Functional Anatomy*

Anatomy, by nature, is a complex, technical subject. Rather than simplify it too much, we have retained the detail for your future reference.

Anatomic Nomenclature

In Figure 1–1, note that the positional adjectives "proximal" and "distal" refer to the limbs and "dorsal" and "ventral" refer to the upper body, head, and neck. "Rostral" is used to indicate the direction toward the nose. With the exception of the eye, the terms "anterior" and "posterior" are not applicable to quadrupeds. "Cranial" and "caudal" apply to the limbs proximal to the knee (antebrachiocarpal radiocarpal) joint and the hock (tarsocrural tibiotarsal) joint. Distal to these joints, "dorsal" and "palmar" (on the forelimb) or "plantar" (on the hindlimb) are the correct terms. The adjective "solar," is used to designate structures on the palmar (plantar) surface of the coffin bone (distal phalanx) and the ground surface of the hoof.

Thoracic Limb (Fig. 1–2)

Digit and Fetlock

The foot and pastern comprise the equine digit. The bones of this region include the coffin bone (also known as [a.k.a.] the distal phalanx, third phalanx, or P_{III}), the navicular bone (a.k.a. the distal sesamoid), the short pastern bone (a.k.a. the middle phalanx, the second phalanx, or P_{II}), and the long pastern bone (a.k.a. the proximal phalanx, the first phalanx, or P_I). The fetlock is the region where the long pastern bone articulates with the cannon bone and the two proximal sesamoid bones.

Foot

The foot consists of the hoof (epidermis) and all it encloses: the corium (dermis), digital cushion, coffin bone, lateral cartilages, coffin joint, distal extremity of the short pastern bone, navicular bone, navicular bursa, several ligaments, tendons of insertion of the common digital extensor and deep digital flexor muscles, blood vessels, and nerves.

The hoof is continuous with the epidermis (outer skin) at the coronet. Here the dermis (inner layer) of the skin is continuous with the dermis (corium) of the hoof. Regions of the corium correspond to the parts of the hoof under which they are located: perioplic corium, coronary corium, laminar corium, corium of the frog, and corium of the sole (Fig. 1–3).

The exterior parts of the hoof protect underlying structures of the foot and dissipate concussive forces when the hoof strikes the ground. Figure 1–4 illustrates the sole, frog, heels, bars, and ground surface of the wall. The ground surface of the forefoot is wider than that of the hindfoot, corresponding to the rounder coffin bone of the forefoot.

The hoof wall extends from the ground surface to the coronary border, where the soft white horn of the periople joins the epidermis of the skin at the coronet. Regions of the wall are the dorsal toe, the medial and lateral quarters, and the heels. From the thick toe, the wall becomes progressively thinner and more elastic toward the heels, where it thickens again at the junction of the bars (the "buttress" of the hoof). The medial wall is usually steeper (more upright) than the lateral wall.

The horn's tubules are sometimes visible as fine lines on the hoof wall, running from the coronet to the ground (Fig. 1–5). Differential growth rates of the wall from the coronary border toward the ground account for the smooth ridges parallel to the coronary border.

Most of the epidermis is devoid of nerve endings; it is the "insensitive" part of the foot.

Three layers comprise the hoof wall: the stratum tectorium, stratum medium, and stratum internum (see Fig. 1–5). The superficial stratum tectorium is a thin layer of horn extending distally from the periople a variable distance that decreases with age. The bulk of the wall is a stratum medium consisting of horn tubules and intertubular horn. The horn tubules are generated by the germinal layer of the coronary epidermis covering the long papillae of the coronary corium. Intertubular horn is formed in between the projections.

Distal to the coronary groove, approximately 600 primary insensitive (epidermal) laminae interlock with the primary sensitive (dermal) laminae of the laminar corium (Figs. 1–4 and 1–5). Approximately 100 microscopic secondary laminae branch at an angle from each primary lamina, further binding the hoof and corium together (Fig. 1–6).

Some confusion exists concerning the terms "insensitive" and "sensitive" laminae. In the strictest sense, the keratinized parts of the primary epidermal

* A large portion of this material is extracted from Kainer RA, Functional Anatomy of Equine Locomotor Organs, In Adam's Lameness in Horses, edited by Ted Stashak, 4th Edition, Philadelphia, PA, Lea & Febiger, 1987.

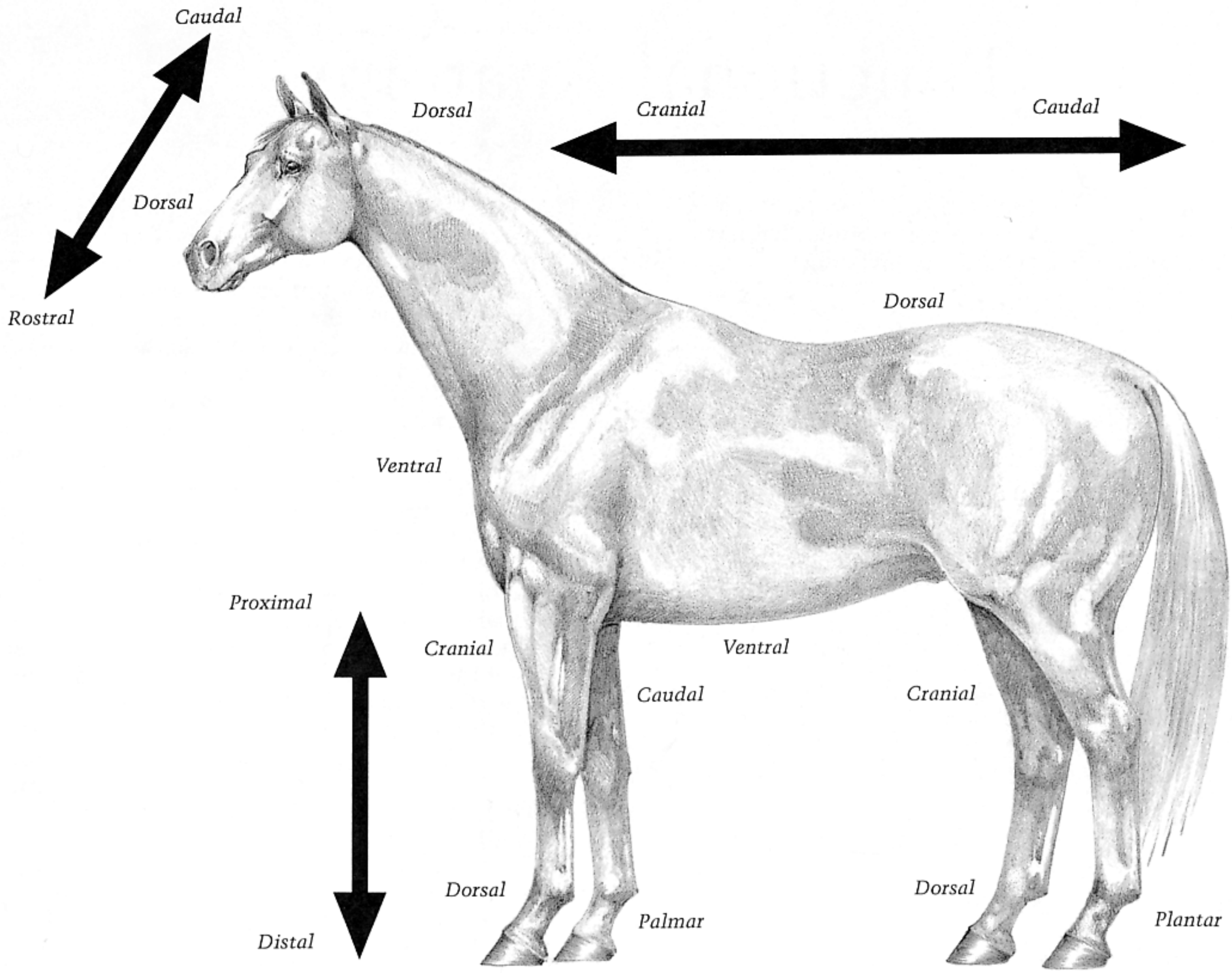

FIG. 1–1A. Topographical and directional terms.

laminae are insensitive; the stratum germinativum, which includes all of the secondary epidermal laminae, and the laminar corium are "sensitive." Although the terms "epidermal" and "dermal" are far more accurate adjectives, the terms "sensitive" and "insensitive" are still in common use.

Submicroscopic, peglike dermal projections increase the surface of attachment of the sensitive and insensitive structures (dermis and epidermis) of the hoof. This configuration and the blending of the laminar corium with the periosteum of the coffin bone suspend and support the bone, aiding in the dissipation of concussion and the movement of blood.

The wall grows approximately 0.25 inch (6 mm) per month, taking from 9 to 12 months for the toe to grow out. Growth tends to be slower in cold or dry environments.

Stratum medium may be pigmented or nonpigmented. Contrary to popular belief, pigmented hooves are not stronger than nonpigmented hooves.

The slightly concave sole should not bear weight on its ground surface, except near its junction with the white line, but it bears internal weight transmitted from the solar surface of the coffin bone through the solar corium. That portion of the sole at the angle formed by the wall and the bars is the angle of the sole (seat of corn). When the wall is trimmed, the white line is visible where the wall joins the sole. The sensitive corium is immediately internal to the white line that serves as a landmark for determining the position and angle for driving horseshoe nails.

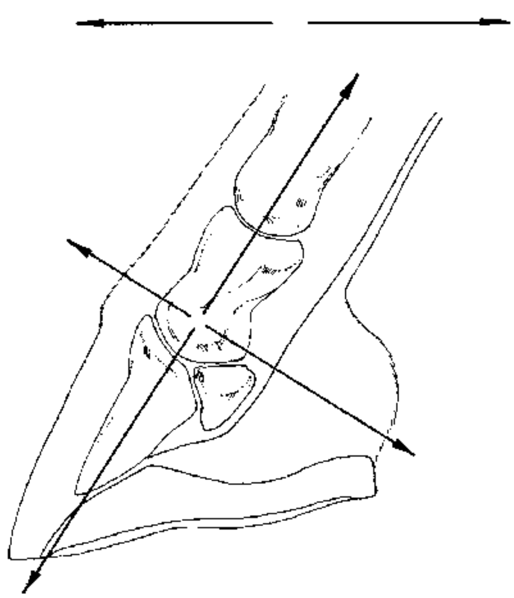

FIG. 1–1B (continued). Topographical and directional terms.

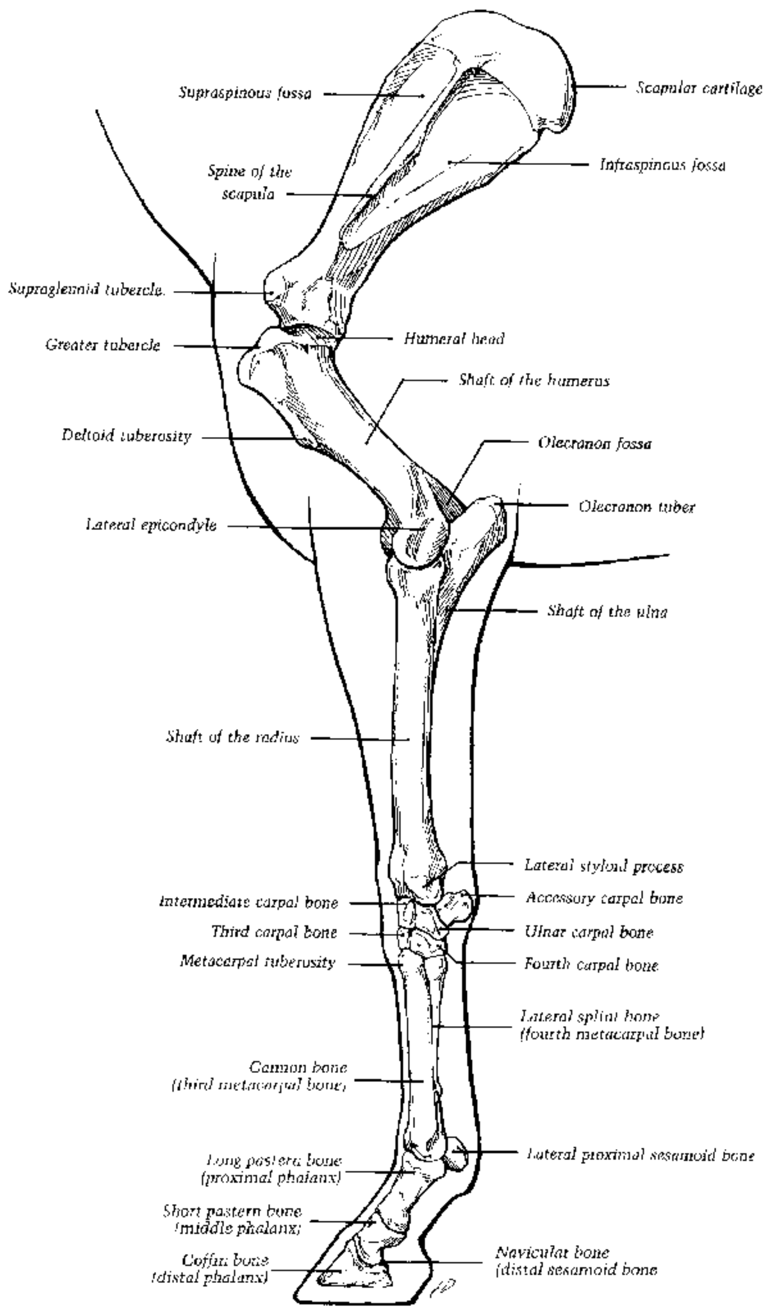

FIG. 1–2. Bones of the equine thoracic limb; lateral view of the left limb.

The sole's horn tubules are oriented vertically, conforming to the direction of the papillae of the solar corium. Intertubular horn binds the tubules together. The relationship of the solar epithelium to the solar corium is responsible for this configuration (Fig. 1–7). Near the ground, the horn tubules curl, accounting for the self-limiting growth of the sole, and cause shedding from the superficial part. Approximately one-third of the sole is water.

The frog (Fig. 1–4) is a wedge-shaped mass of keratinized epithelium rendered softer than other parts of the hoof by a 50% water content. Merocrine glands deliver their secretions onto the surface superficial to the frog stay (Fig. 1–3). The proximally projecting frog stay contacts the digital cushion.

