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1 Introduction

A 65-year-old male was admitted to the emergency department with the sudden onset of a severe crushing pain over the front of his chest, spreading down his left arm and up into his neck and jaw. On questioning, he said that he had had several attacks of pain before and that they had always occurred when he was climbing stairs or digging in the garden. Previously, he found that the discomfort disappeared with rest after about 5 minutes. However, on this occasion, the pain was more severe and had occurred spontaneously while he was sitting in a chair. Additionally, the pain had not abated.

See the Clinical Case Discussion at the end of this chapter for further insight.

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CHAPTER OUTLINE

General Orientation

Anatomic Terminology

Basic Anatomy

Skin

Fascia

Bone

Cartilage

Joints

Ligaments

Bursae and Synovial Sheaths

Muscle

Nervous System

Blood Vessels

Lymphatic System

Mucous and Serous Membranes

Effects of Sex, Age, and Ethnicity on Structure

Medical Imaging

Conventional Radiography (X-Rays)

Computed Tomography

Magnetic Resonance Imaging

Ultrasonography

Nuclear Medicine Imaging

Clinical Case Discussion

LEARNING OBJECTIVES

The purpose of this chapter is to introduce the primary terminology used in describing the position and movement of the human body, some of the basic structures that compose the body (eg, skin, fascia, muscles, and bones), and the principles of medical imaging.

1. Define the anatomic position, major planes of section, and primary terms of direction used in anatomic descriptions.
2. Define the primary movements utilized in anatomic descriptions.
3. Identify the components of the skin and its appendages.
4. Identify the types and distributions of the fasciae of the body.
5. Identify the main structural features of bone. Describe bone classification systems. Describe the developmental processes of bone formation.
6. Identify the major forms of cartilage and the locations where each form is generally

found.

7. Identify the major categories of joints and the structures that characterize each type of joint. Provide examples of each type of joint. Identify the structures responsible for maintaining the stability of joints.
8. Define and differentiate a bursa versus a synovial sheath.
9. Identify the three types of muscle and describe the basic structure of each type. Define the terms used to describe the actions of skeletal muscles. Describe the pattern of innervation of skeletal muscles and the parameters used in naming them.
10. Identify the major subdivisions of the nervous system. Describe the components of a typical spinal nerve. Trace the distribution of a typical spinal nerve.
11. Describe the general organization of the autonomic nervous system. Differentiate between sympathetic and parasympathetic components and pathways, and preganglionic and postganglionic elements.
12. Define a dermatome. Contrast this with the cutaneous territory of a peripheral nerve.
13. Identify the main types of blood vessels and their functional roles in transporting blood.
14. Identify the components of the lymphatic system. Trace the major routes of lymph drainage in the body.
15. Identify and differentiate mucous and serous membranes.
16. Describe the general sex-, age-, and ethnicity-related differences in anatomic form.
17. Describe the major steps in embryonic development. Differentiate ectoderm, endoderm, and mesoderm, and identify the main derivatives of each.
18. Identify the primary forms of medical imaging and the characteristics of images formed by each technique.

GENERAL ORIENTATION

Anatomy is the science of the structure and function of the body. **Clinical anatomy** is the study of the macroscopic structure and function of the body as it relates to the practice of medicine and other health sciences.

Anatomic Terminology

It is essential to understand the terms used for describing the structures in different regions of the body because without these terms, it is impossible to describe the composition of the body in a meaningful way. Clinicians also need these terms so that anatomic abnormalities found on the clinical examination of a patient can be accurately recorded. The accurate use of anatomic terms by medical personnel enables them to communicate with their colleagues both nationally and internationally.

Understanding anatomic terminology (with the aid of a medical dictionary) rather than memorizing rote nomenclature greatly assists you in the learning process. Without anatomic terms, abnormal functions of joints, the actions of muscles, the alteration of position of organs,

or the exact location of swellings or tumors cannot be accurately discussed or recorded.

Terms Related to Position

Spatial orientation and organization are crucial concepts in anatomy, and understanding the standard geometric references that allow uniform, clear descriptions of locations, relations, and movements of structures is important. All descriptions of the human body are based on a conventional reference posture termed the **anatomic position**. In this, a person is standing erect and facing forward, the upper limbs are by the sides, the palms of the hands are directed forward, the lower limbs are together, the soles of the feet are on the ground, and the toes are pointing forward (Fig. 1.1). All directional and movement descriptions are based on this body position. Four geometric planes, three of which are at right angles to the others, are applied to the body in the anatomic position.

