (fig. 8–10) demonstrates a lateral view of the bodies and spinous processes, as well as the first four intervertebral foramina.This is the best view for demonstrating the intervertebral joints and compression fractures of the lumbar spine.

Figure 8–10. Lateral lumbar spine radiograph.

For the L5-S1 spot projection, all of the body, superimposed pedicles and laminae, the spinous process and, above all, the superior and inferior articular surfaces must be seen. The superior articular surface of the sacrum, as well as the anterior and posterior margins of this bone, must be seen. If these portions of the L5 and S1 area are not seen, the projection is useless.

One of the main reasons for the L5-S1 spot projection is to detect spondylolisthesis, which is basically a slipping of the fifth lumbar vertebra forward on the sacrum. While it can be either L4 on L5 or L5 on S1, the latter is more frequently seen. The problem is caused by a failure of the superior and inferior surfaces (i.e., facets) to join, a condition that produces a cleft between them.

Usually these clefts are bilateral and cause the affected vertebra to slip forward. The degree of slippage can only be measured if the entire L5 vertebra and all of the superior aspect of the sacrum are demonstrated on the film.

456. Additional radiographic projections of the lumbar spine

Additional views of the lumbar spine are sometimes requested to help diagnose specific pathology or to better visualize certain anatomy. We will discuss some of the more common additional projections.

Posterior anterior, right and left side bending views

The PA, right and left side bending views are weight-bearing views used to help diagnose intervertebral disc herniations— herniated nucleus pulposus (HNP). The PA projection is used rather than the AP because this position aligns the intervertebral joint spaces with the divergence of the beam. Place the patient's anterior abdominal surface flush against the vertical cassette holder with the median plane centered, ensuring there is no rotation of the body. Instruct the patient to bend as far to the right side as he or she can, without tilting the hips (fig. 8–11). This position is difficult for the patient to maintain, so do it as quickly as possible. The second view is done the same way, except the patient bends to the left side instead of the right.

Figure 8–11. Patient positioned for PA, right side bending view of the lumbar spine.

Lateral, flexion and extension views

Flexion and extension laterals are another method used to help diagnose HNP. Position the patient for an upright lateral, center 1 inch to 1 ½ inches above the iliac crest, and perform two exposures:

1. One with the patient bending as far forward as possible without bending the hips—flexion (fig. 8–12).
2. One with the patient bending as far backward as possible—extension (fig. 8–13).

Again, remember that even for a relatively healthy patient, these positions are difficult. Proceed quickly and carefully but always be in close proximatity to the patient when they are initially bending in either direction.

Figure 8–12. Patient positioned for lateral flexion view of the lumbar spine.

Figure 8–13. Patient positioned for lateral extension view of the lumbar spine.

Obliques

The oblique projections of the lumbar spine are usually taken to demonstrate the zygapophyseal joints. Remember, the zygapophyseal joints are formed by the inferior articular process of one vertebra and the superior articular process of the next lower vertebra. These joints open posteriorly at an angle of 30-60 degrees to the midsagittal plane.

Most times, the oblique images are performed right after completing the AP therefore posterior obliques of the L-spine are most commonly performed. Position the patient by rotating one side up so the body's coronal plane forms a 45 degree angle to the table (and cassette). Both sides are typically imaged. When posterior obliques are performed, the zygapophyseal joints closest to the film are demonstrated. If anterior obliques are performed, the joints farthest from the film will be demonstrated. In other words, to demonstrate the left zygapophyseal joints of the lumbar vertebrae, perform either an LPO or an RAO. To demonstrate the right zygapophyseal joints, perform either an RPO or an LAO. When performing quality control on your images though, it is important to realize that the customary 45 degree oblique typically shows only the zygapophyseal joints for L3 to S1. For L1 to L2 and L2 to L3, the joints are typically visualized on the AP projection. For L4 to L5 and L5 to S1, the zygapophyseal joints are actually sometimes seen on the lateral projection. Figure 8–14 is an example of an oblique view of the lumbar spine.

Figure 8–14. Right posterior oblique lumbar spine radiograph.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

455. Routine radiographic projections of the lumbar spine

1. What is the purpose of flexing the patient's knees and hips for an AP projection of the L-spine?

2. What is the centering point for an AP L-spine if an 11×14 inch film if used?

3. What is the purpose of placing a small pad in between the patient's knees for the lateral projection of the L-spine?

4. What should be centered to the film for the lateral L-spine?

5. Why should the lateral L-spine projection be taken on suspended expiration?

6. What is the centering point for the L5-S1 spot lateral?

7. What is the best view for demonstrating at least the first four intervertebral foramina of the L-spine?

8. What is spondylolisthesis?

456. Additional radiographic projections of the lumbar spine

1. What is the purpose of the PA, right and left side bending views?

2. Why are the bending views of the L-spine performed PA instead of AP?

3. How is the patient positioned for a lateral extension view of the lumbar spine?

4. What structures are specifically demonstrated by oblique views of the L-spine?

5. How many degrees is the patient rotated for L-spine obliques?

6. Which two projections demonstrate the left zygapophyseal articulations of the L-spine?

8–4. The Sacrum, Coccyx, and Sacroiliac Joints

Radiography of the sacrum and coccyx is usually requested as a result of a fall or some other form of trauma to the posterior pelvis. Sacroiliac joints, on the other hand, are usually radiographed because of osteoarthritic changes. In this section, we discuss routine projections of the sacrum, coccyx, and sacroiliac (SI) joints.

457. Radiographic projections of the sacrum and coccyx

The sacrum and coccyx are obviously closely related structures. They are often radiographed together because trauma to one bone can radiate to the other, making clinical differentiation difficult.

Routine positions of the sacrum and coccyx are AP and lateral. Each projection should be accomplished on a 10×12 inch cassette positioned lengthwise. Gonadal shielding is indicated for males, but contraindicated for females.

Anterior posterior sacrum

For the AP projection, place the patient in the supine position on the radiographic table. Center the median plane to the film and ensure there is no rotation of the pelvis. Angle the CR 15 degrees cephalic and direct it so that it will enter at a point on the median plane of the body 2 inches superior to the symphysis pubis. Make the exposure on suspended respiration.

The AP projection is preferred over the PA projection because the AP decreases part-film distance. However, when the patient has sustained an injury to the sacrum, the routine may not be possible. In this case, the prone (PA) position may be used. All factors associated with the AP remain the same, except that the CR is angled 15 degrees caudad.

Anterior posterior coccyx

Patient positioning for this view is the same as for the AP sacrum except for the angulation of the CR. To place the CR at right angles to the coccyx with the patient supine, angle the CR 10 degrees caudal. The CR should enter the patient at the same point as for the AP sacrum, 2 inches superior to the symphysis pubis.

Lateral

Lateral views of the sacrum and coccyx can easily be made on the same film. Begin by placing the patient in the lateral recumbent position on either side. Adjust the patient's pelvis so the sacrum is aligned over the centerline of the table. Ensure that the pelvis is in true lateral and not rotated. For the sacrum, direct the CR perpendicular to the film, 3 inches posterior to the mid-coronal plane at the level of the ASIS. If you are primarily interested in demonstrating the coccyx, center the CR 5 inches posterior to the median coronal plane at the level of the coccyx. Figure 8–15 is an example of a lateral sacrum/coccyx radiograph.

Figure 8–15. Lateral sacrum/coccyx radiograph.