The corium is rich in elastic fibers, highly vascular, and well supplied with nerves. The arterial supply is from numerous branches radiating outward from the

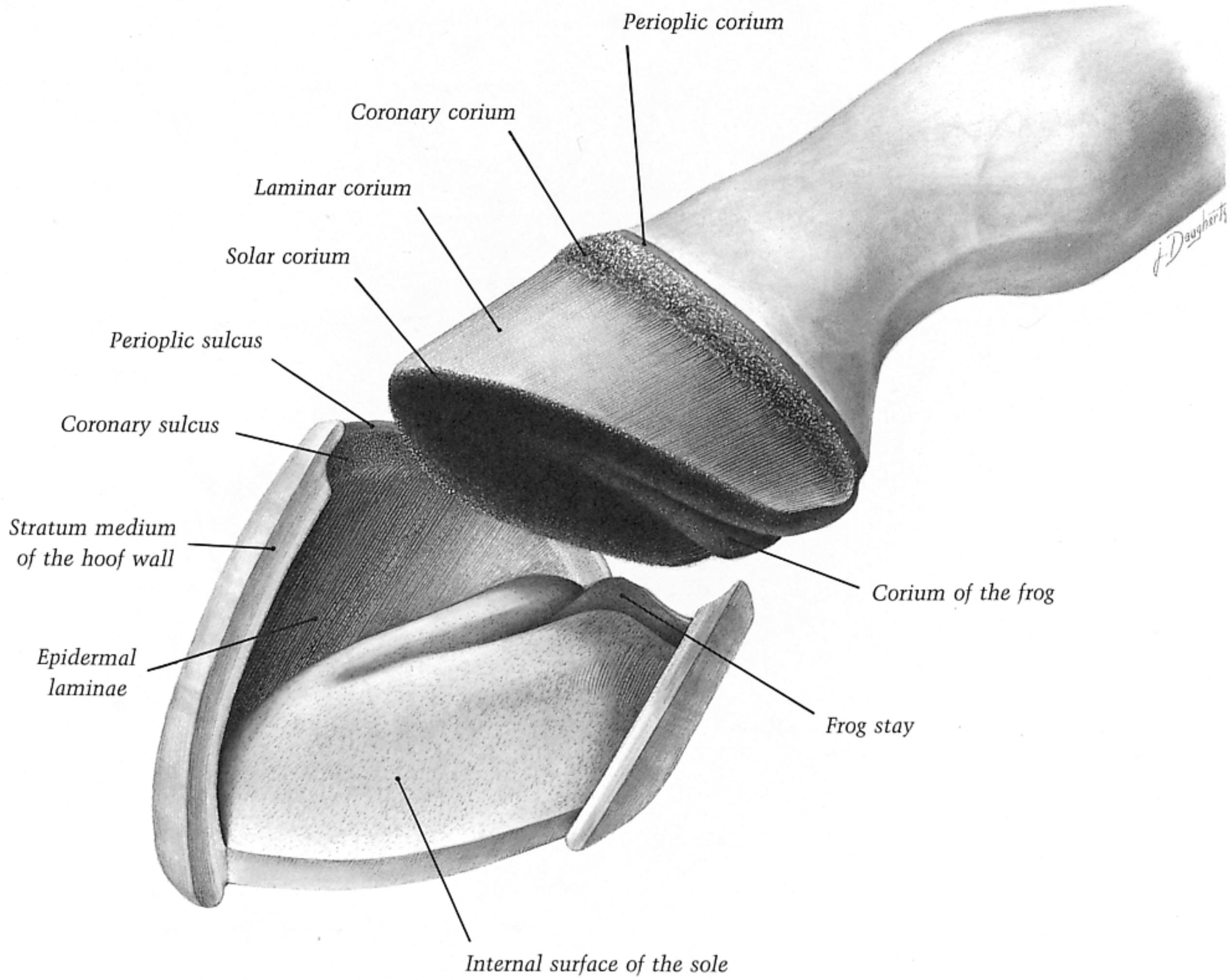

Fig. 1–3. Dissected view of the relationships of the hoof to the underlying regions of the corium.

terminal arch in small canals extending from the solar (semilunar) canal in the coffin bone and from the dorsal and palmar branches of the coffin bone from the digital arteries (Fig. 1–8).

Deep to the coronary band is the highly elastic coronary cushion. The coronary band and cushion form the bulging mass that fits into the coronary groove of the hoof. Part of the coronary venous plexus (network) is within the coronary cushion. The plexus receives blood from the dorsal venous plexus in the laminar corium.

Where the corium is adjacent to the coffin bone, it blends with the bone's periosteum, serving (particularly in the laminar region) to connect the hoof to the bone.

The medial and lateral (collateral) cartilages of the coffin bone lie under the corium of the hoof and the skin, covered by the coronary venous plexus. Roughly rhomboid in shape, they extend above the coronary border of the hoof, where they may be palpated.

Four ligaments stabilize each cartilage of the coffin bone (Fig. 1–9). The cartilages of the coffin bone are hyaline cartilage in young horses and fibrocartilage in middle-aged animals. In older horses, the cartilages tend to ossify (calcify), forming "sidebones."

Between the cartilages is the digital cushion, a highly modified meshwork of collagenous and elastic fibers, depots of adipose (fat) tissue, and small masses of fibrocartilage. It contacts the corium of the frog and thus encloses the frog stay (Fig. 1–10). The apex of the wedge-shaped digital cushion is attached to the deep digital flexor tendon as the latter expands to its insertion on the solar surface of the coffin bone. The base of the digital cushion bulges into the bulbs of the heels, which are separated superficially by a central shallow groove. The structure and relationships of the digital cushion indicate its anticoncussive function.

As the deep digital flexor tendon courses to its insertion on the coffin bone, it is bound in place by the distal digital anular ligament, a sheet of deep fascia supporting the terminal part of the tendon and sweeping proximally to attach on each side of the long pastern bone (Fig. 1–11). The tendon passes deeply over

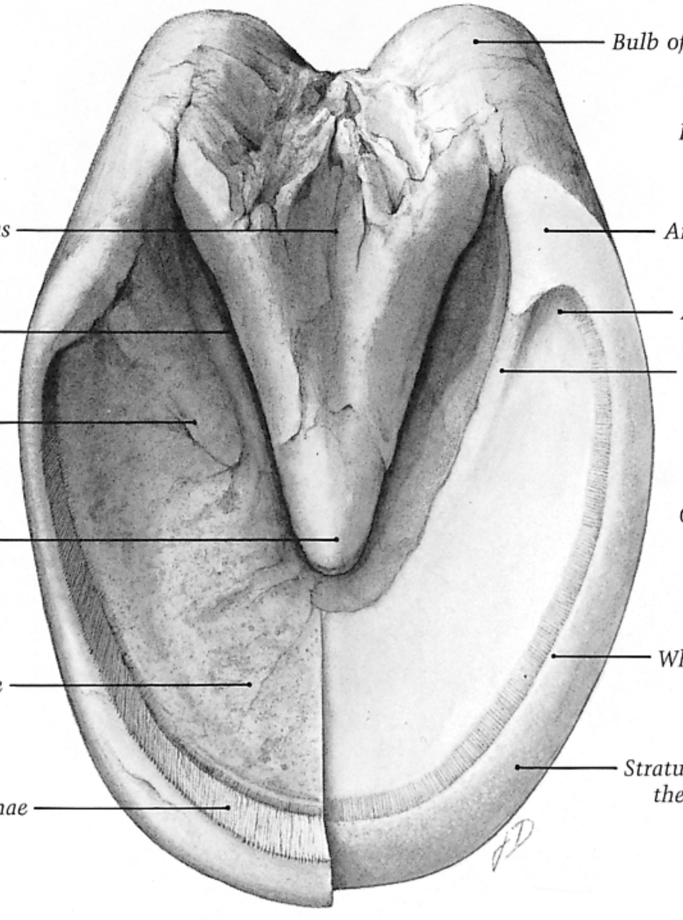

FIG. 1–4. Ground (solar) surface of a right hind hoof. The left half has the epidermal laminar growth extending past the sole to illustrate its contribution to the formation of the white line. The right half has been trimmed to emphasize the formation of the white line by the epidermal laminae.

the navicular bone. The navicular bone is a sesamoid bone that changes the direction of the tendon as it goes to its attachment on the coffin bone. The navicular bursa is interposed between the tendon and the navicular bone, cushioning the movement of the tendon against the bone (see Fig. 1–10). From the exterior, the location of the navicular bursa and bone may be approximated deep to the middle third of the frog.

The proximal border of the navicular bone has a groove containing openings for the passage of small vessels. The distal border of the bone has a small, elongated facet for articulation with the coffin bone. Two concave areas on the main articular surface of the navicular bone contact the distal articular surface of the short pastern bone, resulting in the formation of the coffin joint. The navicular bone is supported in this position by three ligaments. Paired collateral sesamoidean (suspensory navicular) ligaments arise from the distal end of the long pastern bone on each side dorsal to the collateral ligaments of the pastern joint. (Figs. 1–11 and 1–12). They sweep on each side of the short pastern bone and attach to the extremities and proximal border of the navicular bone. Distally, the navicular bone is stabilized by the impar ligament, which attachs it to the flexor surface of the coffin bone palmar to the insertion of the deep digital flexor tendon (see Fig. 1–12).

The distal articular surface of the short pastern bone, the articular surface of the coffin bone, and the two articular surfaces of the navicular bone form the coffin joint. Short collateral ligaments arise from the distal end of the short pastern bone, pass distally deep to the cartilages of the coffin bone and terminate on either side of the extensor process and the dorsal part of each cartilage (Fig. 1–9).

A small dorsal pouch of the joint capsule of the coffin joint blends with the common digital extensor tendon (Fig. 1–10). On either side, the joint capsule blends

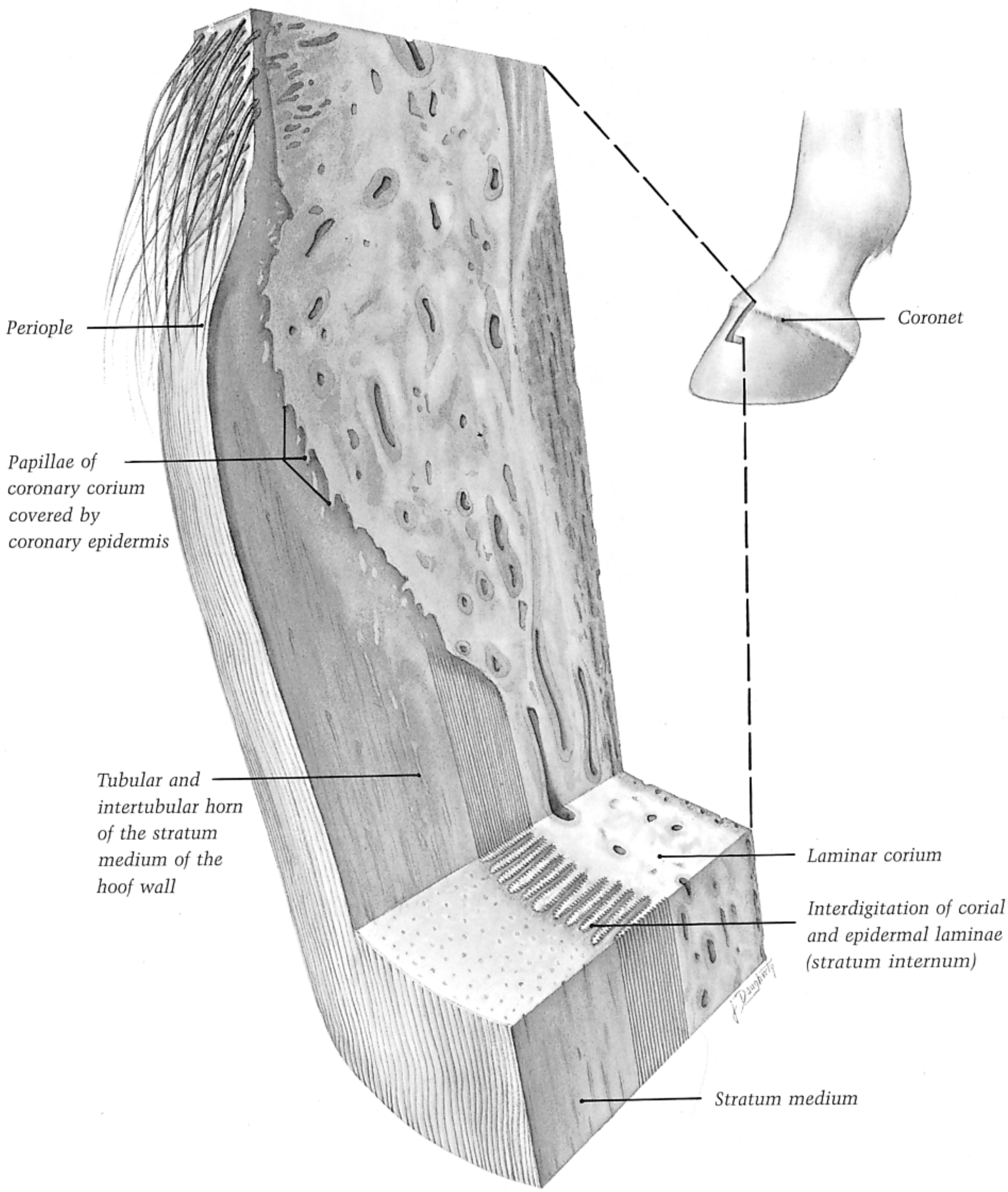

Fig. 1–5. Three-dimensional dissection of the coronary region and the hoof wall.

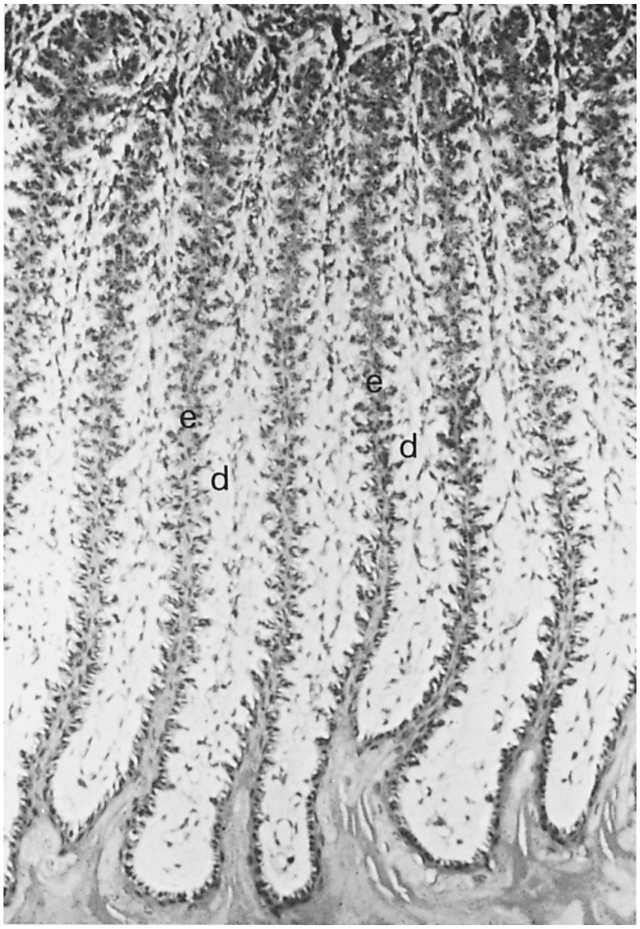

Fig. 1–6. Photomicrograph of a field from a cross section of an equine fetal hoof (×40). Interdigitations of epidermal laminae (e) and dermal (corial) laminae (d). Note the small secondary laminae.

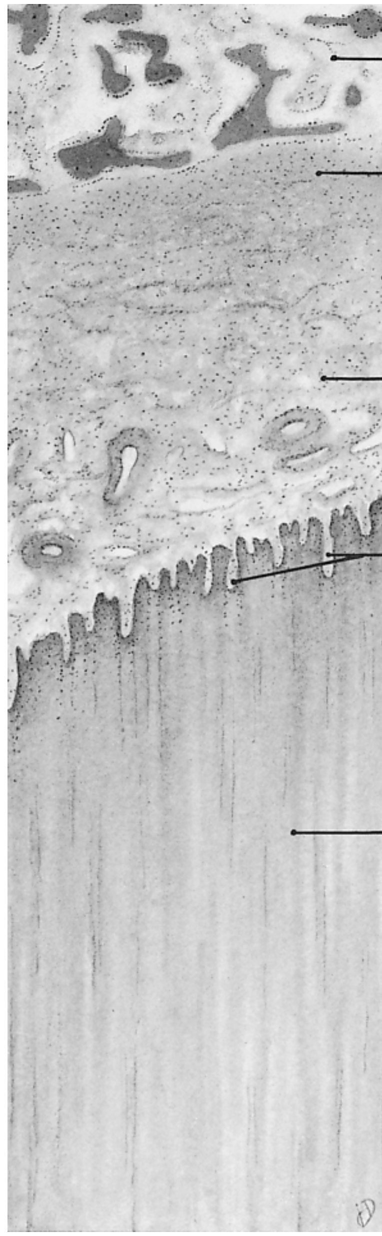

Fig. 1–7. Histologic relationships of periosteum, corium, and horn of the sole.

with the collateral ligaments. The palmar pouch is more extensive, extending proximally midway on the short pastern bone to a transverse fibrous band, the so-called "T ligament" separating the joint capsule from the digital synovial sheath of the flexor tendons (see Fig. 1–10). Medially and laterally protruding pouches of the joint capsule lie against the cartilages of the coffin bone palmar to the collateral ligaments, especially during flexion.