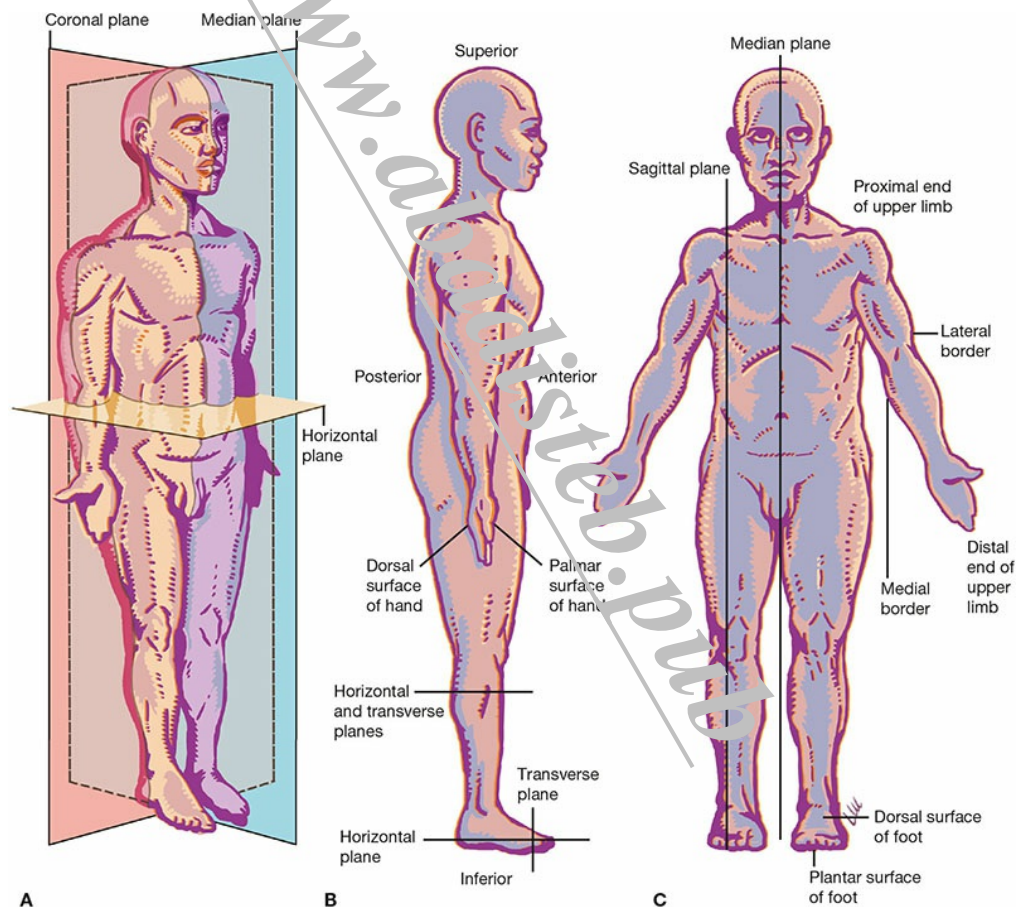


Figure 1.1 Anatomic terms used in relation to position. Note that the subjects are standing in the anatomic position. **A.** Illustration of the median, coronal, and horizontal planes. Note that these planes are aligned at 90° to one another. **B.** Lateral view, demonstrating anatomic planes and directional terms. Note that the horizontal and transverse planes may or may not be equivalent. **C.** Anterior view, showing planes of section and anatomic directions.

- The **median plane** is a vertical plane passing through the center of the body, dividing it into

equal right and left halves (see Fig. 1.1A).

- A **sagittal plane** is any plane parallel to the median plane that divides the body into unequal right and left portions.
- The **coronal (frontal) plane** is a vertical plane situated at a right angle to the median plane. The coronal plane divides the body into the anterior (front) and posterior (back) portions.
- The **horizontal plane** lies at right angles to both the median and the coronal planes. A horizontal plane divides the body into the upper and lower parts.
- A **transverse plane** lies perpendicular to the long axis of a given structure and divides that structure in a cross-sectional orientation. The terms “transverse plane” and “horizontal plane” are often used interchangeably. However, they are not necessarily equivalent. Consider the difference between the horizontal and transverse planes in the leg versus the foot and in the abdomen versus the gut tube. Understand that these planes in such regions produce very different orientations of the structures in question.

The terms **anterior (ventral)** and **posterior (dorsal)** are used to indicate the front and back of the body, respectively (see Fig. 1.1B). To describe the relationship of two structures, one is said to be anterior or posterior to the other, insofar as it is comparatively closer to the anterior or posterior body surface (eg, the nose is on the anterior side of the head, whereas the buttocks are on the posterior side of the body). In describing the hand, the terms **palmar** and **dorsal** surfaces are used in place of anterior and posterior, respectively. In describing the foot, the term **plantar** surface refers to the sole of the foot, and the **dorsal** surface indicates the upper (top) surface (see Fig. 1.1C).