458. Radiographic projections of the sacroiliac joints

The routine projections for the SI joints are AP and bilateral obliques.

Anterior posterior

The AP projection (Ferguson method) may be made on a 10×12 inch cassette positioned lengthwise however, some radiologists prefer to include the entire pelvis on this initial view. In such cases, use a 14×17 inch cassette and refer to your department standard operating procedures for further guidance. For the AP (Ferguson method) projection, the patient is positioned supine with the median plane centered to the film. Ensure there is no rotation of the pelvis. Direct the CR 30 degrees cephalic for males and 35 degrees for females at a level entering 1 ½ inches superior to the symphisis pubis. This method demonstrates the lumbosacral junction, sacrum, and both SI joints.

Obliques

Whether posterior obliques and anterior obliques of the SI joints are performed is typically dependent upon the procedures established in your department. The SI joints are the articulations between the sacrum and the iliac portions of the innominate bones. The joint surfaces form an angle of approximately 25 to 30 degrees anteriorly from the median plane. To demonstrate them adequately, you must oblique the patient 25 to 30 degrees. In doing this, you place one of the SI joints perpendicular to the film, enabling it to be demonstrated. Direct the CR perpendicular 1 inch medial to the raised ASIS.

Posterior obliques will demonstrate the SI joint *farthest* from the film. Figure 8–16 depicts a pelvis positioned for a LPO. Notice by raising the right side 25 to 30 degrees, the perpendicular CR projects through the joint space and accurately demonstrates the right SI joint on the film.

Anterior obliques demonstrate the joint nearest the film. Figure 8–17 illustrates a pelvis positioned for a right anterior oblique.

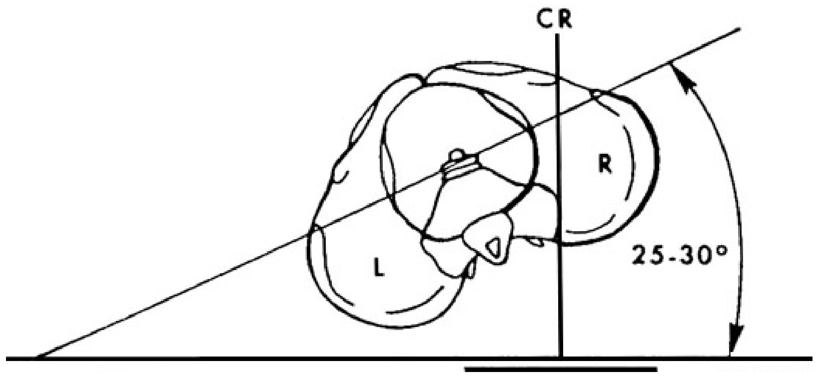


Figure 8–16. Left posterior oblique pelvis (SI joint) illustration.

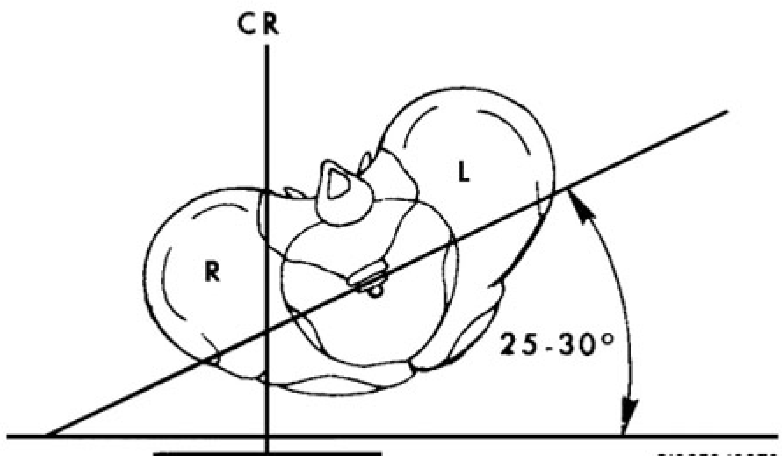


Figure 8–17. Right anterior oblique pelvis (SI joint) illustration.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

457. Radiographic projections of the sacrum and coccyx

1. For the AP projection of the sacrum, how is the CR angled and centered?

2. How is the CR angled for the AP coccyx projection?

3. What is the centering point for the AP sacrum & AP coccyx?

4. What is the centering point for a lateral coccyx?

458. Radiographic projections of the sacroiliac joints

1. What are the routine projections for the sacroiliac joints?

2. What is the centering point for the AP view of the SI Joints?

3. How many degrees is the patient oblqued to open the SI joints?

4. Which SI joint is best demonstrated in the LPO position?

5. Which SI joint is best demonstrated in the LAO position?

Answers to Self-Test Questions

451

1. Angle the CR 15-20 degrees cephalad and center just inferior to the most prominent point of the thyroid cartlidge.
2. At approximately the level of C5.
3. The coronal plane.
4. To overcome the natural OID produced by the left shoulder.
5. The upper incisor and the mastoid tip.
6. The head is tilted too far forward.
7. 45°.
8. Direct the CR 15-20 degrees cephalic and at the level of C4.
9. The intervertebral foramina closest to the film.
10. 1-b; 2-e; 3-b; 4-c; 5-d; 6-a; 7-d.

452

1. Have someone pull the patient’s arms down.
2. To evaluate anterior and posterior mobility of the spine.
3. All the way forward so that the chin rests on the chest.
4. Fracture or dislocation.
5. Judd and Fuchs.
6. The orbitomeatal line forms a 37 degree angle with the film.
7. Within the foramen magnum.

453

1. Flex the patient’s knees and hips.
2. Approximately 2 inches above the shoulders.
3. Suspended expiration.
4. By placing the cathode end of the tube toward the abdomen.
5. Place a foam cushion under the narrow portion of the waist.

6. CR perpendicular to the film at the level of T7 which is approximately 3 inches above the xiphoid process or at the level of the inferior angle of the scapulae.
7. AP; lateral.
8. T3 through T12.

454

1. The Twining is performed upright while the Pawlow is performed lateral recumbent.
2. A lateral view of the cervicothoracic region.
3. The arm nearest the film should be raised above the head and the shoulder away from the film should be depressed and rotated slightly backward or forward to move the humeral head away from vertebral bodies.
4. Angle the CR 3-5 degrees caudad.
5. Zygapophyseal articulations.
6. 70 degrees anterior or posterior obliques.
7. The zygapophyseal joints nearest the film.
8. Because there is only a little difference in object-image distance between PA and AP.

455

1. To reduce the natural lordotic curvature of the spine and open the intervertebral joint spaces.
2. 1 ½ inches above the level of the iliac crests.
3. To prevent over-rotation of the pelvis.
4. Center the spine to the film.
5. To prevent the costophrenic angles from superimposing the upper lumbar vertebrae and causing them to be overpenetrated.
6. 2 inches posterior to the ASIS and 1½ inches inferior to the iliac crest.
7. The lateral.
8. A slipping of the fifth lumbar vertebra forward on the sacrum.

456

1. To help diagnose intervertebral disc herniations.
2. To align the intervertebral joint spaces with the divergence of the beam.
3. The patient is placed in an upright lateral and instructed to bend as far backward as possible.
4. Zygapophyseal joints.
5. 45 degrees.
6. LPO and RAO.