The tendon of insertion of the common digital extensor muscle terminates on the extensor process of the coffin bone, receiving a ligament from each cartilage as it inserts (Fig. 1–9).

Pastern

Deep to the skin and superficial fascia on the palmar aspect of the pastern, the proximal digital anular ligament adheres to the superficial digital flexor tendon and extends to the medial and lateral borders of the long pastern bone (Fig. 1–13). This fibrous band of deep fascia covers the superficial digital flexor as it bifurcates (splits) and aids in binding the deep digital flexor tendon as well.

Two ligaments of the ergot diverge from beneath the horny ergot on the palmar skin of the fetlock. Each ligament descends obliquely just under the skin

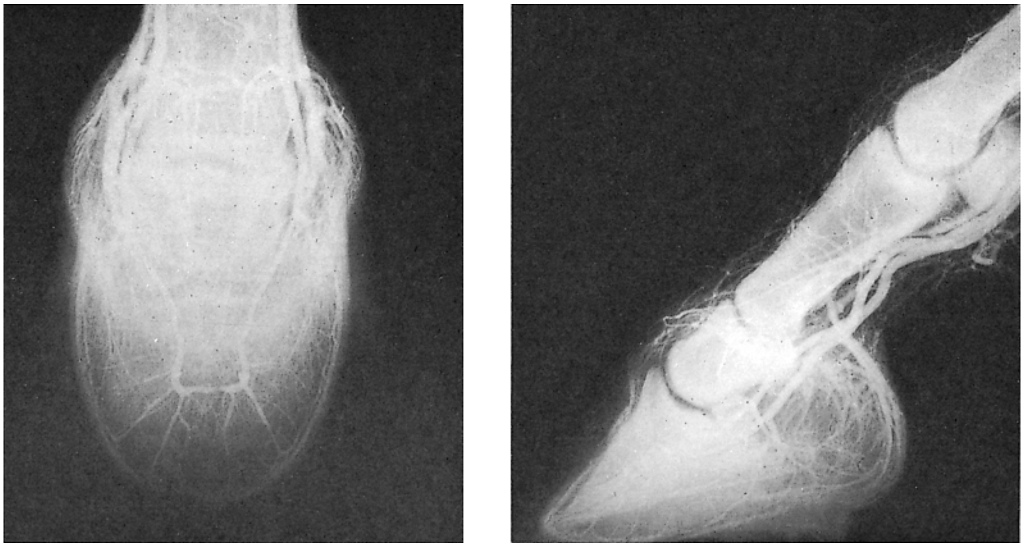

Fig. 1–8. Angiograms of the foot following intra-arterial injection of radiopaque medium.

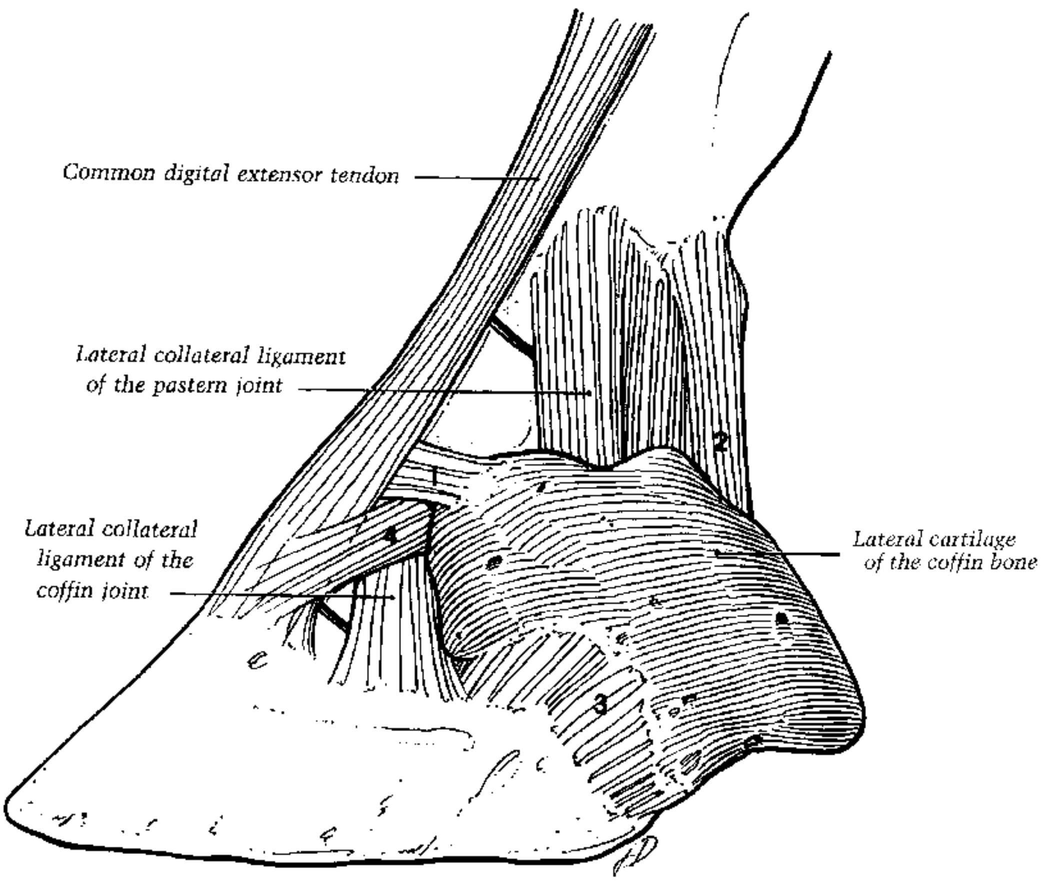

Fig. 1–9. Four ligaments (1, 2, 3, and 4) stabilizing each cartilage of the coffin bone.

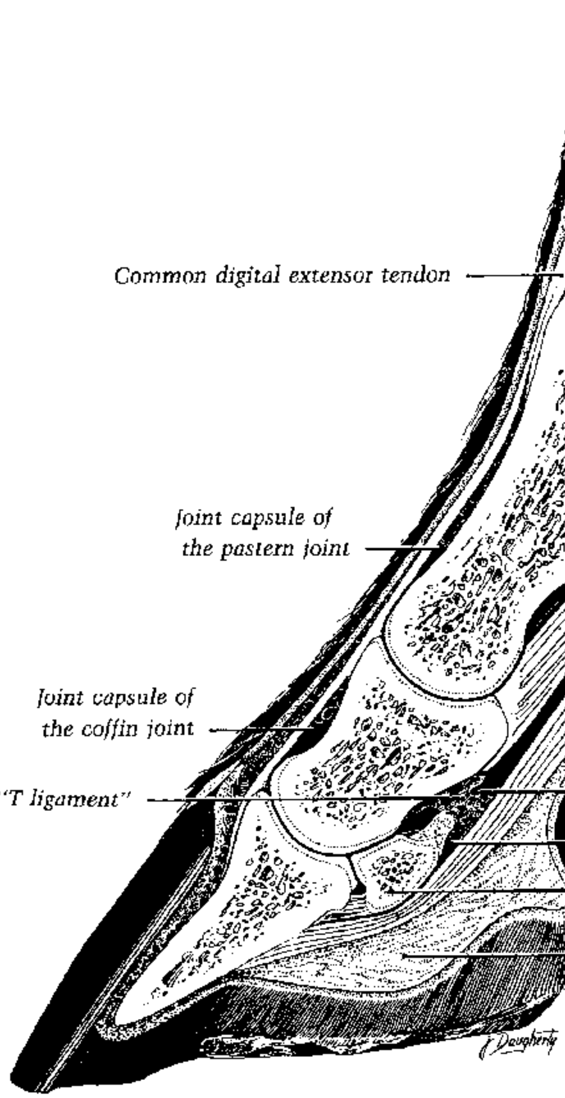

Fig. 1–10. Parasagittal section through the equine fetlock and digit.

superficial to the proximal digital anular ligament, the terminal branch of the superficial digital flexor tendon, and the palmar digital artery and nerve, finally widening and connecting with the distal digital anular ligament (Fig. 1–13).

The tendon of insertion of the superficial digital flexor muscle terminates by bifurcating into two branches that insert on the distal extremity of the long pastern bone and the proximal extremity of the short pastern bone just palmar to the collateral ligaments of the pastern joint (see Fig. 1–11). The tendon of insertion of the deep digital flexor muscle descends between the two branches of the superficial flexor tendon. A digital synovial sheath enfolds both tendons, including both branches of the superficial flexor tendon and continuing around the deep flexor tendon as far as the T ligament (see Fig. 1–10). The latter is a fibrous partition attaching to the middle of the palmar surface of the short pastern bone.

Deep to the flexor tendons, three distal sesamoidean ligaments extend distally from the bases of the two proximal sesamoid bones (Fig. 1–11). The superficial straight sesamoidean ligament attaches distally on the proximal extremity of the palmar surface of the short pastern bone; the triangular middle sesamoidean ligament attaches distally to a rough area on the palmar surface of the long pastern bone; and the pair of deep sesamoidean ligaments cross, each attaching to

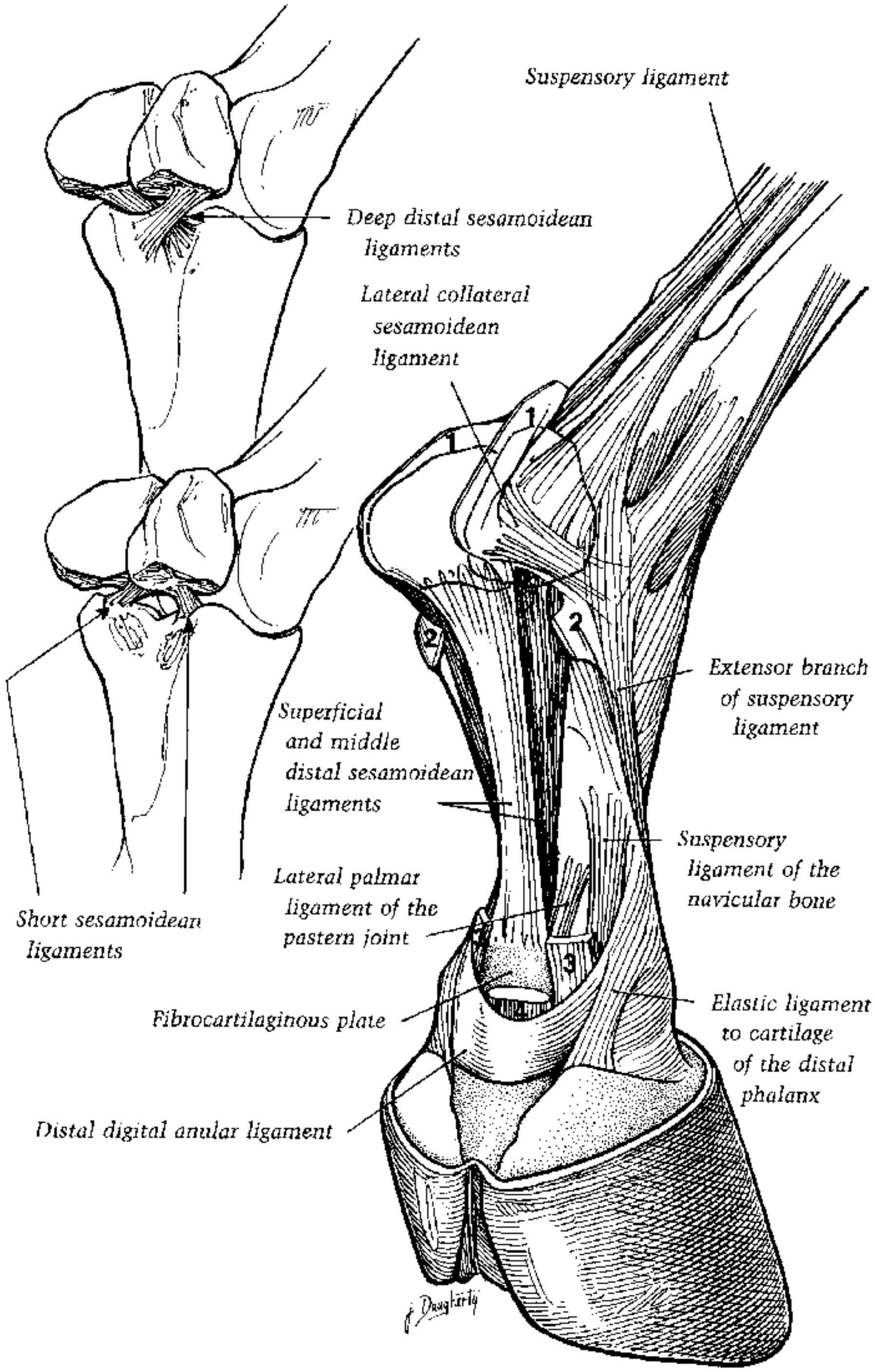

FIG. 1–11. Dissections of the sesamoidean ligaments. Dashed lines indicate the positions of the proximal sesamoid bones embedded in the metacarpointersesamoidean ligament. Numbers indicate the cut stumps of the palmar anular ligament of the fetlock (1), proximal digital anular ligament (2), superficial digital flexor tendon (3), and deep digital flexor tendon (4).

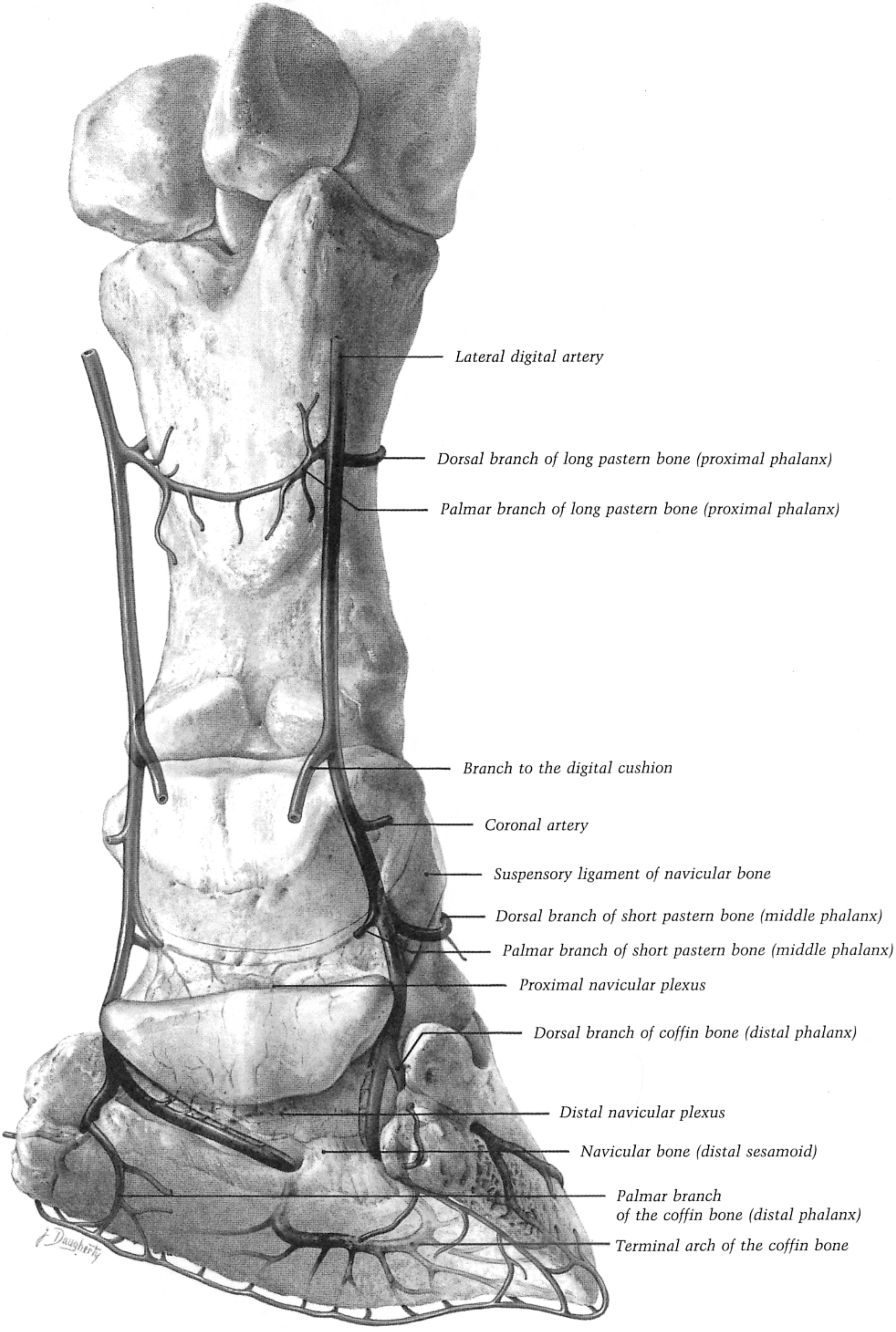

FIG. 1–12. Arterial supply to the digit of the forelimb with emphasis on branches supplying the navicular bone and coffin bone.