A structure situated nearer to the median plane of the body than another is said to be **medial** to the other. Similarly, a structure that lies farther away from the median plane than another is said to be **lateral** to the other (eg, in the head, the eyes are lateral to the nose, and the nose is medial to the eyes).

The terms **superior (cranial; cephalic)** and **inferior (caudal)** denote the levels relatively high or low with reference to the upper and lower ends of the body (eg, the head is at the superior end of the body, whereas the feet are at the inferior end of the body).

The terms **proximal** and **distal** describe positions relative to the core, root, or attached end of a reference point. Proximal is closer to the core, and distal is further away from the core (eg, in the upper limb, the shoulder is proximal to the elbow, and the hand is distal to the elbow).

The terms **superficial** and **deep** denote positions relative to the surface of the body or a given structure. Superficial is closer to the surface, whereas deep is farther away from the surface (eg, the skin is superficial to the ribs, but the heart is deep to the ribs).

The terms **internal** and **external** are used to describe locations relative to the center of a structure or space. Internal is inside the structure, and external is outside the structure (eg, the thoracic cavity is an internal space in the trunk of the body, whereas the skin is the external layer of the trunk).

Ipsilateral and **contralateral** are terms referring to positions relative to a reference side of the body. Ipsilateral is on the same side as the reference point, and contralateral is on the opposite side from the reference point (eg, the right eye is ipsilateral to the right ear; however, the right eye is contralateral to the left ear).

The **supine** position of the body is lying on the back. The **prone** position is laying face downward.

The terms **afferent** and **efferent** refer to the direction of flow relative to a reference point. Afferent is flow toward the reference point, whereas efferent is flow away from the reference point (eg, venous blood flow is afferent to the heart, and arterial blood flow is efferent to the heart).

Terms Related to Movement

In the musculoskeletal system, movement takes place at joints (Fig. 1.2). A joint is a site where two or more bones articulate, or come together. Some joints have no movement (eg, sutures of the skull), some have only slight movement (eg, superior tibiofibular joint), and some are freely movable (eg, shoulder joint).

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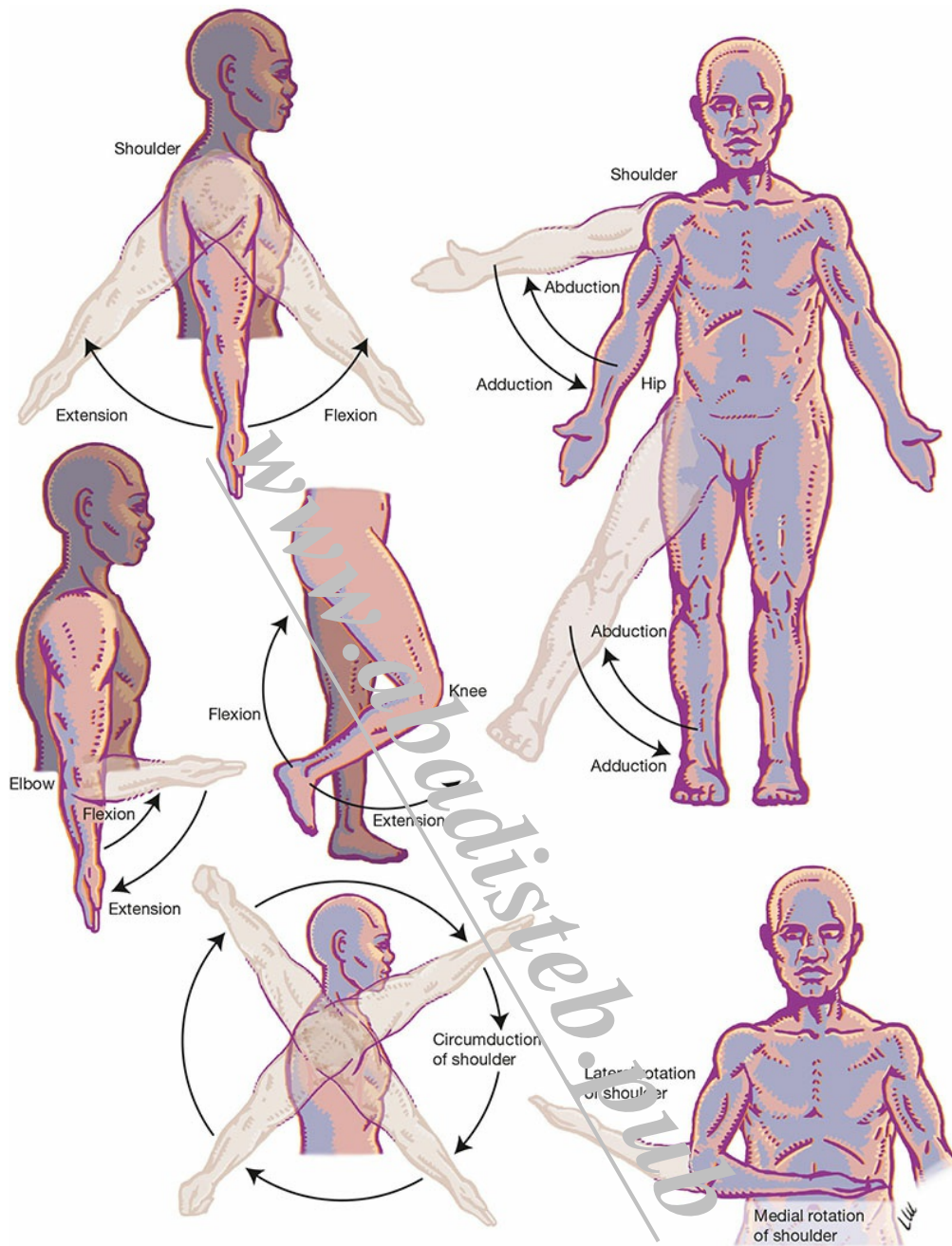