457

1. 15 degrees cephalad.
2. 10 degrees caudad.
3. 2 inches superior to the symphysis pubis.
4. 5 inches posterior to the median coronal plane at the level of the coccyx.

458

1. AP and bilateral obliques.
2. Direct the CR 30 degrees cephalic for males and 35 degrees for females at a level entering 1 ½ inches superior to the symphisis pubis
3. 25 to 30 degrees.
4. The right.
5. The left.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

84. (451) The *primary purpose* for performing oblique views of the cervical spine (C-spine) is to demonstrate the
    a. vertebral arches.
    b. transverse foramina.
    c. intervertebral foramina.
    d. zygapophyseal articulations.

85. (452) When imaging the odontoid process, which of the following does *not* describe the Fuchs method?
    a. The tip of the chin and mastoid processes are perpendicular to the film.
    b. Place the orbital meatal line (OML) at a 37 degree angle.
    c. The lens is projected within the foramen magnum.
    d. Patient is supine.

86. (453) Where is the film placed for the anterior posterior (AP) projection of the thoracic spine (T-spine)?
    a. Upper border 2 inches above the shoulders.
    b. Lower border at the level of the iliac crests.
    c. Upper border at the manubrial notch.
    d. Centered to the xiphoid.

87. (454) Which structure is demonstrated by an right posterior oblique thoracic spine (RPO T-spine) radiograph?
    a. Left zygapophyseal joints.
    b. Left intervertebral foramina.
    c. Right zygapophyseal joints.
    d. Right intervertebral foramina.

88. (455) If a 14×17 inch cassette is used for an anterior posterior lumbar spine (AP L-spine) projection, where should the film be placed?
    a. Top border at the xiphoid process.
    b. Centered to the level of the iliac crests.
    c. Centered 1 ½–2 inches above the iliac crests.
    d. Lower border at the level of the greater trochanter.

89. (456) Posterior anterior (PA), right and left side bending views are taken to help diagnose
    a. spondylolisthesis.
    b. compression fracture.
    c. reduced range of motion.
    d. herniated nucleus pulposus.

90. (457) For the anterior posterior (AP) projection of the coccyx the central ray (CR) is directed
    a. 10 degrees caudal.
    b. 15 degrees caudal.
    c. 10 degrees cephalic.
    d. 15 degrees cephalic.

91. (457) The centering point for a lateral projection of the sacrum is
    a. five inches posterior to the mid-coronal plane at the level of the anterior superior iliac spine (ASIS).
    b. three inches posterior to the mid-coronal plane at the level of the symphysis pubis.
    c. five inches posterior to the mid-coronal plane at the level of the symphysis pubis.
    d. three inches posterior to the mid-coronal plane at the level of the ASIS.

92. (458) When radiographing the sacroiliac joints, how is the central ray (CR) directed for the anterior posterior (AP) Ferguson method?
    a. Perpendicular.
    b. 15–20 degrees caudal for male and female.
    c. Cephalic, 25 degrees for males and 30 degrees for females.
    d. Cephalic, 30 degrees for males and 35 degrees for females.

93. (458) Which position should be used to demonstrate the right sacroiliac joint?
    a. 15–20 degrees right anterior oblique (RAO).
    b. 15–20 degrees left anterior oblique (LAO).
    c. 25–30 degrees RAO.
    d. 25–30 degrees LAO.

Please read the unit menu for unit 9 and continue ➔

Student Notes

Unit 9. Positioning of the Skull

IN THIS FINAL UNIT of the volume we will discuss the positioning of, perhaps the most challenging part of the human body, the skull. The multitude of angles formed by the irregularly shaped bones of the skull, as well as the many superimposed bony structures, make some bones of the skull difficult to view radiographically. Precise part positioning and central ray alignment are often critical in successful radiography of the skull and facial bones.

It is not practical to present all of the many projections of the skull and facial bones in this unit. There are commercial publications typically available in most Air Force hospitals that cover skull projections to a much greater extent. Included though are many of the basic projections of the skull, sinuses, optic foramina, and facial bone projections for the zygomatic arches and mandible.

NOTE: As in the previous units, any reference to film, a cassette, and/or image receptor is meant to be synonymous with each other. Always expose each image with the appropriate right or left lead anatomical marker. Using stickers, sharpie permanent markers, or computer aided text is neither authorized nor legal in a court of law to mark human radiographic images.

9–1. The Skull

As we begin the discussion of the radiographic positions of the skull it is important to note that general radiographic surveys of the skull may be ordered for a variety of reasons yet probably the most common reason for imaging is trauma. This section deals with the routine and additional projections used in most departments when a “skull series” is requested. (**NOTE:** All SIDs in this section are assumed to be 40 inches unless otherwise indicated.)

459. Routine radiographic projections of the skull

Routine radiographic projections of the skull may differ slightly from one department to the next, but most include the following projections as a minimum: PA, lateral, and AP axial (Towne) method.

Image receptor

All routine skull projections should be accomplished on 10×12 inch film, one image per cassette. The cassette orientation (lengthwise or crosswise) varies with each position. Reference your department’s standard operating procedures or imaging protocols for further guidance.

Positioning

All skull projections may be accomplished either recumbent or upright. Patient condition and technologist preference determine which method is used. Because procedures are the same regardless of the method selected, we discuss only the upright method.

Before we can discuss skull positioning, we need to review some common radiographic positioning landmarks and lines used briefly when discussing positioning of the head. Review figure 9–1 to refresh your memory and refer to it as we discuss positioning throughout this unit.