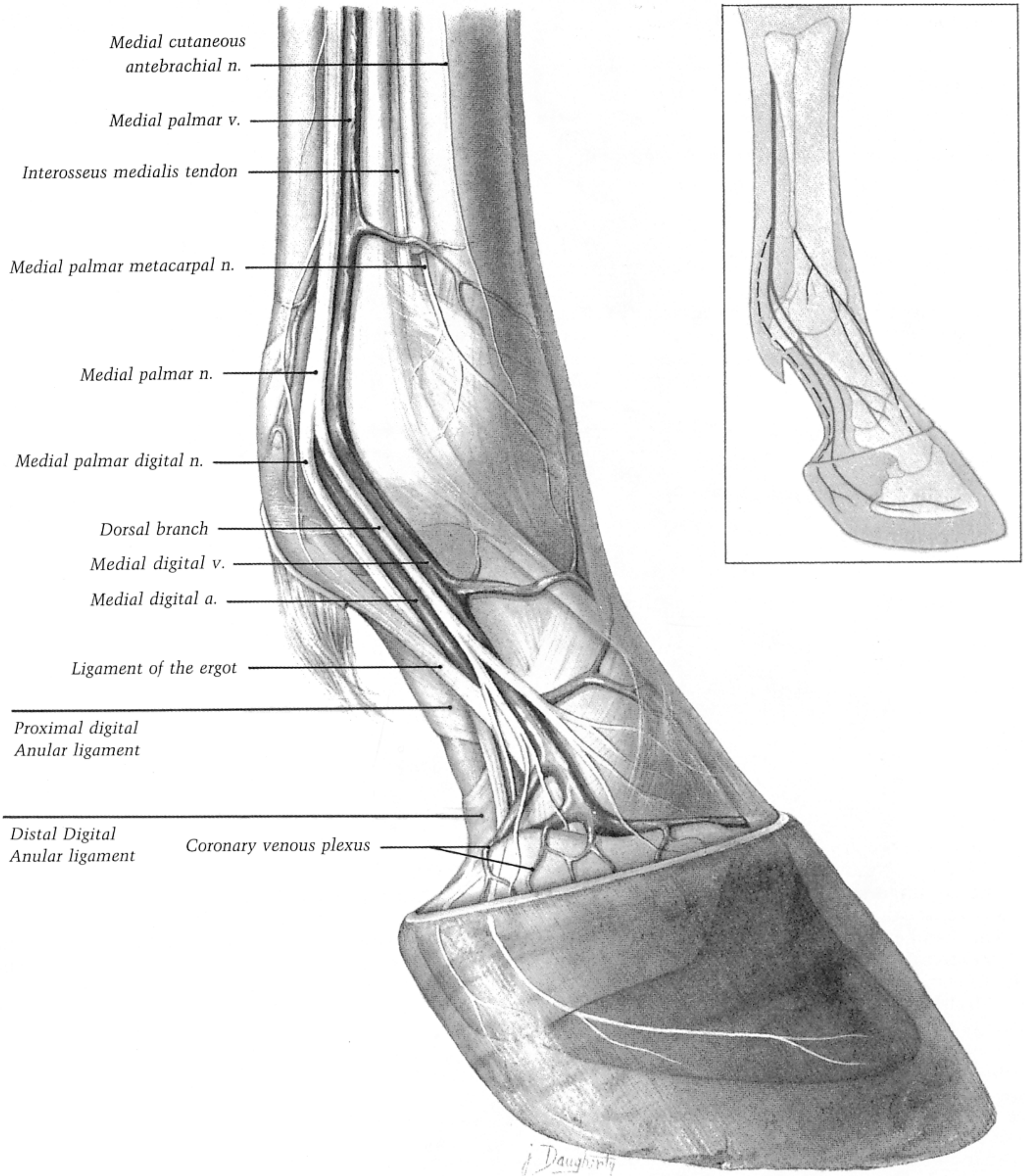

FIG. 1–13. Medial aspect of the distal cannon, the fetlock, and digit. Skin and superficial fascia removed. n., nerve; v., vein; a., artery. Inset: schematic of the distribution of major nerves indicating variant branches (dashed lines).

a prominence on the opposite side of the long pastern bone (see Fig. 1–11).

In addition, each sesamoid bone is further attached to the long pastern bone by a short sesamoidean ligament (Fig. 1–11).

A ligamentous extensor branch of the suspensory ligament (Figs. 1–11 and 1–12) passes from the respective proximal sesamoid bone obliquely across each side of the long pastern bone to the dorsal surface where each branch joins the tendon of insertion of the common digital extensor muscle near the distal extremity of the long pastern bone.

The tendon of the common digital extensor muscle inserts partially on the proximal extremities of the long and short pastern bones on its way to a final insertion on the extensor process of the coffin bone.

The pastern joint is formed by two convex areas on the distal extremity of the long pastern bone and two shallow concave areas on the proximal extremity of the short pastern bone. Bones of the pastern joint are held together by two short collateral ligaments and four palmar ligaments.

The joint capsule of the pastern joint blends with the deep surface of the common digital extensor tendon (see Fig. 1–10).

Fetlock (Metacarpophalangeal Joint)

The fetlock of the thoracic limb is the region around the fetlock joint. The horny ergot gives origin to the two distally diverging ligaments of the ergot.

Deep to the skin and superficial fascia, the palmar anular ligament of the fetlock binds the digital flexor tendons and their enclosing digital synovial sheath in the sesamoid groove.

The sesamoid groove contains the deep digital flexor tendon. Immediately proximal to the canal formed by the palmar anular ligament of the fetlock and the sesamoid groove, the deep digital flexor tendon perforates through a circular opening in the superficial digital flexor tendon.

The common and lateral digital extensor tendons pass over the dorsal aspect of the fetlock joint.

The distal extremity of the cannon bone, the proximal extremity of the long pastern bone, the two proximal sesamoid bones, and the extensive ligament in which the proximal sesamoids are embedded form the fetlock joint.

A pouch of the fetlock joint capsule extends proximally between the cannon bone and the suspensory ligament. This pouch is palpable and even visible when the joint is inflamed, distending the palmar recess with synovial fluid.

Support for the fetlock and stabilization during locomotion is provided by its suspensory apparatus, a part of the stay apparatus. The suspensory apparatus of the fetlock includes the suspensory ligament (interosseus medius muscle) and its extensor branches to the common digital extensor tendon and the distal sesamoidean ligaments extending from the bases of the proximal sesamoid bones distal to the long or short pastern bones.

The blood vessels and nerves of the digit and fetlock are illustrated in Figures 1–12, 1–13, and 1–14.

Functions of the Digit and Fetlock

In the standing position, essentially in extension, the fetlock and digit are supported by the suspensory apparatus of the fetlock (interosseus muscle, intersesamoidean ligament, and distal sesamoidean ligaments), the digital flexor and extensor tendons, and the collateral ligaments of the joints. The forelimbs support more weight than the hindlimbs. On the forelimb, the angle of the toe (with the ground) varies from 53 to 58°.

The locomotor functions of the digit and fetlock include the flexion essential to movement, extension when the foot is off the ground, the dissipation of concussion when the hoof contacts the ground, and the recovery from extension.

During flexion of the fetlock and digit, most of the movement is in the fetlock; the least amount of movement is in the pastern joint; and movement in the coffin joint is intermediate.

Contraction of the common and lateral digital extensor muscles brings the bones and joints of the digit into alignment just before the hoof strikes the ground.

Normally, when the unshod hoof contacts the ground, the heels strike first. Most of the impact is sustained by the hoof wall, and compression of the wall creates tension on the interlocking insensitive and sensitive laminae and to the periosteum of the coffin bone. The domed sole is depressed slightly by the pressure of the coffin bone, causing expansion of the quarters. Descent of the coffin joint occurs and the navicular bone is compressed between the deep digital flexor tendon and the coffin joint. Concussion is dissipated by the digital cushion and the cartilages of the coffin bone.

Compression of the venous plexus between the laterally expanding digital cushion and the nonyielding hoof wall forces blood out of the hoof capsule. The hydraulic shock-absorption by the blood within the vessels augments the direct cushioning by the frog and digital cushion and the resiliency of the hoof wall.

During concussion, the four palmar ligaments of the pastern joint, the straight sesamoidean ligament, and the tendon of the deep digital flexor provide the tension necessary to prevent overextension of the joint. Tension of the contracting superficial digital flexor muscle tightens against its tendon's insertions on the distal end of the long pastern bone and proximal end of the short pastern bone, preventing the pastern joint from buckling.

The suspensory apparatus of the fetlock and the digital flexor tendons ensure that overextension of the fetlock joint, i.e., decreasing the dorsal articular angle, is minimal when the hoof strikes the ground. Yet at the gallop, when all of the horse's weight is on one

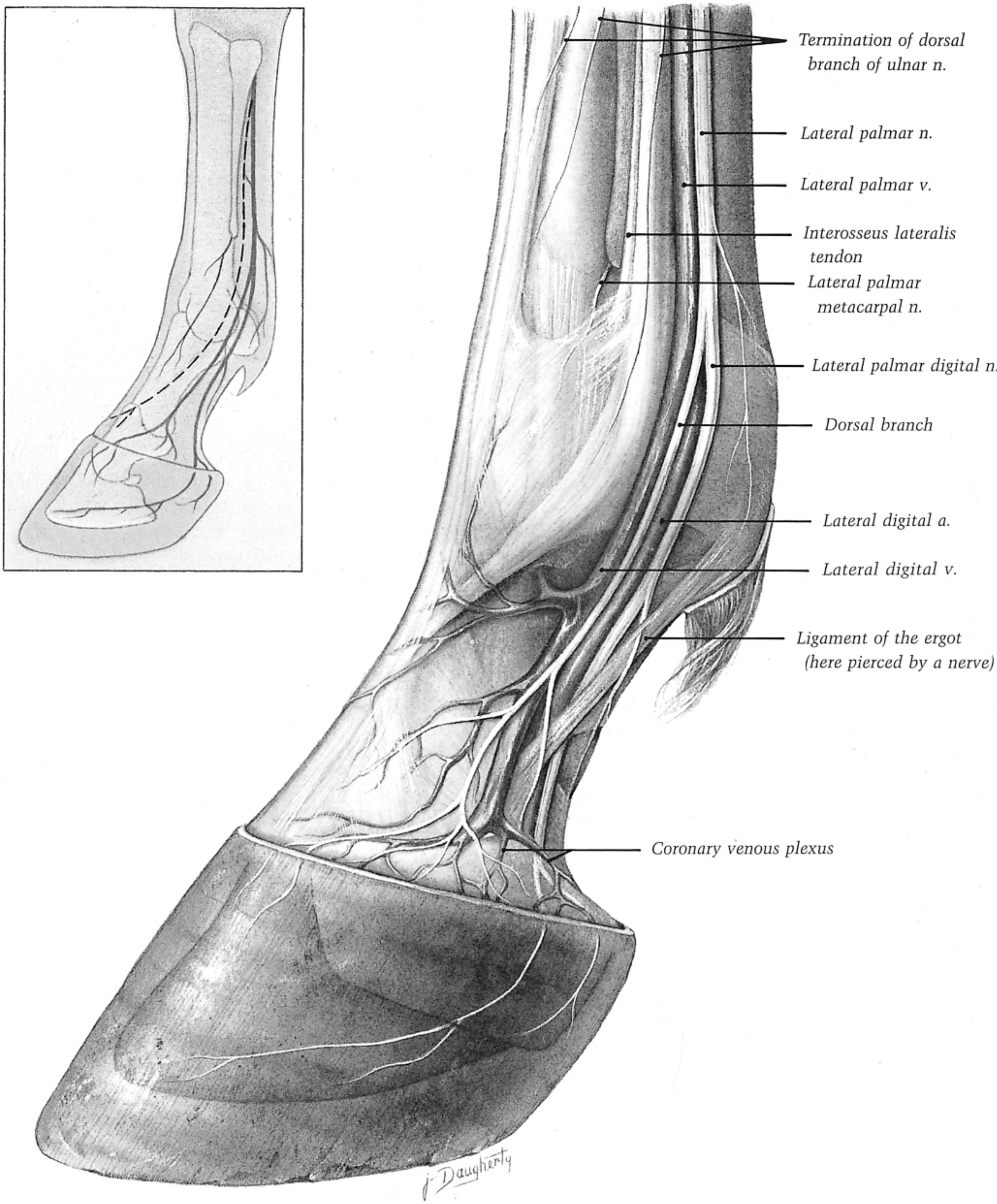

FIG. 1–14. Lateral aspect of the distal cannon, the fetlock, and digit. Skin and superficial fascia have been removed. n., nerve; v., vein; a., artery. Inset: schematic of the distribution of major nerves indicating variant branches (dashed lines).