Figure 1.2 Some anatomic terms used in relation to movement. Note the difference between flexion of the elbow versus the knee.

Flexion is the movement in which a joint angle is decreased (closed) during motion occurring in a sagittal plane. **Extension** is the opposite movement in which the joint angle is increased (opened; straightened) in a sagittal plane (eg, flexion of the elbow approximates the anterior surface of the forearm to the anterior surface of the arm; extension of the elbow is the reverse motion). Flexion usually is an anterior movement, but it is occasionally directed posteriorly, as in the case of the knee joint. Also, flexion typically implies a relatively more powerful, antigravity

movement directed toward the embryonic ventral aspect of the body.

Dorsiflexion and **plantar flexion** are special terms used to simplify descriptions of the movements of the foot. Dorsiflexion (the equivalent to extension) refers to lifting the top of the foot superiorly, toward the shin. Plantar flexion (the equivalent to flexion) refers to moving the sole of the foot inferiorly, as in standing on the toes. These points will become clearer in the following chapters on the back and limbs. “Lateral flexion” is an imprecise term sometimes used in clinical settings that refers to a sideways bending movement of the trunk in the coronal plane (Fig. 1.3). However, “abduction” is the more correct term and the one that should be used.

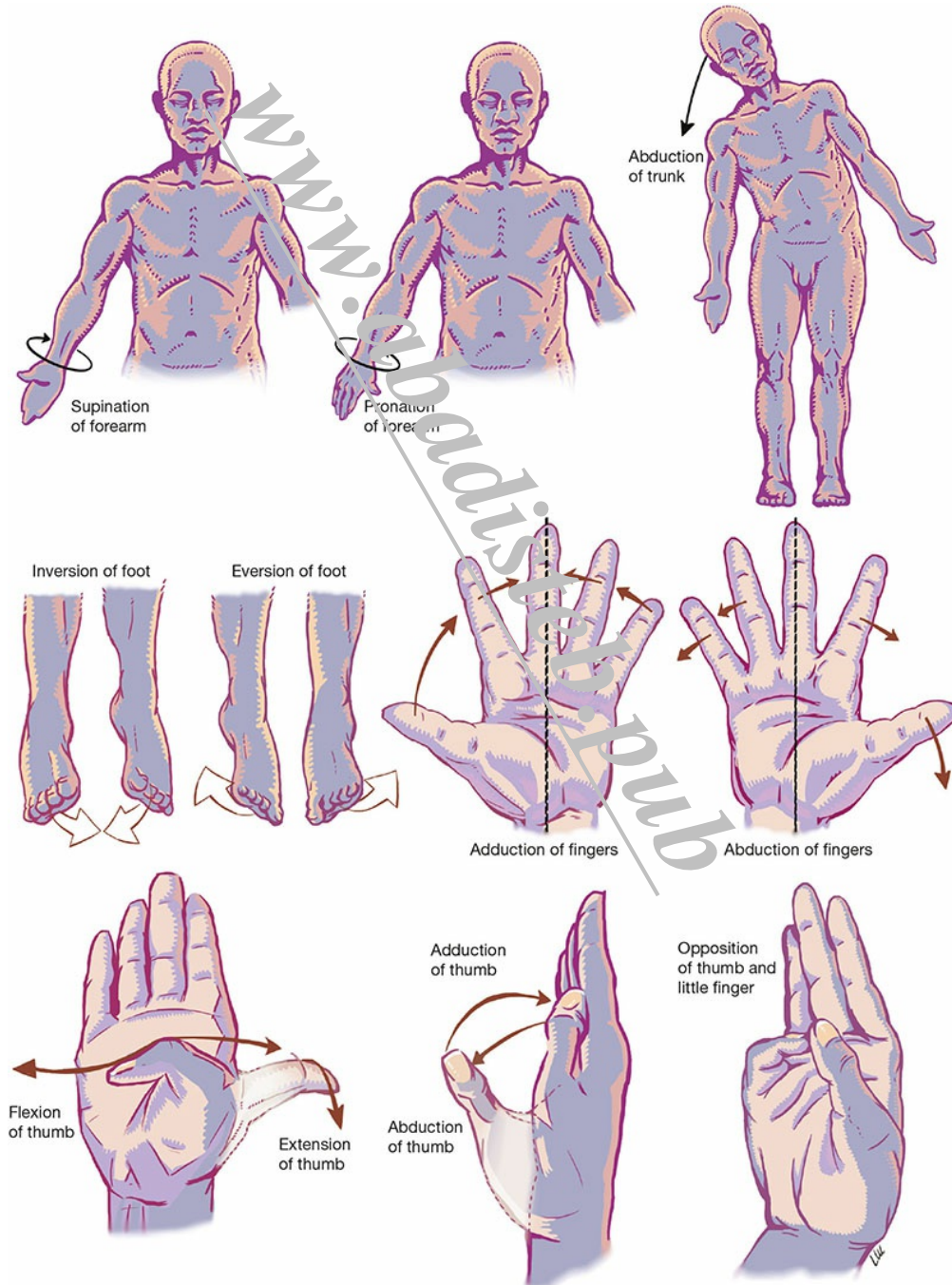


Figure 1.3 Additional anatomic terms used in relation to movement.

Abduction is movement away from the midline of the body in the coronal plane. **Adduction** is movement toward the midline of the body in the coronal plane (see Fig. 1.2). In the fingers and toes, abduction is applied to spreading apart the digits, and adduction is applied to drawing them together. The movements of the thumb, which are more complicated, are described in Chapter 3.

Inversion and **eversion** are the special terms used to describe certain movements of the foot (see Fig. 1.3). Inversion is turning the sole of the foot so that it faces in a medial direction, toward the midline, and eversion is the opposite movement of the foot so that the sole faces in a lateral direction.

Rotation is the term applied to the movement of a part of the body around its long axis, with little to no movement through space. **Medial (internal) rotation** results in the anterior surface of the part facing medially, and **lateral (external) rotation** results in the anterior surface of the part facing laterally (see Fig. 1.2).