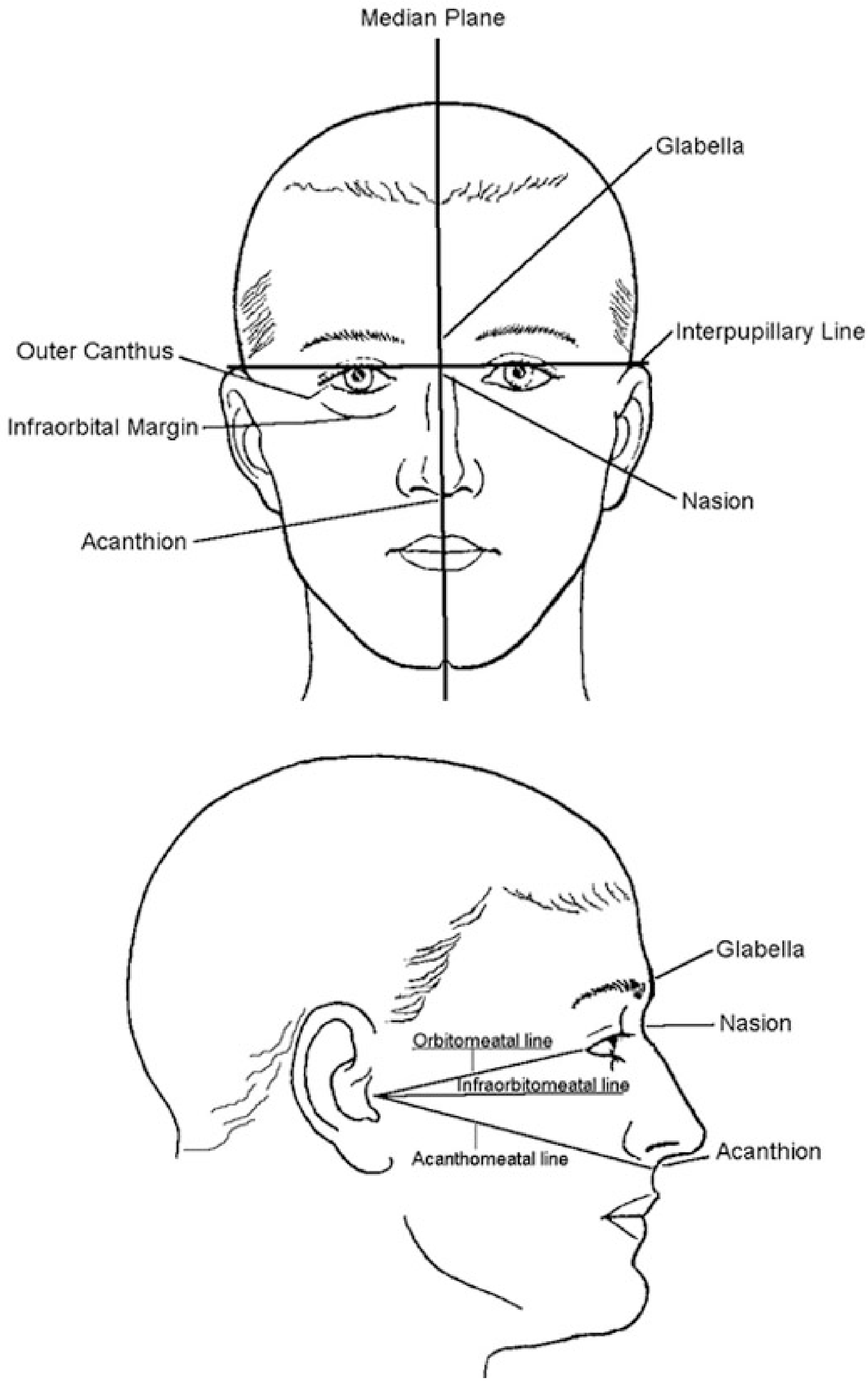


Figure 9–1. Radiographic positioning landmarks of the head.

An important concept in skull positioning is distinguishing between head rotation and tilt. Some positions of the skull (e.g., PA and lateral) require the complete absence of rotation and tilt, while others require precise degrees of one or the other. Obviously, we need to understand the definition of each to be able to control them.

Rotation involves a turning of the head to one side or the other so that the median plane is no longer perpendicular or parallel to the film (fig. 9–2). Tilt, or angulation as it is sometimes called, can refer to either of two types of movement. The first is anterior or posterior (forward or backward) tilt. This is the kind of movement we make when nodding our heads in agreement. Anterior, or forward, tilt means bringing the chin closer to the chest. Posterior, or backward, tilt means raising the chin. The second type of tilt is side to side tilt. This is tilting of the sagittal plane by moving the top of the head toward one side of the other (fig. 9–3). Learning to recognize and adjust the various types of head rotation and tilt is the key to proper positioning of the skull.

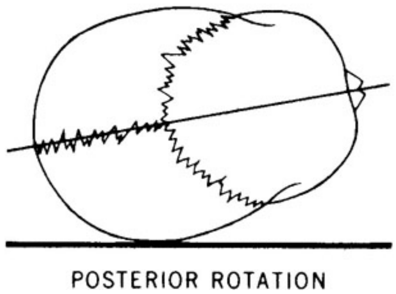


Figure 9–2. Rotation of the head.

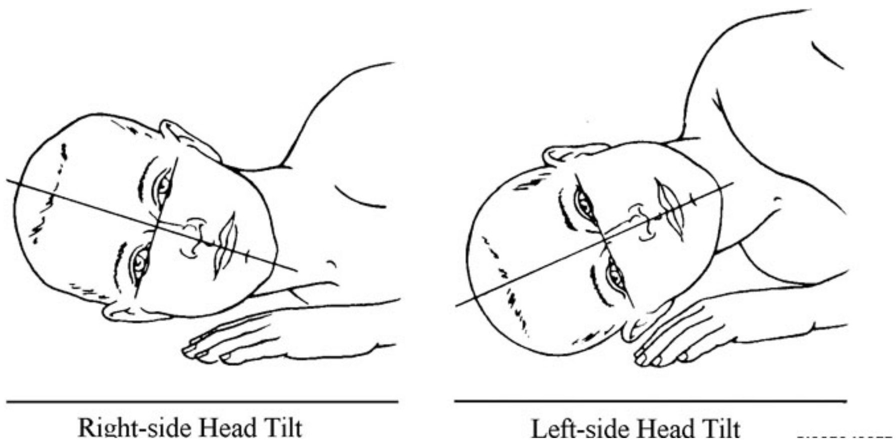


Figure 9–3. Side to side tilt of the head.

PA skull (Caldwell method)

For the PA projection of the skull, begin by having the patient face the vertical cassette holder. Place the patient's nose and forehead on the cassette with nasion centered to the cassette. Adjust the midsagittal plane and the orbital meatal line (OML) perpendicular to the cassette. Direct the CR perpendicular to the film and exiting at the nasion when the frontal bone is of primary interest (fig. 9–4). If positioned as a true Caldwell method, direct the CR 15 degrees caudal, exiting at the nasion.

Figure 9–4. Patient positioned for a PA skull.

Lateral

To position for the lateral skull radiograph, begin by placing the patient in a shallow anterior oblique position with the side of primary interest down. For example, if you are performing a left lateral, place the patient in a shallow LAO position. Turn the head to the side, placing it in true lateral; the median (sagittal) plane should be parallel to the film. With the film oriented crosswise, adjust the anterior, posterior tilt of the head until the infraorbital meatal line (IOML) line is parallel to the long axis of the film. Make one final adjustment to ensure the interpupillary line is perpendicular to the film (which should be the case if the median plane is truly parallel). Direct the CR perpendicular to the film, centering 2 inches superior to the external auditory meatus (EAM). This position is illustrated in figure 9–5.

Figure 9–5. Patient positioned for a lateral skull.

If the examination is being performed specifically to visualize the sella turcica, center to the midpoint of the film and direct the CR to a point ¾ of an inch anterior and ¾ of an inch superior to the EAM. This is very important because the radiologist may have difficulty evaluating the sella turcica if it is projected with divergent rays.

There are several bony structures to look for to check the lateral radiograph of the skull for proper positioning. Refer to figure 9–6 as we discuss them.

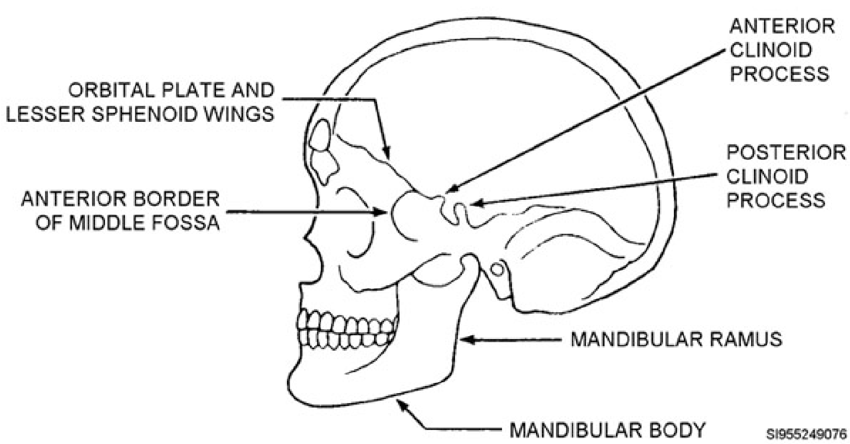


Figure 9–6. Structures visualized on a lateral projection of the skull.