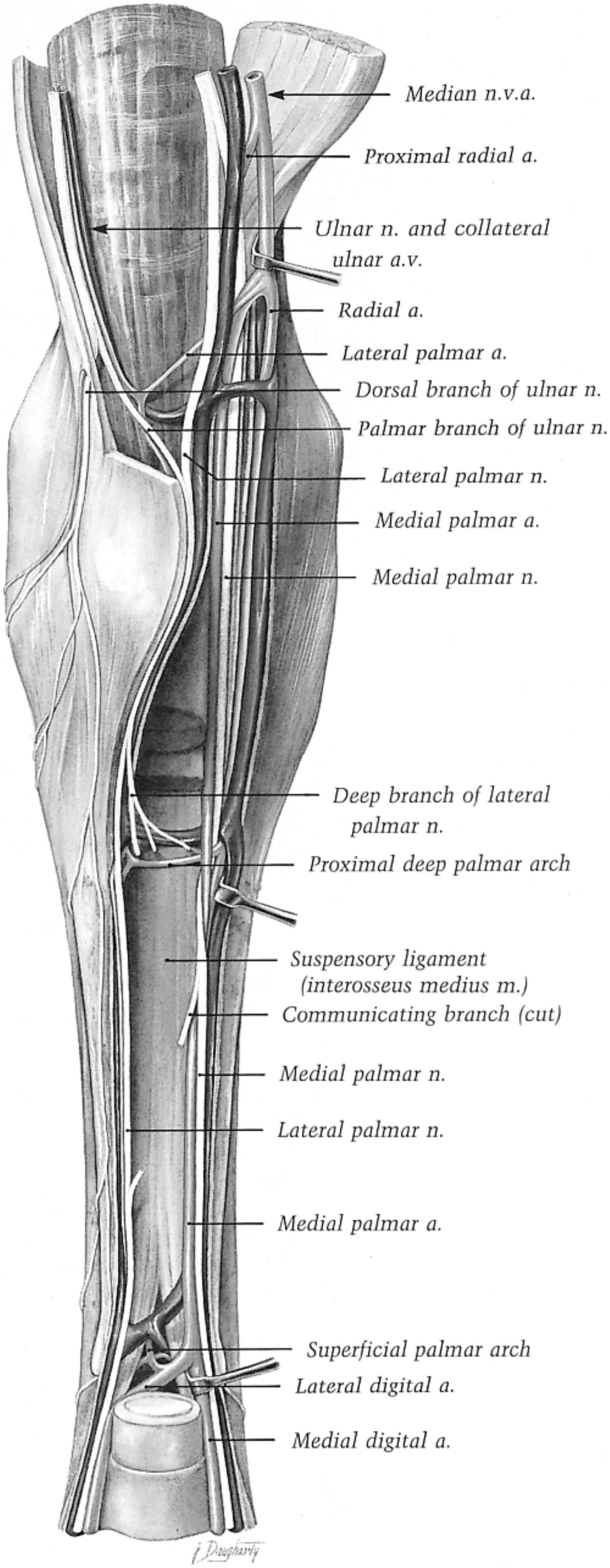

FIG. 1–15. Caudal view of the left carpus and cannon; most of the digital flexor tendons have been removed. n., nerve; v., vein; a., artery.

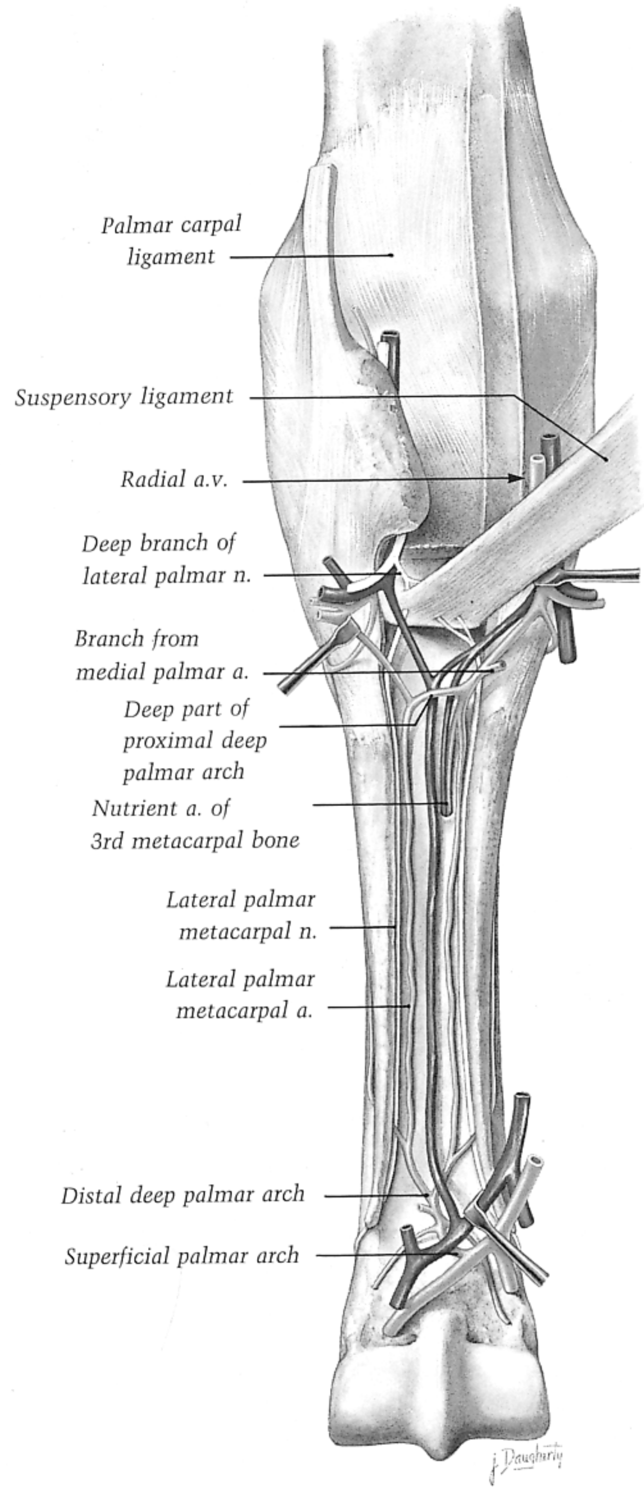

FIG. 1–16. Deep dissection of the caudal aspect of left carpus and cannon, with the medial palmar artery removed. n., nerve; v., vein; a., artery.

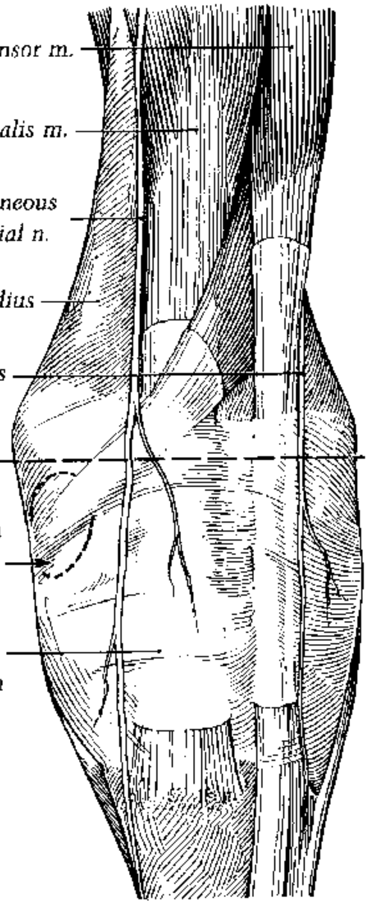

FIG. 1–17. Dorsal view of the left carpus. m., muscle; n., nerve.

forelimb momentarily, the palmar aspect of the fetlock comes very close to the ground.

Cannon Bone Region (Metacarpus)

The equine metacarpus consists of the cannon bone and the medial and lateral splint bones and the structures associated with them. Each splint bone is united by an interosseous ligament to the cannon bone. Length and curvature of the shafts and the prominence of the free distal extremities ("buttons") of the splint bones are variable. The proximal extremities of the metacarpal bones articulate with the distal row of carpal bones.

Deep to the skin, the common digital extensor tendon is located on the dorsal surface of the cannon bone (Fig. 1–15).

The superficial digital flexor tendon is deep to the skin and subcutaneous fascia throughout the length of the cannon. The deep digital flexor tendon lies against the superficial surface of the suspensory ligament. The carpal synovial sheath extends distally to enclose both digital flexor tendons as far as the middle of the cannon. At this level, the deep digital flexor tendon is joined by its accessory ligament (carpal check ligament or "inferior" check ligament) (see Fig. 1–22). The digital synovial sheath around the flexor tendons extends proximally into the distal fourth of the cannon (see Fig. 1–10).

The metacarpal groove, formed by the palmar surface of the cannon bone and the axial surfaces of the splint bones contains the suspensory ligament (interosseus medius muscle) and the diminutive interosseus medialis and lateralis muscles. The suspensory ligament arises from the distal row of carpal bones and the proximal end of the cannon bone (Fig. 1–16). In the distal fourth of the cannon, the suspensory ligament splits into two branches (see Fig. 1–15). Each branch extends to a sesamoid bone with an extensor branch and extends to the distal third of the pastern region continuing on to join the common digital extensor tendon.

Knee (Carpus)

The carpal region includes the carpal bones (radial, intermediate, ulnar, and accessory in the proximal row; first, second, third, and fourth in the distal row), the distal extremity of the radius (and fused ulna), the proximal extremities of the cannon and splint bones, and the structures adjacent to these bones.

Under the skin on the dorsal aspect of the carpus are the tendon sheaths of the extensor carpi radialis, extensor carpi obliquus, and the common digital extensor tendons, which are enclosed in fibrous extensor retinaculum. The tendon sheaths of the common digital and oblique carpal extensor tendons extend from the carpometacarpal articulation proximally to 6 to 8 cm proximal to the carpus (see Figs. 1–17 and 1–18).

The tendon sheath of the extensor carpi radialis muscle terminates at the middle of the carpus, and then the tendon becomes adherent to the retinaculum as it extends to its insertion on the metacarpal tuberosity. Deeply, the extensor retinaculum serves as the dorsal part of the common fibrous joint capsule of the carpal joints. Blood vessels and nerves of the carpus are illustrated in Figs. 1–17, 1–18, and 1–19.

The lateral collateral carpal ligament extends distally from its attachment on the styloid process of the radius (Fig. 1–20). The superficial part of the ligament attaches distally on the lateral splint bone and partly on the cannon bone. A canal between the superficial part and the deep part of the ligament provides passage for the tendon of the lateral digital extensor muscle and its synovial sheath. The deep part of the ligament attaches on the ulnar carpal bone.

Palmar to the lateral collateral carpal ligament, four ligaments support the accessory carpal bone (Fig. 1–20). Tendons of two muscles are associated with the accessory carpal bone. The short tendon of the ulnaris

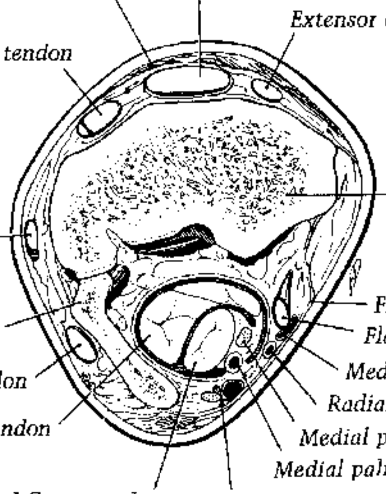

FIG. 1–18. Cross section of left forearm immediately proximal to the antebrachiocarpal joint. n., nerve; v., vein; a., artery.

lateralis muscle attaches to the proximal border and lateral surface of the bone; the muscle's long tendon passes through a groove on the bone's lateral surface and then continues distally to insert on the proximal extremity of the lateral splint bone (see Fig. 1–17). The single tendon of the flexor carpi ulnaris muscle attaches to the proximal border of the accessory carpal bone.

On the medial side of the carpus, the medial collateral carpal ligament extends from the medial styloid process of the radius and widens distally to attach to the proximal ends of the medial splint and cannon bones. Bundles of fibers also attach to the radial, second, and third carpal bones (Fig. 1–21). The inconstant first carpal bone may be embedded in the palmar part of the medial collateral carpal ligament adjacent to the second carpal bone.

The flexor retinaculum is a broad fibrous band extending from the medial collateral carpal ligament to the accessory carpal bone, bridging the carpal groove and forming the carpal canal (see Fig. 1–18). Fibrous connective tissue fills the carpal canal, supporting several structures that pass through the canal. The superficial and deep digital flexor tendons are enclosed in the carpal synovial sheath extending from a level 8 to 10 cm proximal to the carpus distally to the middle of the metacarpus (see Fig. 1–19).

The palmar carpal ligament forms the dorsal wall of the carpal canal, its deep face serving as the palmar part of the common fibrous capsule of the carpal joints. It attaches to the three palmar radiocarpal ligaments, three palmar intercarpal ligaments, four palmar carpometacarpal ligaments, and the palmar surfaces of the carpal bones. Distally, the palmar carpal ligament gives origin to the accessory ligament (carpal check ligament) of the deep digital flexor tendon, which joins the tendon at the middle of the metacarpus.

The antebrachiocarpal joint is located between the radius and ulna and the proximal row of carpal bones. The midcarpal joint is located between the proximal and distal rows of carpal bones (these are hinge joints). The carpometacarpal joint is located between the distal row of carpal bones and the cannon and splint bones form a plane joint with minimal movement. An extensive antebrachiocarpal synovial sac is deep to the fibrous joint capsule. A palmarolateral pouch extends from this sac. The midcarpal synovial sac communicates with the small carpometacarpal sac between the third and fourth carpal bones.

The antebrachiocarpal and midcarpal joints are flexed by the combined action of the flexor carpi radialis, flexor carpi ulnaris, and ulnaris lateralis muscles; the joints are extended by the extensor carpi radialis and extensor carpi obliquus (abductor digiti I longus) muscles. The flattened dorsal articular areas of the carpal joints and the palmar carpal ligament uniting the palmar aspect of the carpal bones all serve to prevent overextension of the antebrachiocarpal and midcarpal joints.

Further stability is given to the extended carpus dorsally by the tendon of the extensor carpi radialis tendon and palmarly by the tendoligamentous support of the "check ligaments" and the digital flexor tendons. The accessory (radial check) ligament (really the radial head) of the superficial digital flexor is a flat fibrous band originating on a ridge on the caudomedial aspect of the distal part of the radius and joining the tendon

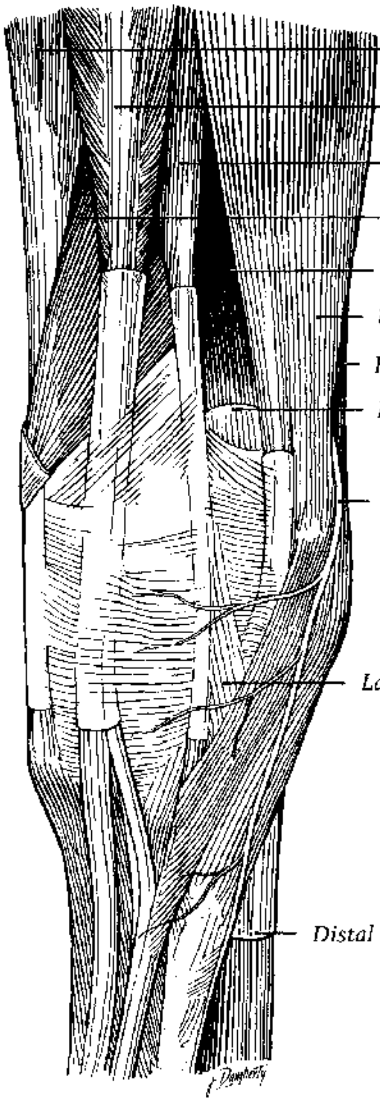

FIG. 1–19. Lateral view of the left distal forearm, carpus, and proximal metacarpus. m., muscle; n., nerve.