Circumduction is a complex sequence of movements combining flexion, extension, abduction, adduction, and rotation. The overall movement results in transcribing a cone through space, with the apex of the cone being the more proximal articular cavity of a joint and the base of the cone being the more distal end of a bone or limb segment. Circumduction is most easily envisioned at the shoulder.

Pronation and **supination** are the special movements of the forearm in which the radius moves around the ulna (see Fig. 1.3). Pronation is turning the forearm medially such that the palm of the hand faces posteriorly, and supination is turning the forearm laterally from the pronated position so that the palm of the hand comes to face anteriorly. These movements are composed of both rotation (at the proximal end of the radius) and circumduction (at the distal end of the radius). Some references describe pronation/supination of the ankle and the foot. Clinically defined, pronation and supination of the foot are the complex movements of the ankle region that include plantar flexion, dorsiflexion, eversion, and inversion. Pronation and supination of the forearm and ankle are very different movements that should not be confused with one another.

Protraction is the term used to describe moving a body part forward. **Retraction** is to move a part backward. Examples of these movements are the forward and backward movements of the jaw at the temporomandibular joints (as when jutting the chin forward) and the forward/backward motion of the scapula across the rib cage (as when reaching forward).

Eponyms

International commissions reflecting the views of multiple professional anatomic societies determine official anatomic terminology. One of the guidelines used in producing this *Terminologica Anatomica* is that eponyms shall not be used. In a scientific context, an eponym is an identifying term formed from the name of a person (eg, ampere, volt, foramen of Winslow, and circle of Willis). However, eponyms are used randomly, conveying no information about the structure in question, and they are often historically misleading in that the person honored by the

naming did not necessarily contribute the first description of the structure (eg, François Poupart was not the first to describe the inguinal ligament). Unfortunately, eponyms remain in wide use in the biomedical sciences, especially in clinical settings. Newer generations of anatomists and other health science professionals should adopt current official terminology and avoid eponyms whenever possible to reverse this trend.