The orbital plates of the frontal bone and the lesser wings of the sphenoid bone appear on the radiograph as solid, dense lines extending from behind the frontal sinuses to just anterior to the sella turcica. These dense lines should appear superimposed over each other when the skull is in the true lateral position. If they are separated, the skull is tilted side to side.

The bilateral anterior and posterior clinoid processes of the sella turcica also should be superimposed. Depending on the direction of the displacement, they can indicate rotation or angulation of the skull. The mandible can also help you determine if rotation or tilt is present. The mandibular rami and bodies should be perfectly superimposed over each other.

Anterior posterior axial (Towne method)

The AP axial (Towne method) projection, sometimes called *Chamberlain-Towne's method*, produces a posterior view of the posterior and inferior aspects of the skull. An angled CR is used to introduce controlled distortion to better demonstrate structures such as the foramen magnum and the petrous pyramids. There are many variations of the Towne method; we will discuss the one usually performed as part of a routine skull series. Place the patient as you would for an AP projection with the median plane and OML perpendicular to the film. Direct the CR 30 degrees caudad, exiting at the external occipital protuberance.

One common adjustment is required for patients who, because of trauma, obesity, or some other condition, cannot tilt their head far enough forward to place the OML line perpendicular to the film. If this is the case, attempt to place the IOML line perpendicular to the film and increase the CR angulation to 37 degrees caudad. Figure 9–7 illustrates proper positioning for the Towne method.

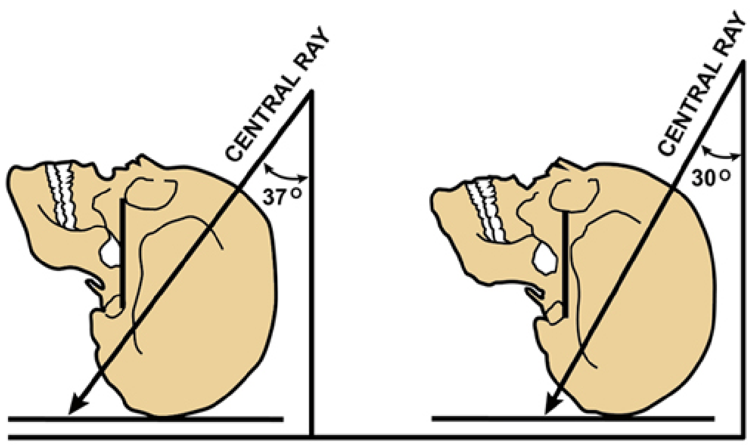


Figure 9–7. Illustrated positioning of the AP axial (Towne) method.

Anatomy demonstrated

The PA skull shows an anterior view of the cranium and facial bones with the petrous ridges superimposed over the orbits. This position is preferred when the frontal bone is the main area of interest.

The lateral skull presents a lateral view of both sides of the skull. However, the side closest to the film is best demonstrated. In addition, the sella turcica, anterior and posterior clinoid processes, dorsum sella, and sphenoid sinuses are clearly visualized.

The AP axial (Towne method) projection is taken to visualize four main structures—the occipital bone, posterior portion of the parietal bones, petrous ridges, and posterior portion of the foramen magnum, as well as other structures.

460. Additional radiographic projections of the skull

There are literally dozens of additional projections of the skull, each used to demonstrate a particular point of osteology; however, most of these are performed infrequently. We will discuss three of the most common ones still used in radiography—the Caldwell method, AP skull, and submentovertical (SMV).

Caldwell method

The Caldwell method is a modified version of the PA skull. It demonstrates several bony structures of the skull that are not ideally visualized on the routine PA projection. Some of these structures are the upper two-thirds of the orbits, the frontal and temporal bones, anterior ethmoidal sinuses, frontal sinuses, and the greater and lesser wings of the sphenoid that are projected in the upper third of the orbits.

Position the patient as you would for the PA skull with the median plane and the OML both perpendicular to the film. For demonstration of sinus fluid levels, the patient must be erect. As discussed earlier, the main difference between the PA skull and the Caldwell method is that the CR is directed 15 degrees caudad exiting the nasion. The resulting radiograph with the 15 degrees caudal angulation will project the petrous ridges into the lower third of the orbits.If the orbits are of primary interest, increase the CR angulation to 20–25 degrees caudad. At this angulation, the petrous ridges are projected completely below the orbits.

Anterior posterior skull

The AP skull is the reverse position of the PA skull. It is used whenever the patient cannot be positioned for the PA (e.g., in trauma situations or when radiographing small children). The median plane and OML line are still perpendicular to the film, but the patient is facing the tube instead of the film. The CR is still directed perpendicular to the nasion. While this projection does provide radiograph similar to the PA, the structures on the anterior portion of the skull are significantly more magnified therefore, the AP should only be used when the PA cannot be obtained.

Basal projection—submentovertical

The basal projection of the skull demonstrates, among other things, the cranial base. It receives its name, submentovertical, because of the path of the CR in each projection. In the SMV projection, the CR enters the base of the skull near the mental symphysis of the mandible (submento) and exits at the top of the skull (vertex). The SMV is used to demonstrate several structures of the skull and facial bones sphenoid and ethmoid sinuses, external and internal auditory meati, mastoid areas, base of the skull, mandible, and zygomatic arches.

The structures are best demonstrated if the skull is positioned so the IOML line is parallel with the film (fig. 9–8). Depending upon the patient’s ability to cooperate, it is sometimes difficult to achieve this position with the SMV projection therefore make certain to direct the CR perpendicular to the IOML in all cases.

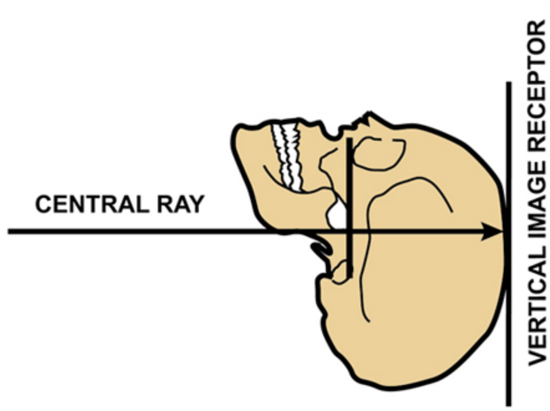


Figure 9–8. Illustrated positioning of the submentovertical projection.

To achieve the desired position of the head and to make the position more comfortable for the patient, perform this projection with the patient seated using the vertical image receptor (bucky). Extend the patient’s neck as far back as possible and touch the vertex to the film holder. Ensure the median plane is perpendicular to the film. There should be no rotation or side-to-side tilt of the head. Direct the CR perpendicular to the IOML line entering at a point midway between the mandibular angles (fig. 9–9). (**NOTE:** If you use the recumbent position, make sure to elevate the patient's trunk on pillows or pads.)

Figure 9–9. Patient positioned for submentovertical projection.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

459. Routine radiographic projections of the skull

1. Which radiographic plane and positioning line are perpendicular to the film for the PA (Caldwell method) projection of the skull?