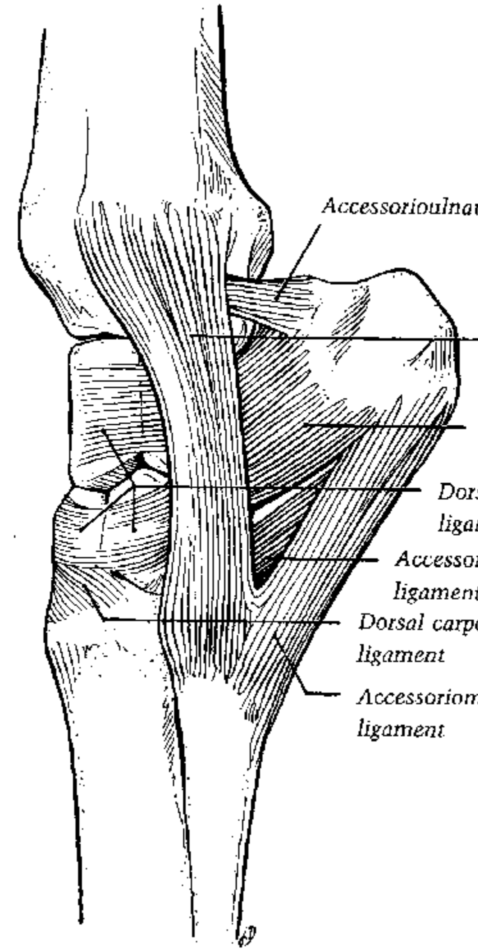

FIG. 1–20. Dissection of carpal ligaments; lateral view.

of the humeral head under the proximal part of the flexor retinaculum (Fig. 1–22). The accessory (carpal check) ligament of the deep digital flexor continues distally from the palmar carpal ligament to join the main tendon near the middle of the metacarpus.

Forearm (Antebrachium)

The forearm includes the radius and ulna and the muscles (Fig. 1–22), vessels, nerves (Fig. 1–23), and skin surrounding the bones. The prominent muscle belly of the extensor carpi radialis muscle bulges under the skin on the cranial aspect (Fig. 1–24). A horny cutaneous structure, the chestnut, is present on the medial skin of the distal one-third of the forearm. The chestnut is considered to be a vestige of the first digit.

Four muscles comprise the extensor group of the antebrachium. The lateral digital extensor muscle, the common digital extensor muscle, the extensor carpi radialis muscle, and the smallest muscle of the extensor group, the extensor carpi obliquus muscle (Figs. 1–19 and 1–24).

The flexor carpi radialis, the flexor carpi ulnaris, and the ulnaris lateralis muscles flex the carpal joint and extend the elbow joint (Fig. 1–25).

The superficial digital flexor muscle and the deep digital flexor muscle flex the digit and fetlock. The accessory ligament (radial or "superior" check ligament) attaches the mediocaudal surface of the distal half of the radius to the superficial flexor tendon (see Fig. 1–22).

Some nerves and blood vessels are illustrated in Figure 1–23.

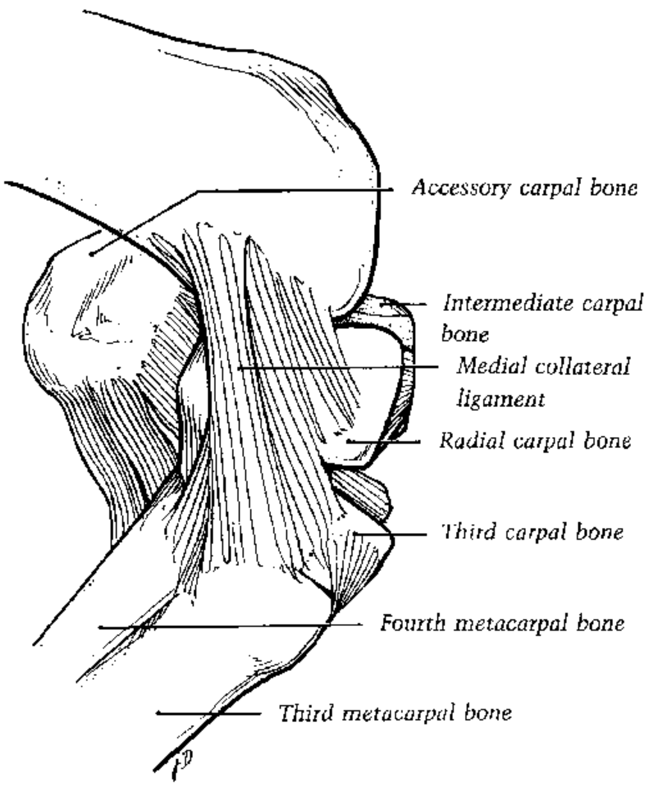

FIG. 1–21. Dissection of carpal ligaments; medial view.

An interosseous ligament attaches the shaft of a foal's ulna to the radius. Ossification of the ligament occurs in the young horse, but the proximal part of the ligament persists until it becomes ossified in very old horses.

Elbow Joint (Humeroradiol Joint and Olecranon)

Muscles associated with the elbow joint include two principal flexors, the biceps brachii and the brachialis (aided by the extensor carpi radialis and common digital extensor muscles), and three principal extensors, the tensor fasciae antebrachii, the triceps brachii, and the anconeus (assisted by the flexors of the carpus and digit) (Figs. 1–26 and 1–27).

A medial collateral ligament (Fig. 1–27) and a lateral collateral ligament add stability to this joint.

Arm and Shoulder (Humerus and Scapula)

The arm is the region around the humerus. The shoulder includes the shoulder joint (scapulohumeral joint), the region around the scapula (which blends dorsally into the withers) (Figs. 1–22 and 1–25) and the muscles of the shoulder (see Figs. 1–22, 1–25, and 1–26).

The articular configuration of the ball-and-socket shoulder joint and the support of the surrounding muscles give great stability to the joint. Major movements are flexion and extension. While standing, the angle of the shoulder joint is 50 to 60°.

The equine shoulder girdle is muscular and ligamentous. Component parts of the shoulder girdle connect the shoulder, arm, and forearm to the trunk, neck, and head.

The medial aspect of the arm and shoulder contains the large vessels and nerves supplying the thoracic limb (Fig. 1–27).

Stay Apparatus of the Thoracic Limb

The stay apparatus consists of the ligaments, tendons, and muscles serving to stabilize the joints of the thoracic limb in the standing position. This permits the horse to sleep while standing with a minimum of muscular activity (see Fig. 1–22).

The four palmar ligaments stretched tightly across the pastern joint, the straight distal sesamoidean ligament attached to the short pastern bone, and the deep digital flexor tendon stabilize the pastern joint and prevent its overextension. Under tension in the standing position, the superficial digital flexor tendon forestalls flexion of the pastern joint by exerting palmar force on the joint.

The suspensory apparatus of the fetlock consists of the suspensory ligament (interosseus medius muscle), the metacarpointersesamoidean ligament and embedded proximal sesamoid bones, and the three distal sesamoidean ligaments. The suspensory apparatus prevents extreme overextension of the fetlock joint. Reinforcing support is provided by the digital flexor tendons, the superficial digital flexor tendon as it extends from the accessory (radial check) ligament on the radius to the long and short pastern bones, and the deep digital flexor tendon as it extends from the accessory (carpal check) ligament off the palmar carpal ligament to the coffin bone.

The carpus is stabilized by the palmar carpal ligament and the configuration of the articular surfaces of the carpal bones. The digital flexor tendons in the carpal canal and the extensor tendons dorsally, especially the extensor carpi radialis tendon, lend further stability to the carpus.

Although a certain amount of muscle tone is present in all "resting" muscles of the limb, the tension exerted by the long head of the triceps brachii muscle is essential to prevention of flexion of the elbow joint and collapse of the forelimb. The elbow joint is stabilized further by its collateral ligaments and surrounding muscles originating from the humerus.

A tendinous continuum extending from the supraglenoid tubercle to the metacarpal tuberosity is

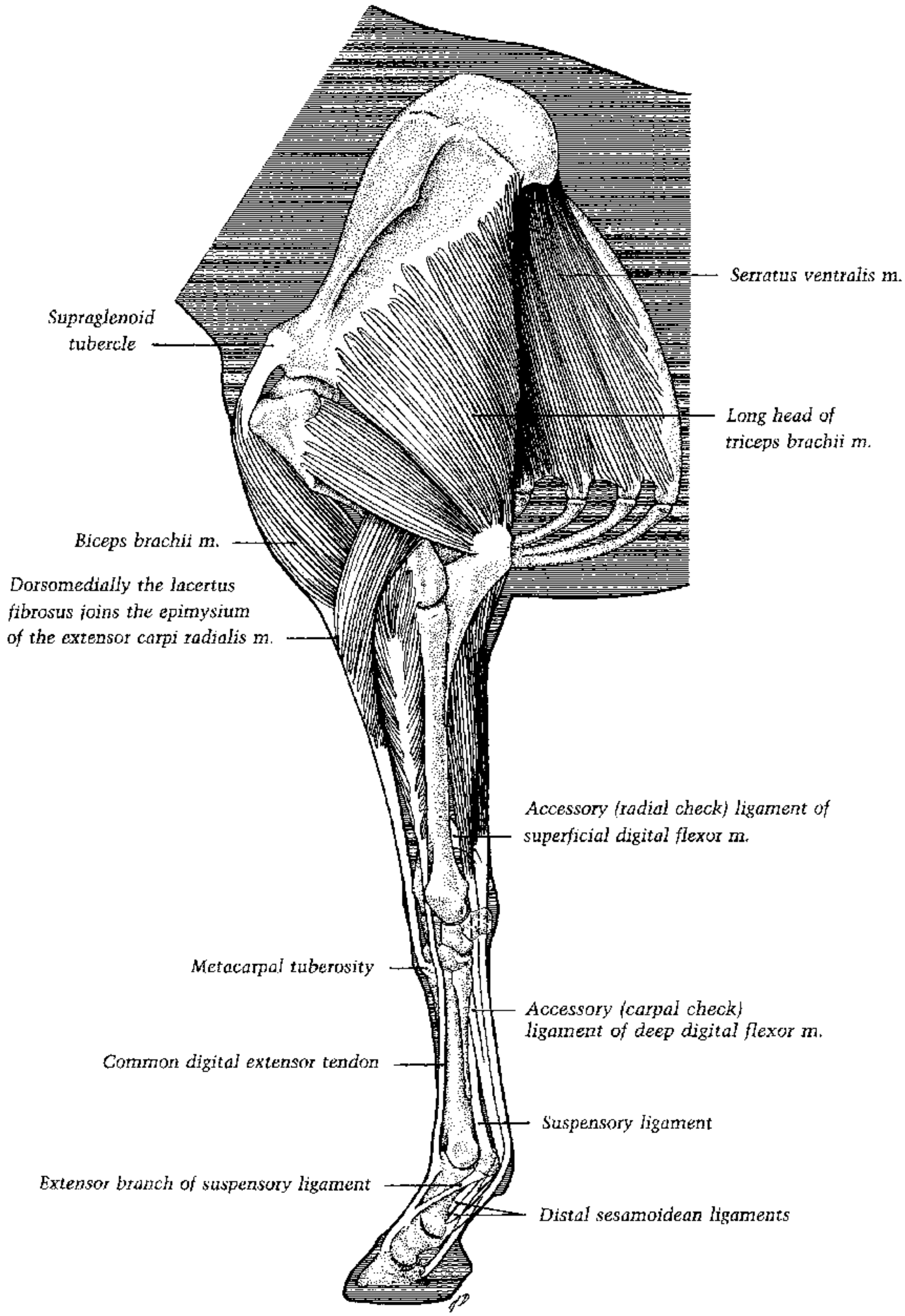

FIG. 1–22. Stay apparatus of the thoracic limb. m., muscle.

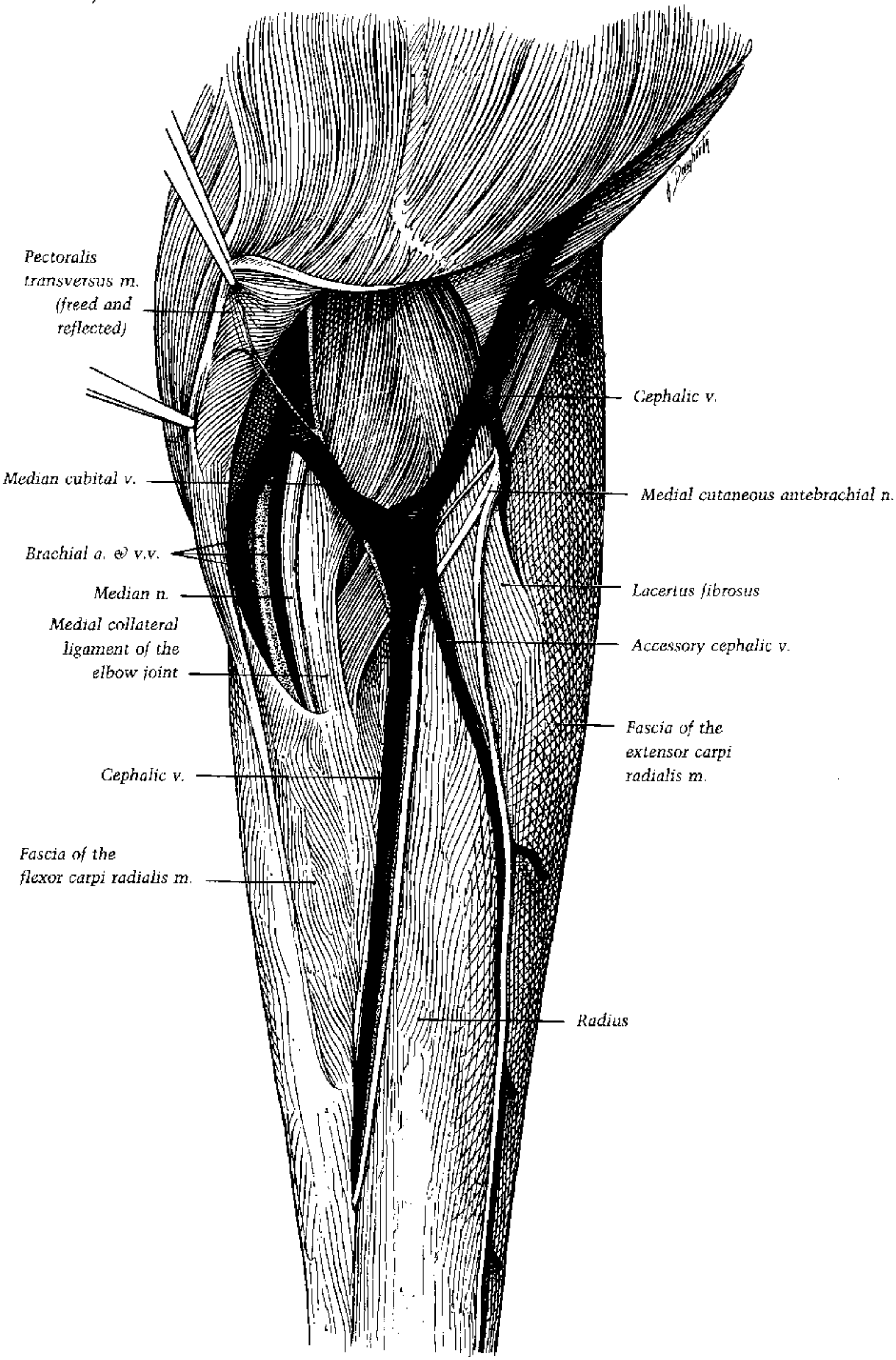

FIG. 1–23. Caudomedial view of a superficial dissection of the left elbow and forearm. m., muscle; n., nerve; v., vein; a., artery.