BASIC ANATOMY

Basic anatomy is the study of the minimal amount of anatomy consistent with the understanding of the overall structure and function of the body.

Skin

The skin is divided into two parts: the superficial part, the **epidermis**, and the deep part, the **dermis** (Fig. 1.4). The epidermis is a stratified epithelium with cells that flatten as they mature and rise to the surface. The epidermis is extremely thick on the palms of the hands and soles of the feet to withstand the wear and tear that occurs in these regions. It is thin on other areas of the body, such as on the anterior surface of the arm and the forearm. The dermis is composed of dense connective tissue containing many blood vessels, lymphatic vessels, and nerves. It shows considerable variation in thickness in different parts of the body, tending to be thinner on the anterior than on the posterior surface. It is thinner in women than in men. The dermis of the skin is connected to the underlying deep fascia or bones by the **superficial fascia**, otherwise known as **subcutaneous tissue**.

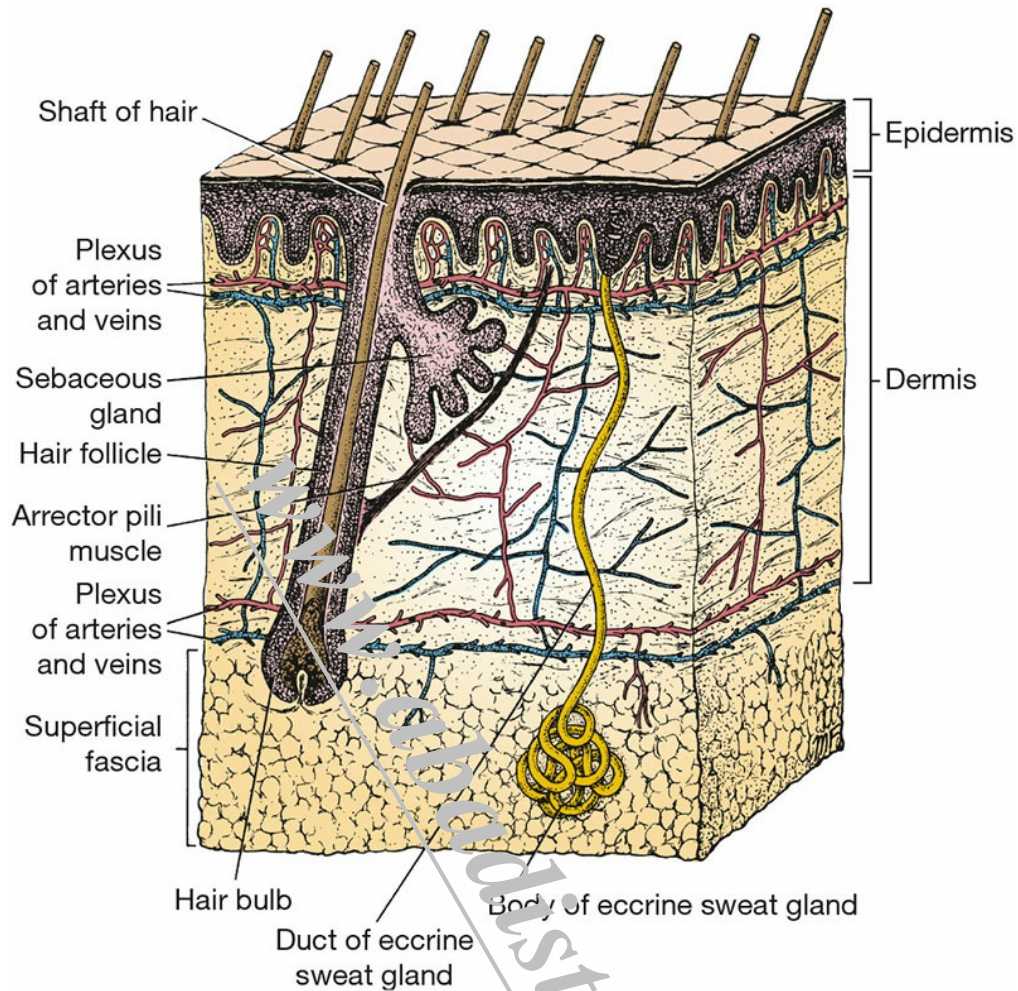


Figure 1.4 General structure of the skin and its relationship with the superficial fascia. Note that hair follicles extend into the deeper part of the dermis or into the superficial fascia, whereas sweat glands extend deeply into the superficial fascia.