2. How is the CR directed for a PA skull when the frontal bone is of primary interest?

3. What is the centering point for a routine lateral skull?

4. What structures form solid dense lines extending from behind the frontal sinuses to just anterior to the sella turcica on a lateral skull radiograph?

5. How should the anterior clinoid processes appear on a properly positioned lateral skull?

6. To what degree is the CR angled for the AP axial projection (Towne method)?

7. What positioning adjustment is often necessary for obese patients when the AP axial (Towne method) projection is performed?

8. Where do the petrous ridges appear on a PA skull radiograph?

9. Name four structures demonstrated by the AP axial (Towne method) projection.

460. Additional radiographic projections of the skull

1. What is the primary difference in positioning between the PA skull and the Caldwell method when imaging the skull?

2. If the orbits are of primary interest, how is the CR directed for the Caldwell method when imaging the skull?

3. Under what circumstances would you perform an AP projection of the skull?

4. Name the eight skull or facial bone structures the SMV projection demonstrates.

5. How is the CR directed for the basal projections of the skull?

9–2. Paranasal Sinuses, Orbits, and Facial Bones

By this point in your career, you are undoubtedly aware of the frequency with which sinus series are ordered, especially during cold season. Sinusitis is an extremely painful condition that requires antibiotic therapy to resolve. Radiographs are often requested to diagnose and document the effectiveness of treatment for sinusitis.

Radiography of the mastoids, internal auditory canals (IAC), and petrous pyramids was once extremely popular and there are many projections designed specifically for these structures however, with the advances in computed tomography, most of these projections are no longer performed with any frequency. The cross-sectional images provided by CT offer much more detailed information than conventional radiography. For this reason, these studies have been removed from this course and we will move on to a discussion about imaging the orbits and other facial bones. (**NOTE:** All SIDs in this section are assumed to be 40 inches unless otherwise indicated.)

461. Radiographic projections of the paranasal sinuses

The routine sinus series varies from department to department depending on the preferences of the radiologist in charge however, the standard series is usually composed of a combination of the following views: the Caldwell method, Waters method (parietoacanthial projection), SMV, lateral, and open-mouth Waters projections.

Image receptor

An 8x10 inch cassette is generally all that is needed to cover the paranasal sinuses projections. As with the skull projections though, reference your departments' standard operating procedures or imaging protocols for further guidance.

Positioning

All projections of the paranasal sinuses should be made in the upright position whenever possible to visualize air-fluid levels. Imaging the sinuses in the recumbent position does not permit visualization of air-fluid levels that often accompany sinusitis. In instances when you must perform sinus radiographs recumbent due to patient condition, mark the films as such so that the radiologist will be aware of this during interpretation.

We have already discussed the Caldwell method and submentovertex projection, and, with the exception of film size, they do not change when used as sinus projections. Similarly, the lateral projection of the sinuses differs from the lateral skull only in its centering point. The lateral sinus projection uses the outer canthus of the eye farthest from the film as its centering point.

Waters method (Parietoacanthial projection)

The Waters method or parietoacanthial projection is an extremely versatile radiograph. It is used as part of the routine series for several cranial/facial structures—paranasal sinuses, orbits, facial bones, nasal bones, and zygomatic arches.

To position for the Waters method, begin by having the patient face the vertical cassette holder. Adjust the head so that the median plane is perpendicular to the film and instruct the patient to tilt his or her head backward and rest the chin on the film holder. Adjust the head tilt until the OML forms a 37 degree angle with the film (fig. 9–10). Direct the CR perpendicular to the film, exiting at the acanthion.

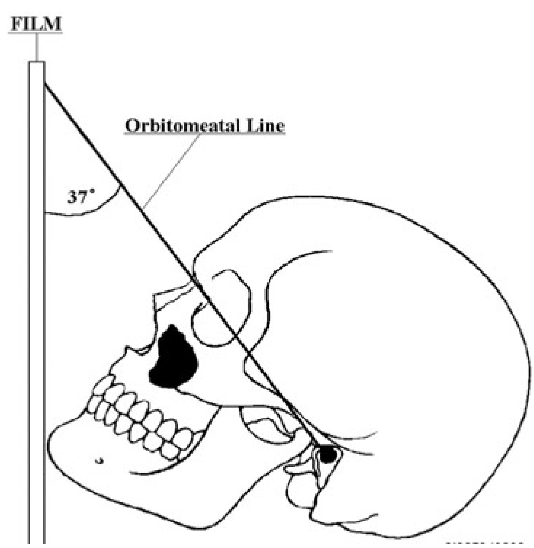


Figure 9–10. Illustrated positioning for the Waters method (parietoacanthial projection).

One of the more common errors made in positioning the patient for the Waters method is the improper alignment of the OML. When this positioning line forms a 37 degree angle with the film, the petrous ridges will be projected below the floor of the maxillary sinuses. An angle of *less* than 37 degrees (head tilted too far back) will superimpose the teeth over the floor of the maxillary sinuses and foreshorten the sinuses, obscuring fluid levels or sinusitis. An angle of *more* than 37 degrees (head tilted too far forward) will cause the petrous ridges to be superimposed in the maxillary sinuses.

Open-mouth Waters method

The open-mouth Waters method is a slight modification of the standard parietoacanthial projection. Begin by positioning the patient upright as you would for the standard Waters method. Adjust the patient's head so that the OML again forms a 37 degree angle with the film. Then, have the patient slowly open his or her mouth as wide as possible and center it to the film. The CR is directed horizontally to the cassette and exits through the acanthion.

Anatomy demonstrated

The Caldwell method provides excellent visualization of the frontal and ethmoid sinuses. The maxillary sinuses are demonstrated, but they are superimposed by the petrous ridges.

The lateral is the only projection that adequately demonstrates all four sets of sinuses.The SMV is used as part of a sinus series to demonstrate sphenoid and ethmoid sinuses.

The Waters method of the skull demonstrates most of the facial bones, orbits, maxillary sinuses, frontal and ethmoid sinuses, nasal septum, and zygomatic arches. It is the best position for demonstrating the maxillary sinuses; the frontals and ethmoids are somewhat distorted

The open-mouth Waters method is used to demonstrate sphenoid sinuses. This method gets its name because the sphenoid sinuses are projected through the open mouth of the patient.

462. Radiographic projections of the orbits

As you know, the orbits are formed by a combination of cranial and facial bones. Their major purpose is to house the eyes. In cases of trauma to the orbit, prompt medical attention, including radiographic examination, is vital to minimize the damage to the eye and prevent loss of sight.

Several of the positions we have already discussed are used to demonstrate the orbits—the Caldwell, method, the Waters method, and lateral projection. However, there is one particular projection designed specifically to demonstrate the optic foramen that is frequently requested as part of an orbit series—the parieto-orbital oblique (Rhese method) projection.

Rhese method (Parieto-orbital oblique projection)

The Rhese method is included in studies of orbits to give the radiologist a view of the orbital rim and optic foramen (i.e., optic canal). To visualize the optic foramen properly, precise skull positioning is necessary. The Rhese method may be performed either PA or AP.

Posterior anterior Rhese method

The PA (prone) Rhese method is the *best* way to demonstrate the optic foramen. Positioning begins by having the patient rest the head with the nose, the zygoma, and the chin of the affected side touching the table. Adjust the head until the acanthomeatal line is perpendicular to the plane of the film. Rotate the posterior portion of the head toward the side under study as shown in Figure 9–11. The midsagittal (median) plane should form a 53 degree angle with the plane of the film or a 37 degree angle with the vertical plane. Direct the CR perpendicular to the film, centered on the orbit closest to the film.