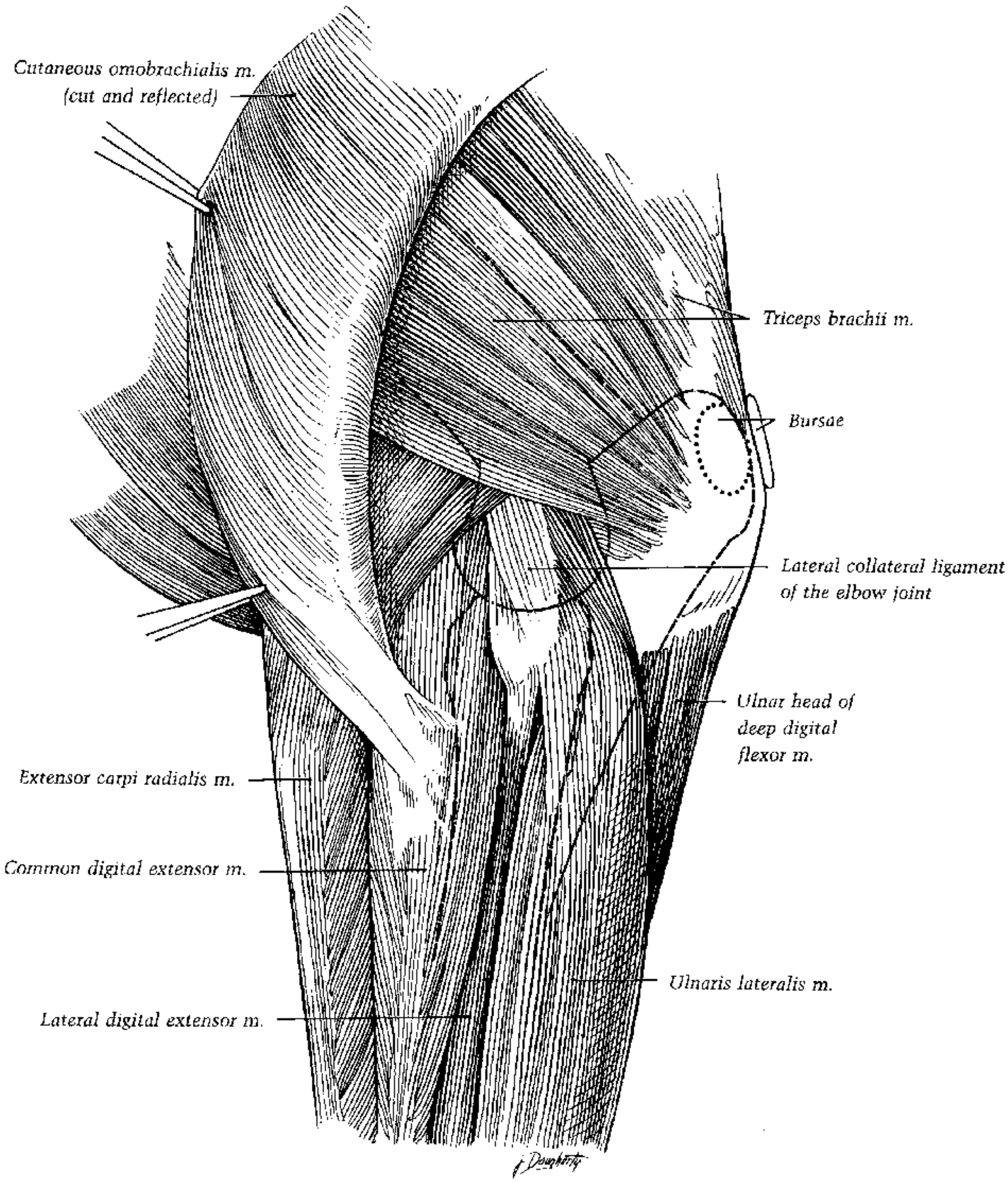

FIG. 1–24. Lateral view of the left elbow. The distal extremity of humerus, the proximal extremity of radius, and the ulna are indicated by dashed lines. m., muscle.

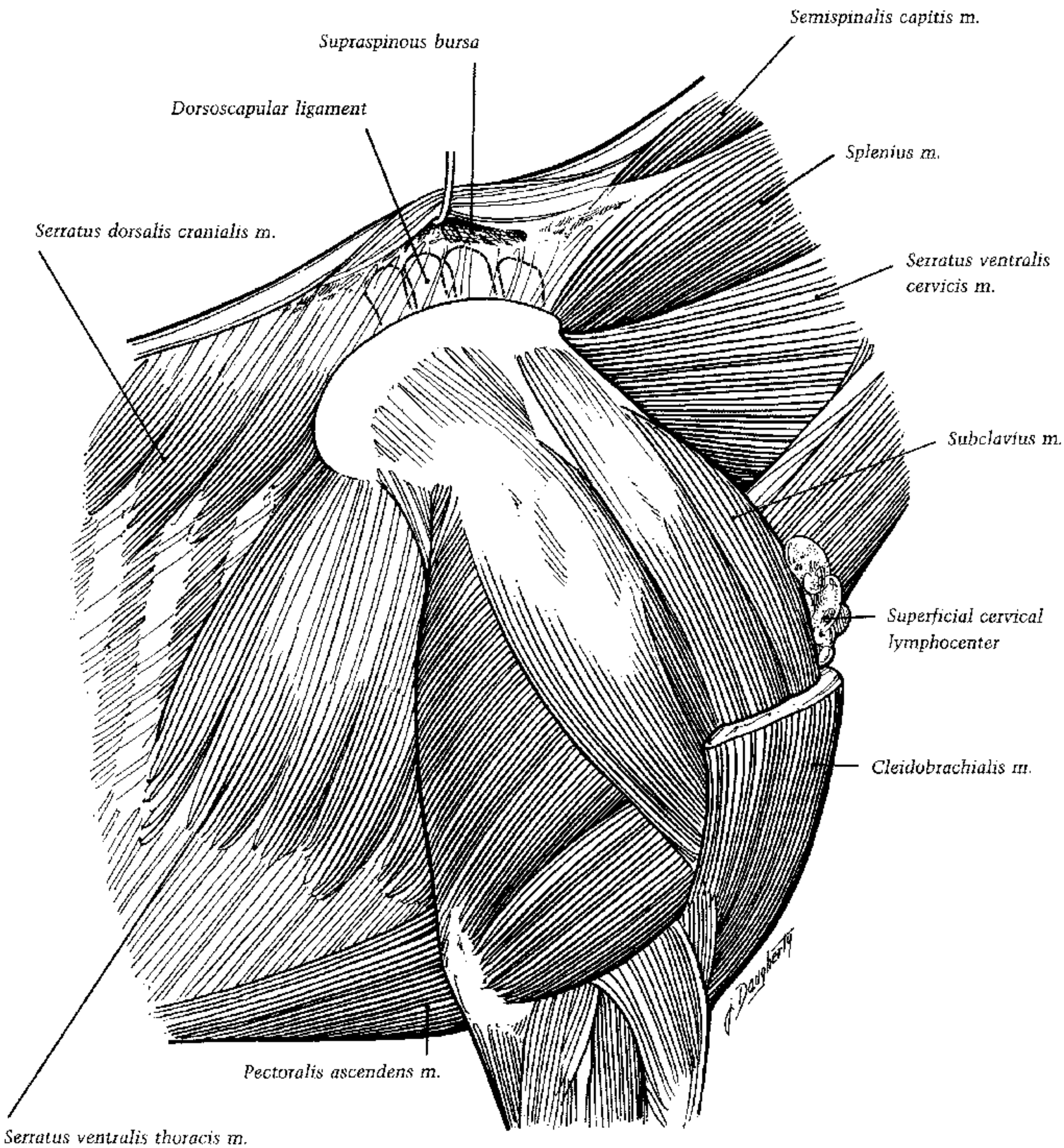

FIG. 1–25. Dissection of the right shoulder and dorsoscapular ligament. Spines of thoracic vertebrae 2 to 5 are outlined by dashed lines. m., muscle.

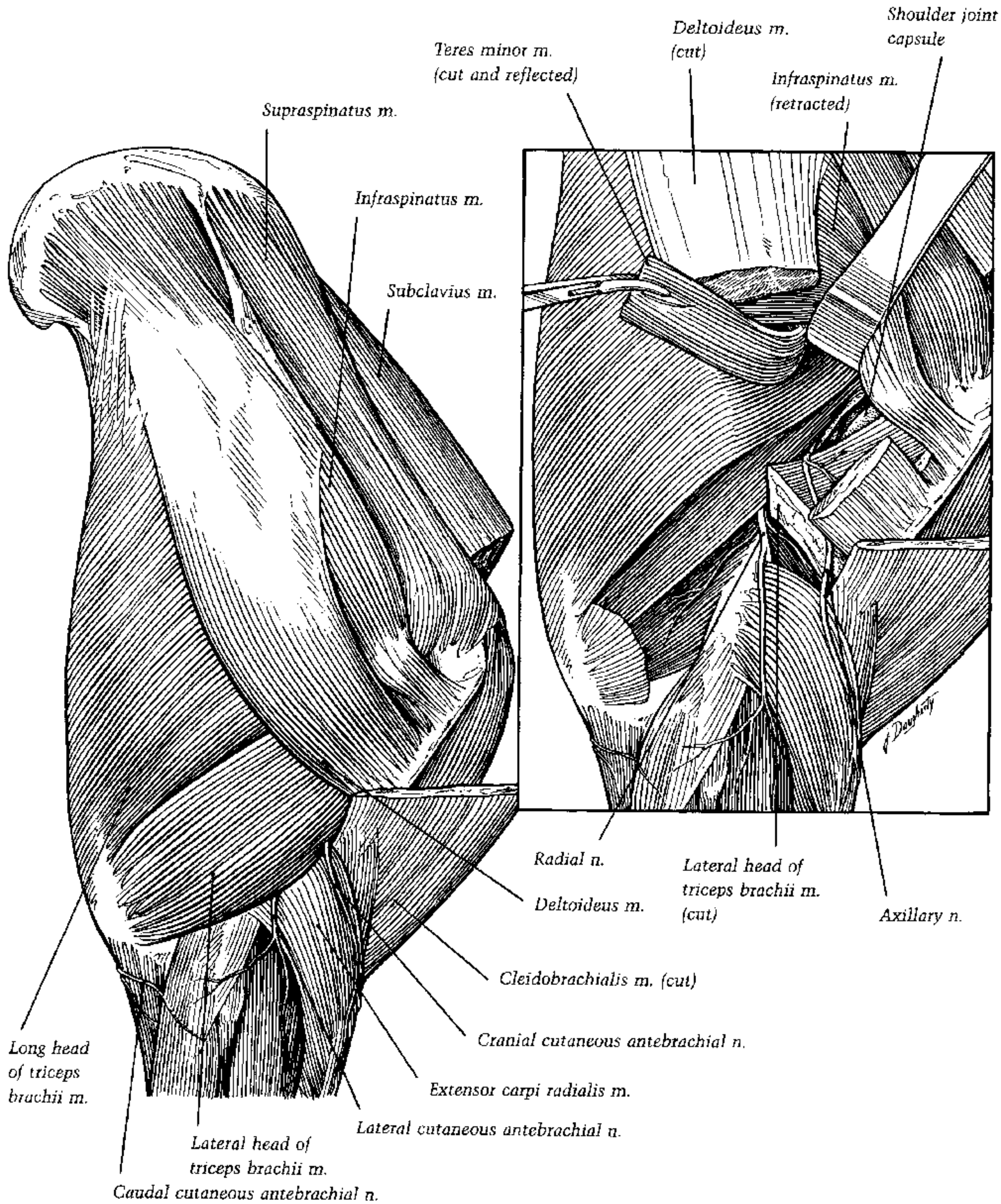

FIG. 1–26. Lateral aspect of the right shoulder. Inset: deeper dissection exposing the shoulder joint. m., muscle; n., nerve.

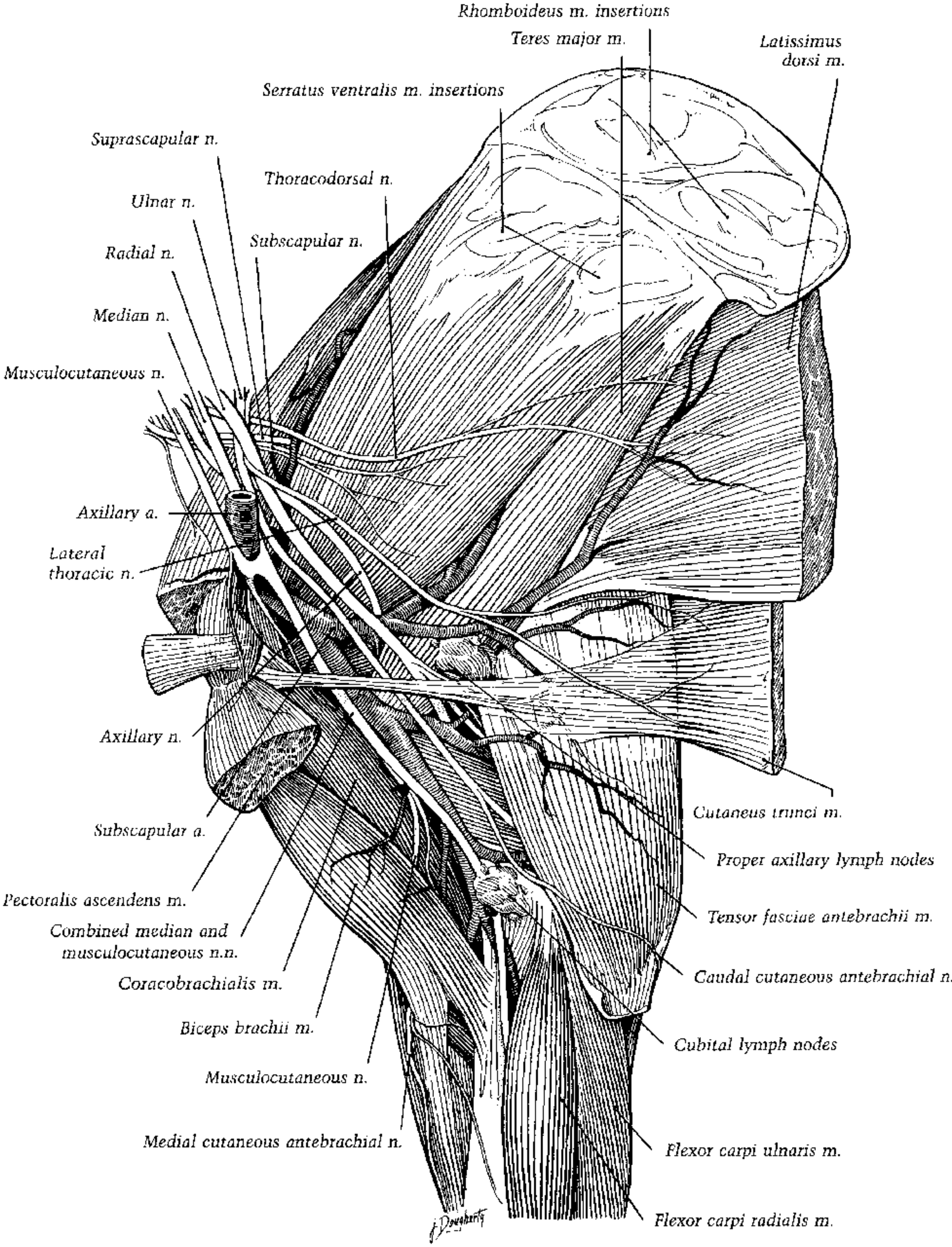

FIG. 1–27. Medial dissection of the left shoulder, arm, and proximal forearm. m., muscle; n., nerve; a., artery.

formed by the main tendon of the biceps brachii muscle and its distal superficial tendon joining the tendon of the extensor carpi radialis muscle. This complex prevents flexion of the shoulder joint caused by the weight of the trunk. Additionally, the deep radial tendon of the biceps brachii helps stabilize the elbow joint, and the tendon of the extensor carpi radialis opposes flexion of the carpus.

Growth Plate Closure

Several investigators have reported on closure times for the growth plates (epiphyseal cartilages) of the bones in equine limbs. Tables 1–1 and 1–2 (see p. 40) summarize the ranges of reported closure times based on examination of x-rays and gross and microscopic specimens.