The skin over joints always folds in the same place, the **skin creases** (Fig. 1.5). At these sites, the skin is thinner than elsewhere and is firmly tethered to underlying structures by strong bands of fibrous tissue.

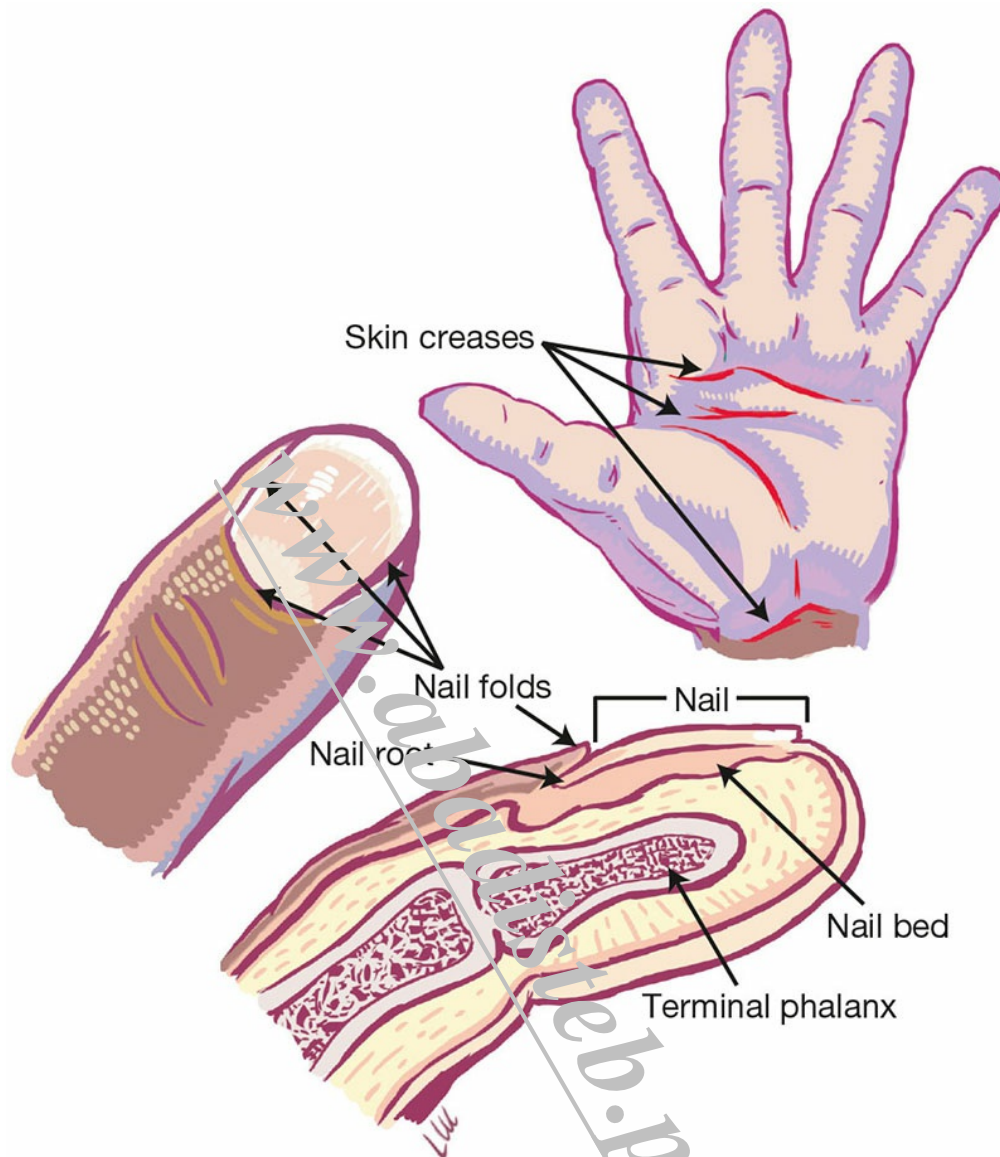


Figure 1.5 The various skin creases on the palmar surface of the hand and the anterior surface of the wrist joint. The relationship of the nail with other structures of the finger is also shown.

The appendages of the skin are the nails, hair follicles, sebaceous glands, and sweat glands.

The **nails** are keratinized plates on the dorsal surfaces of the tips of the fingers and toes. The proximal edge of the plate is the **root** of the nail. With the exception of the distal edge of the plate, the nail is surrounded and overlapped by folds of skin known as **nail folds**. The surface of skin covered by the nail is the **nail bed**.