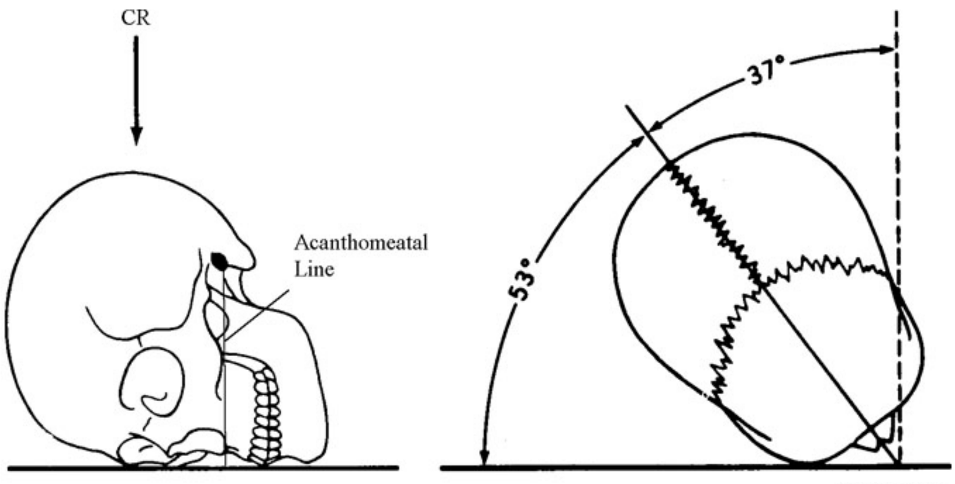


Figure 9–11. Illustrated positioning of the PA Rhese method.

AP Rhese method

The Rhese method can be made with the patient supine (AP) if the prone (PA) position cannot be achieved. If this is the case, there is an increase of about 2 inches in the part-film distance and resultant magnification on the radiograph. Still, this position is easier with young children.The AP Rhese is made in the same way as the PA Rhese, except that the patient is supine. You still need to place the midsagittal (median) plane at an angle of 53 degrees to the film (fig. 9–12). Notice that the acanthomeatal line is still perpendicular to the film. Direct the perpendicular CR through the orbit farthest from the film. This position demonstrates the orbit and optic foramen farthest from the film.

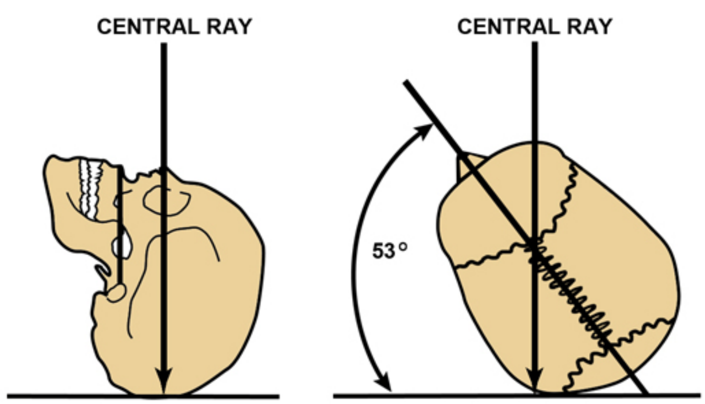


Figure 9–12. Illustrated positioning of the AP Rhese method.

Anatomy demonstrated

If the skull is correctly positioned for the Rhese method, the optic foramen appears in the lower, outer quadrant of the orbit. If the angle of the median plane to the film is more than 53 degrees, the foramen is projected medially from the normal location; an angle of less than 53 degrees projects it laterally. Flexion of the head beyond the correct acanthomeatal-film relationship projects the foramen superior to the normal location. Over-extension projects it inferior to the normal location.

463. Radiographic projections of the facial bones

The standard, generic facial bone series in most departments is very similar to the sinus series—Caldwell method (PA view), Waters method (parietoacanthial view), and lateral. Certain facial bones though, require additional projections to adequately visualize them (e.g., zygomatic arches, the mandible, and nasal bones). In this lesson, we briefly discuss a few of these additional positions.

Zygomatic arch projections

You will recall that the SMV (submentovertical-basal projection) demonstrates the zygomatic arches. At times, this projection reveals both zygomatic arches free of superimposed structures and no further studies are required. Sometimes, however, the arches do not protrude enough from the side of the face to be visualized simultaneously on a basal projection. When this is the case, image the arches one at a time using a variation of the basic SMV projection.

The positioning procedures remain the same except that the top of the head should be tilted about 15° away from the affected side. Notice that we said *tilt* the head. This *does not mean rotate* the head.

The SMV variation is also referred to as the tangential projection of the zygomatic arch. Proper alignment of the CR and the IOML are very important when positioning the SMV. Be sure to direct the CR perpendicular to the IOML because this line parallels the zygomatic arch. If the CR-IOML line relationship is not maintained, the arch will appear foreshortened on the radiograph.

Mandible projections

In most cases, a mandible series includes at least a PA projection and both axiolateral obliques. Some departments also include an AP axial (Towne method) projection to demonstrate the mandibular condyloid processes better.

Posterior anterior

The PA projection is typically a standard view because it offers a full anterior view of a mandible with emphasis on the rami. The skull is positioned as for a PA skull with the median plane and OML perpendicular to the film. Direct the CR perpendicular to the film, centered on the acanthion. For a better view of the mandibular body, rest the patient's chin on the film holder to minimize OID and center to the level of the lips.

Axiolateral oblique

There are various ways you can obtain a lateral oblique view of the mandible. Regardless of the method preferred in your department, projections showing both sides of the mandible *should always* be taken even though only one side may be traumatized. Both sides should always be included because trauma to one side of the mandible usually affects the other side also.

One method has the patient positioned with the side of the face resting on the film holder. Adjust the head so that the mandibular body is parallel with the lower border of the film. Direct the CR 25 degrees cephalic to prevent both sides of the mandibular body from being superimposed and center midway between the mandibular angles. It may be necessary to oblique the patient's trunk slightly (fig. 9–13).

Figure 9–13. Patient positioned for an axiolateral oblique projection of the mandible.

Nasal bones

Nasal bones are usually demonstrated by Waters method (parietoacanthial projection) and both laterals. The Waters method, which we previously described, gives an excellent view of the nasal septum to assess for deviated septum and if performed upright, it can demonstrate blood fluid levels in the maxillary sinuses caused by trauma.

The lateral projections of the nasal bone are very simple to perform. Both sides are imaged on separate cassettes. Simply place the patient's head in true lateral and direct the CR perpendicular to the film, centered on the bridge of the nose about ¾ inch distal to the nasion. You need not use a grid for the lateral nasal projections, and radiographic technique should be similar to that of a finger projection. Figure 9–14 is an example of a lateral nasal bone projection.

Figure 9–14. Lateral nasal bone radiograph.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

461. Radiographic projections of the paranasal sinuses

1. What patient position—upright or recumbent—should be used when radiographing the sinuses? Why?

2. What is the centering point for the lateral projection of the sinuses?

3. List five radiographic series that routinely include the Waters method (parietoacanthial projection).

4. How far back should the head be tilted for the Waters method?

5. How is the Central Ray directed for the Waters method?

6. What is probably the most common error in patient positioning for the Waters method?

7. How can you tell by looking at a parietoacanthial radiograph that the OML line forms an angle considerably more than 37 degrees with the film?