Hairs grow out of **follicles**, which are invaginations of the epidermis into the dermis (see Fig. 1.4). The follicles lie obliquely to the skin surface, and their expanded extremities, called **hair bulbs**, penetrate to the deeper part of the dermis. Each hair bulb is concave at its end, and the concavity is occupied by the vascular connective tissue called the **hair papilla**. A band of smooth muscle, the **arrector pili**, connects the undersurface of the follicle to the superficial part

of the dermis. The muscle is innervated by sympathetic nerve fibers, and its contraction causes the hair to move into a more vertical position; it also compresses the sebaceous gland and causes it to extrude some of its secretion. The pull of the muscle also causes dimpling of the skin surface, so-called **gooseflesh** (“goose bumps” and “goose pimples”). Hairs are distributed in various numbers over the whole surface of the body, except on the lips, palms, sides of the fingers, glans penis and clitoris, labia minora and the internal surface of the labia majora, the soles and sides of the feet, and the sides of the toes.

Sebaceous glands secrete **sebum** onto the **shafts of the hairs** as they pass up through the necks of the follicles. They are situated on the sloping undersurface of the follicles and lie within the dermis. Sebum is an oily material that helps preserve the flexibility of the emerging hair. It also oils the surface epidermis around the mouth of the follicle.

Sweat glands are long, spiral, tubular glands distributed over the surface of the body, except on the red margins of the lips, nail beds, and the glans penis and clitoris. These glands extend through the full thickness of the dermis, and their extremities may lie in the superficial fascia. The sweat glands are therefore the most deeply penetrating structures of all the epidermal appendages.



Clinical Notes

Skin Infections

The nail folds, hair follicles, and sebaceous glands are common sites for pathogenic organisms such as *Staphylococcus aureus* to enter into the underlying tissues. Infection occurring between the nail and the nail fold is called a **paronychia**. Infection of the hair follicle and sebaceous gland is responsible for the common **boil**. A **carbuncle** is a staphylococcal infection of the superficial fascia that commonly occurs in the nape of the neck and usually starts as an infection of a hair follicle or a group of hair follicles.

Sebaceous Cyst

A **sebaceous cyst** is caused by the obstruction of the mouth of a sebaceous duct. It may also be caused by the damage from a comb or by infection. It occurs most frequently on the scalp.

Shock

A patient who is in a state of **shock** may be pale and may have gooseflesh because of the overactivity of the sympathetic system, which causes vasoconstriction of the dermal arterioles and contraction of the arrector pili muscles. However, depending on the nature of

the shock, dermal vessels may be dilated, resulting in more flushed skin tone.

Skin Burns

The depth of a **burn** determines the method and rate of healing. A partial-thickness burn heals from the cells of the hair follicles, sebaceous glands, and sweat glands as well as from the cells at the edge of the burn. A burn that extends deeper than the sweat glands heals slowly and from the edges only. The fibrous tissue at the margins of the burn causes considerable contracture of the wound. A deep burn often is grafted in order to speed up healing and reduce the incidence of contracture.

Skin Grafting

The two main types of skin grafts are split-thickness and full-thickness grafts. In a **split-thickness graft**, the greater part of the epidermis, including the tips of the dermal papillae, is removed from the donor site and placed on the recipient site. This leaves the epidermal cells on the sides of the dermal papillae and the cells of the hair follicles and sweat glands at the donor site for repair purposes.

A **full-thickness graft** includes both the epidermis and the dermis and requires rapid establishment of a new circulation within it at the recipient site to survive. The donor site is usually covered with a split-thickness graft. In certain circumstances, the full-thickness graft is made in the form of a pedicle graft, in which a flap of full-thickness skin is turned and stitched in position at the recipient site, leaving the base of the flap with its blood supply intact at the donor site. Later, when the new blood supply to the graft is established, the base of the graft is cut across.

Fascia

Fascia is the connective tissue that encloses the body deep to the skin and also envelops and separates individual muscles and groups of muscles as well as deeper organs. Think of fascia as the connective tissue sheaths that hold the structures of the body together in organized arrangements. There are two types of fasciae of the body: superficial and deep.

The **superficial fascia**, or **subcutaneous tissue**, is a mixture of loose areolar and adipose tissue that unites the dermis of the skin to the underlying deep fascia (Fig.1.6). In most areas, superficial fascia allows the skin to move relatively easily over deeper structures. However, in the scalp, back of the neck, palms, and soles, it contains numerous bundles of collagen fibers that hold the skin firmly to the deeper structures. The eyelids, nose, auricle of the ear, clitoris, penis, and scrotum are devoid of adipose tissue. The superficial fascia transmits the cutaneous blood vessels and nerves. In some areas, it contains skeletal muscles (eg, the facial muscles in the face and neck) or smooth muscle (eg, the dartos muscle in the scrotum).