8. How is the CR directed for the open-mouth Waters method?

9. What projection best demonstrates all four sets of sinuses?

10. Which sinuses are demonstrated in the SMV projection?

11. What method best demonstrates the maxillary sinuses?

12. Which sinuses are best visualized when performing the open-mouth Water's method?

462. Radiographic projections of the orbits

1. When performing the Parieto-orbital oblique (Rhese method) projection, what structures are specifically demonstrated?

2. What is the best way to perform the Rhese method?

3. What radiographic positioning line is perpendicular to the film for the Rhese method?

4. What angle is formed by the median plane and the film for the Rhese method?

5. Which orbit is demonstrated on an AP Rhese method?

6. Where is the optic foramen on a properly positioned Rhese method?

463. Radiographic projections for the facial bones

1. When performing the variation of the SMV to demonstrate an individual zygomatic arch, how is the head tilted?
2. How is the CR directed for the zygomatic arch variation of the SMV projection?
3. What structures are demonstrated by the AP axial (Towne method) projection when it is used as a mandible projection?
4. When performing the PA mandible projection specifically to demonstrate the mandibular body, how should you position the head?
5. Why should you always perform both axiolateral oblique views of the mandible?
6. What is the centering point for the axiolateral oblique mandible projection?
7. Give two reasons for including a Waters method as part of a nasal series.
8. What is the centering point for the lateral nasal bone projection?

Answers to Self-Test Questions

459

1. Midsagittal plane and the OML.
2. Perpendicular to the film exiting at the nasion.
3. Perpendicular to the film, centering 2 inches superior to the EAM.
4. The orbital plates of the frontal bone and the lesser wings of the sphenoid.
5. Superimposed.
6. 30 degrees caudad.
7. Place the IOML perpendicular to the film and increase the CR angle to CR 37degrees caudad.
8. Superimposed over the orbits.

9. The occipital bone, posterior portion of the parietal bones, petrous ridges, and posterior portion of the foramen magnum.

460

1. For the PA skull the CR is directed perpendicular; for the Caldwell method the CR is directed 15 degrees caudad exiting the naison.
2. 20–25 degrees caudad.
3. When the patient cannot be positioned for the PA.
4. Sphenoid and ethmoid sinuses, external and internal auditory meati, mastoid areas, base of the skull, mandible, and zygomatic arches
5. Perpendicular to the IOML.

461

1. Upright; to visualize air-fluid levels.
2. The outer canthus of the eye farthest from the film.
3. Paranasal sinuses, orbits, facial bones, nasal bones, and zygomatic arches.
4. Until the OML line forms a 37 degree angle with the film.
5. Perpendicular to the film, exiting at the acanthion.
6. Improper alignment of the OML line.
7. The petrous ridges will be superimposed in the maxillary sinuses.
8. Horizontally to the cassette and exits through the acanthion.
9. Lateral.
10. Sphenoid and ethmoid.
11. Waters.
12. Sphenoid.

462

1. The orbital rim and optic foramen.
2. PA (prone).
3. Acanthomeatal line.
4. 53 degrees.
5. The orbit farthest from the film.
6. In the lower outer quadrant of the orbit.

463

1. Tilt the top of the head 15 degrees away from the affected side.
2. Perpendicular to the IOML.
3. The mandibular condyloid processes.
4. With the patient’s chin resting on the film holder.
5. Because trauma to one side of the mandible usually affects the other side also.
6. Midway between the mandibular angles.
7. To assess for deviated septum and blood in the maxillary sinuses.
8. ¾ of an inch distal to the nasion.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

94. (459) Which projection of the skull uses controlled distortion to produce a view of the foramen magnum and petrous pyramids?
    a. Lateral.
    b. Rhese method.
    c. Posterior anterior (Caldwell method).
    d. Anterior posterior axial (Towne method).

95. (459) Under what circumstance should you increase the central ray angulation to 37 degrees caudal for the anterior posterior (AP) axial (Towne) projection?
    a. When the Infraorbital meatal line (IOML) is perpendicular to the film.
    b. When the orbital meatal line (OML) is perpendicular to the film.
    c. When the patient has a dolichocephalic skull.
    d. When the patient has a brachycephalic skull.

96. (460) For the basal projections of the skull, the central ray is directed perpendicular to the
    a. infraorbitomeatal line.
    b. glabellomeatal line.
    c. acanthomeatal line.
    d. orbitomeatal line.

97. (461) Sinus radiographs should be performed with the patient in the upright position to
    a. reduce distortion.
    b. reduce magnification.
    c. visualize air-fluid levels.
    d. increase patient comfort and minimize motion.

98. (461) When position for the Waters method (parieto-acanthial projection), what radiographic positioning line forms a 37 degrees angle with the film?
    a. Orbitomeatal line.
    b. Infraorbitomeatal line.
    c. Acanthomeatal line.
    d. Mentomeatal line.

99. (462) How is the head positioned for the Rhese method (parieto-orbital oblique projection)?
    a. Midsagittal plane 53 degrees to the film, orbitomeatal line perpendicular.
    b. Midsagittal plane 53 degrees to the film, acanthomeatal line perpendicular.
    c. Midsagittal plane 37 degrees to the film, orbitomeatal line perpendicular.
    d. Midsagittal plane 37 degrees to the film, acanthomeatal line perpendicular.

100. (463) What positioning variation to the submentovertical (SMV) projection is sometimes used to clearly visualize the zygomatic arches on separate images?
    a. Tilt the head 15 degrees toward affected side.
    b. Tilt the head 15 degrees away from affected side.
    c. Rotate the head 15 degrees toward affected side.
    d. Rotate the head 15 degrees away from affected side.

Student Notes

Glossary

AAA	abdominal aortic aneurism
AC	acromioclavicular
AEC	automatic exposure control
AIIS	anterior inferior iliac spine
AP	anterior posterior
ASIS	anterior superior iliac spine
C (1-7)	cervical vertebrae and number in sequence
CDC	career development course
CR	central ray
C-spine	cervical spine
CT	computed tomography
DIP	distal interphalangeal
DNA	deoxyribonucleic acid
DP	dorsal plantar
EAM	external auditory meatus
HNP	herniated nucleus pulposus
IAC	internal auditory canal
IOML	infraorbital meatal line
KUB	kidneys, ureters, and bladder
kVp	kilovoltage peak
L (1-5)	lumbar vertebrae and number in sequence
LAO	left anterior oblique
LPO	left posterior oblique
L-spine	lumbar spine
MP	metatarsal-phalangeal
OID	object-to-image distance
OML	orbital meatal line
PA	posterior anterior
PIIS	posterior inferior iliac spine
PIP	proximal interphalangeal
PSIS	posterior superior iliac spine
RAO	right anterior oblique
R/O Fx	rule out fracture
RPO	right posterior oblique
SC	sternoclavicular
SI	sacroiliac
SID	source-to-image distance
SMV	submentovertical
SOP	standard operating procedures

T (1-12)	thoracic vertebrae and number in sequence
T-spine	thoracic spine
X-ray	X-radiation

Student Notes

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