Pelvic Limb (Fig. 1–28)

Digit and Fetlock

The hindfoot is narrower than the forefoot, corresponding to the shape of the coffin bone. Compared to the forefoot, the angle of the toe of the hindfoot is slightly greater, varying from 55 to 60°.

The long digital extensor muscle's tendon attaches to the dorsal surfaces of the long and short pastern bones and the extensor process of the coffin bone.

The hind cannon is about 16% longer than the corresponding front cannon, and the hind cannon bone is more rounded than the front cannon bone. The hind's lateral splint bone, particularly its proximal extremity, is larger than the hind's medial splint bone.

The nerves, arteries, veins, and muscles of the cannon bone region are portrayed in Figures 1–29 and 1–30.

Hock (Tarsus)

The bones of the hock include the talus, calcaneus, and the central, first and second fused, third and fourth tarsal bones (Fig. 1–28). Proximally, the trochlea of the talus articulates with the tibia in the tarsocrural (tibiotarsal) joint; distally, the distal row of tarsal bones and the cannon and two splint bones articulate in the tarsometatarsal joint. The nerves and vessels of the hock region are illustrated in Figures 1–29, 1–30, and 1–31. The long and lateral digital extensor tendons and their sheaths are illustrated in Figure 1–29.

The tendon of the peroneus tertius muscle is superficial to the tendon of the tibilias cranialis muscle (see Figs. 1–31, 1–32, and 1–33). The tendon of the peroneus tertius forms a sleevelike cleft through which the tendon of the tibialis cranialis and its synovial sheath pass. The latter tendon then bifurcates into a dorsal tendon, which inserts on the large metatarsal bone, and a medial (cunean) tendon, which inserts on the first tarsal bone.

A horny chestnut, the presumed vestige of the first digit, is located in the skin on the medial aspect of the hock.

A palpable feature of the medial aspect of the hock is the medial (cunean) tendon of the tibialis cranialis muscle as it goes to its insertion on the first tarsal bone (see Fig. 1–32).

The principal component of the composite hock joint is the tarsocrural joint, a hinge based on the shape of the articular surfaces or a snap joint based on

TABLE 1–1. ***Ranges of Growth Plate Closure Times in Equine Thoracic Limbs***

Scapula		Cannon Bone	
Proximal*	36+ mo.	Proximal	Before Birth
Distal	9–18 mos.	Distal	6–18 mos.
Humerus		Long Pastern Bone	
Proximal	26–42 mos.	Proximal	6–15 mos.
Distal	11–34 mos.	Distal	Before Birth to 1 mo.
Radius		Short Pastern Bone	
Proximal	11–25 mos.	Proximal	6–15 mos.
Distal	22–42 mos.	Distal	Before Birth to 1 wk.
Ulna		Coffin Bone	
Proximal	27–42 mos.	Proximal	Before Birth
Distal	2–12 mos. (some up to 4 yrs.)		

*Ossification center

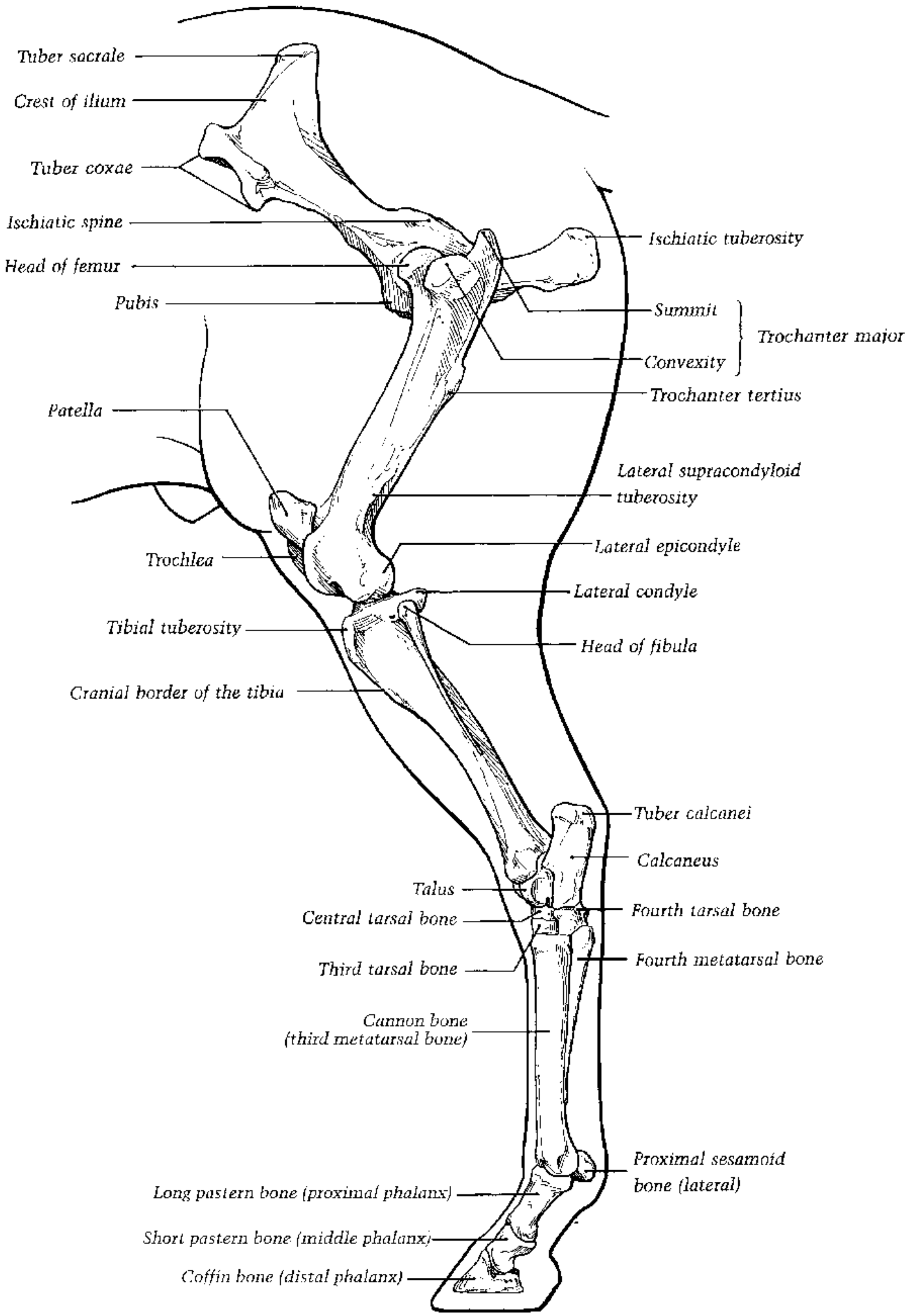

Fig. 1–28. Bones of the left hind pelvic limb; lateral view.

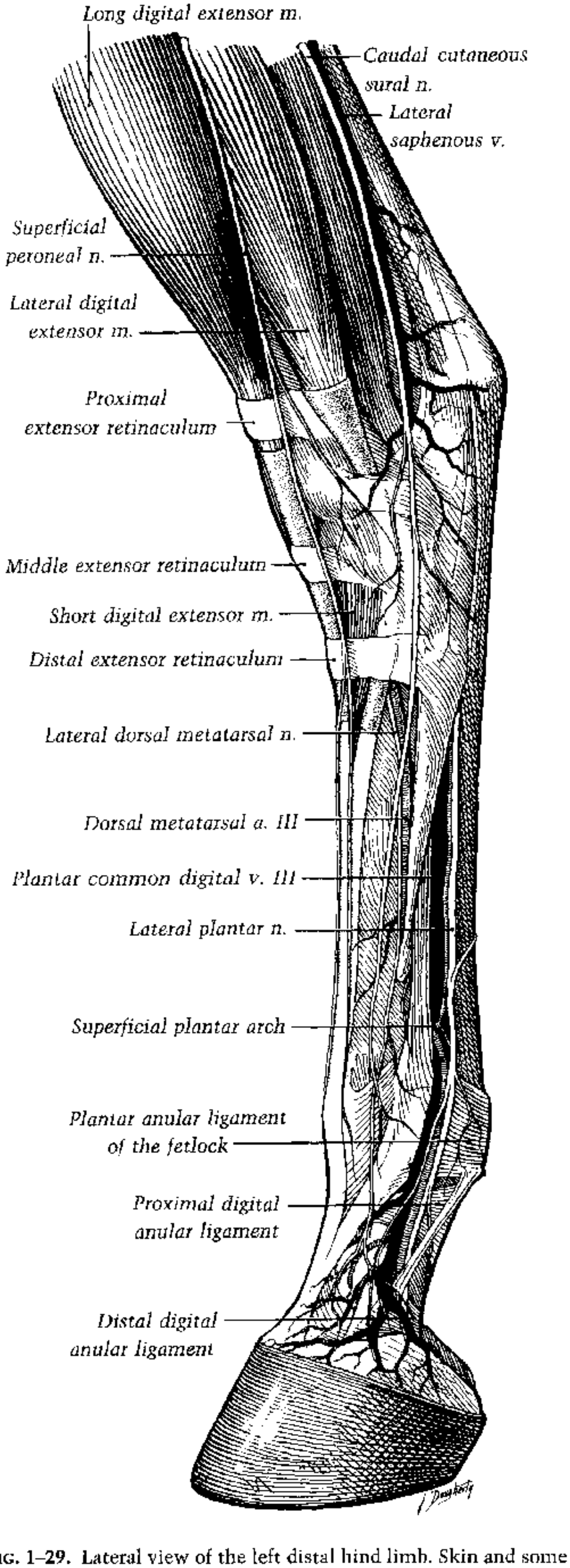

FIG. 1–29. Lateral view of the left distal hind limb. Skin and some of the fascia have been removed. m., muscle; n., nerve; v., vein; a., artery.

the snapping movement of the joint into or out of extension. The interarticular and tarsometatarsal joints are plane joints capable of only a small amount of gliding movement.

A long collateral ligament and three short collateral ligaments bind each side of the equine hock (Figs. 1–34 and 1–35).

Three pouches can protrude from the large tarsocrural synovial sac where it is not bound down by ligaments.

The tarsocrural joint is flexed by contraction of the tibialis cranialis muscle and the passive pull of the tendinous peroneus tertius muscle. Contraction of the gastrocnemius, biceps femoris, and semitendinosus muscles and the passive pull of the tendinous superficial digital flexor muscle extends the joint. By virtue of its attachments in the extensor fossa of the femur proximally, and on the lateral aspect of the hock and dorsal surface of the cannon bone distally, the peroneus tertius passively flexes the joint when the stifle joint is flexed. The superficial digital flexor muscle originates in the supracondyloid fossa of the femur and inserts first on the calcaneal tuber. This part of the superficial digital flexor serves to passively extend the hock joint when the stifle joint is extended. The two tendinous, passively functioning muscles constitute the reciprocal apparatus (see Fig. 1–36).

During flexion of the hock joint, the lower leg limb moves slightly outward due to the configuration of the joint. As the hock articulates, approximately one-third of the distance from the point of maximum extension to the point of maximum flexion, a snapping motion occurs influenced through tension exerted by the three short medial collateral ligaments (Fig. 1–37).

Gaskin (Crus)

The gaskin is the region of the hind limb containing the tibia and fibula. Thus, it extends from the hock joint to the stifle joint.

Stifle (Femorotibial and Femoropatellar Joint)

The stifle is the region including the stifle joint and surrounding structures. Deep to the skin, three patellar ligaments descend from the patella, converging to their attachments on the tibial tuberosity.

Overall, the two joints of the stifle, the femoropatellar and femorotibial joints, form a hinge.

The patella is essentially a sesamoid bone interposed in the termination of the quadriceps femoris muscle with the three patellar ligaments comprising the tendon of insertion.

The femorotibial joint is complex, the cranial and caudal cruciate ligaments lie between the joint capsule's medial and lateral synovial sacs.

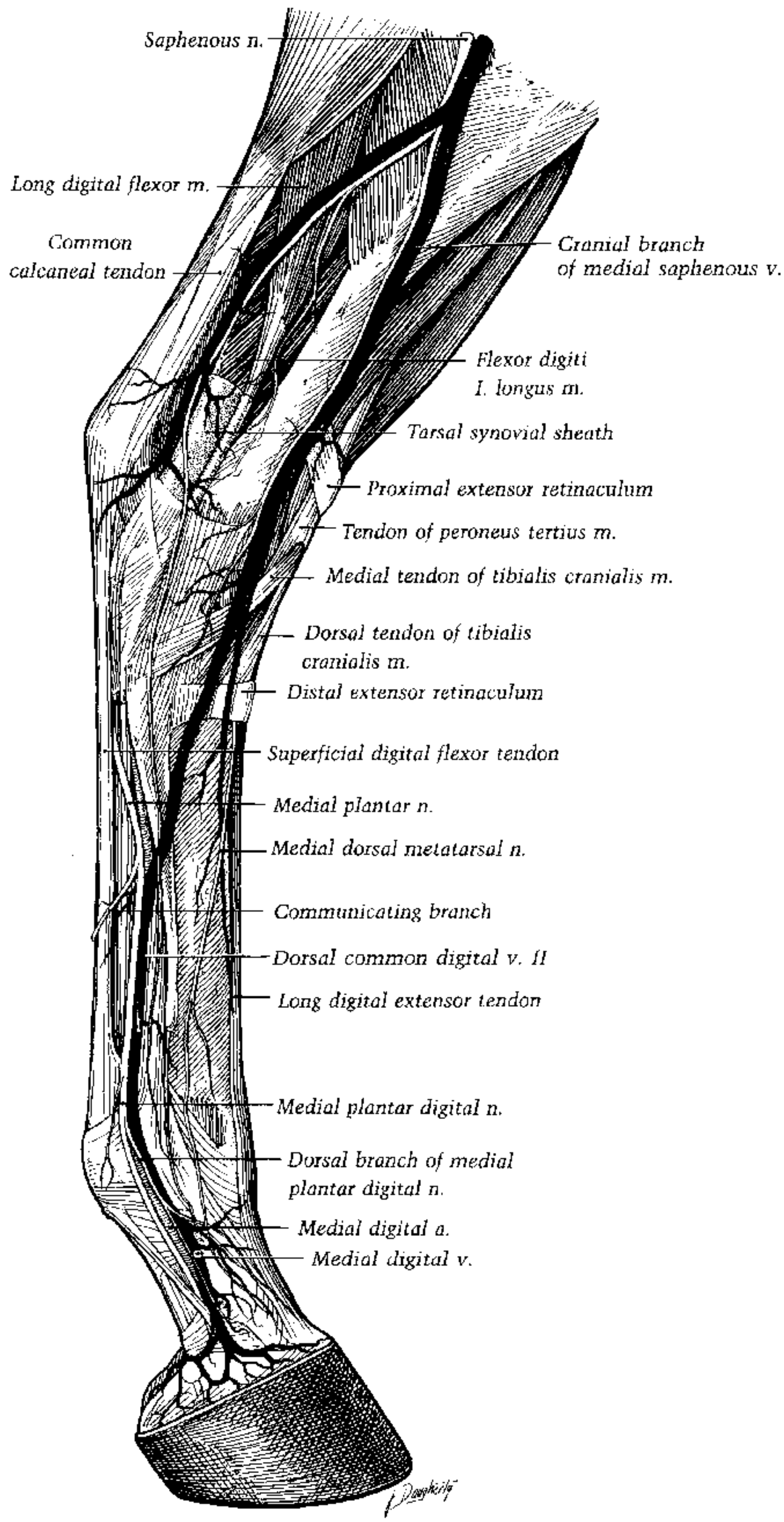

FIG. 1–30. Medial view of the left distal hind limb. Skin and some of the fascia have been removed. m., muscle; n., nerve; v., vein; a., artery.

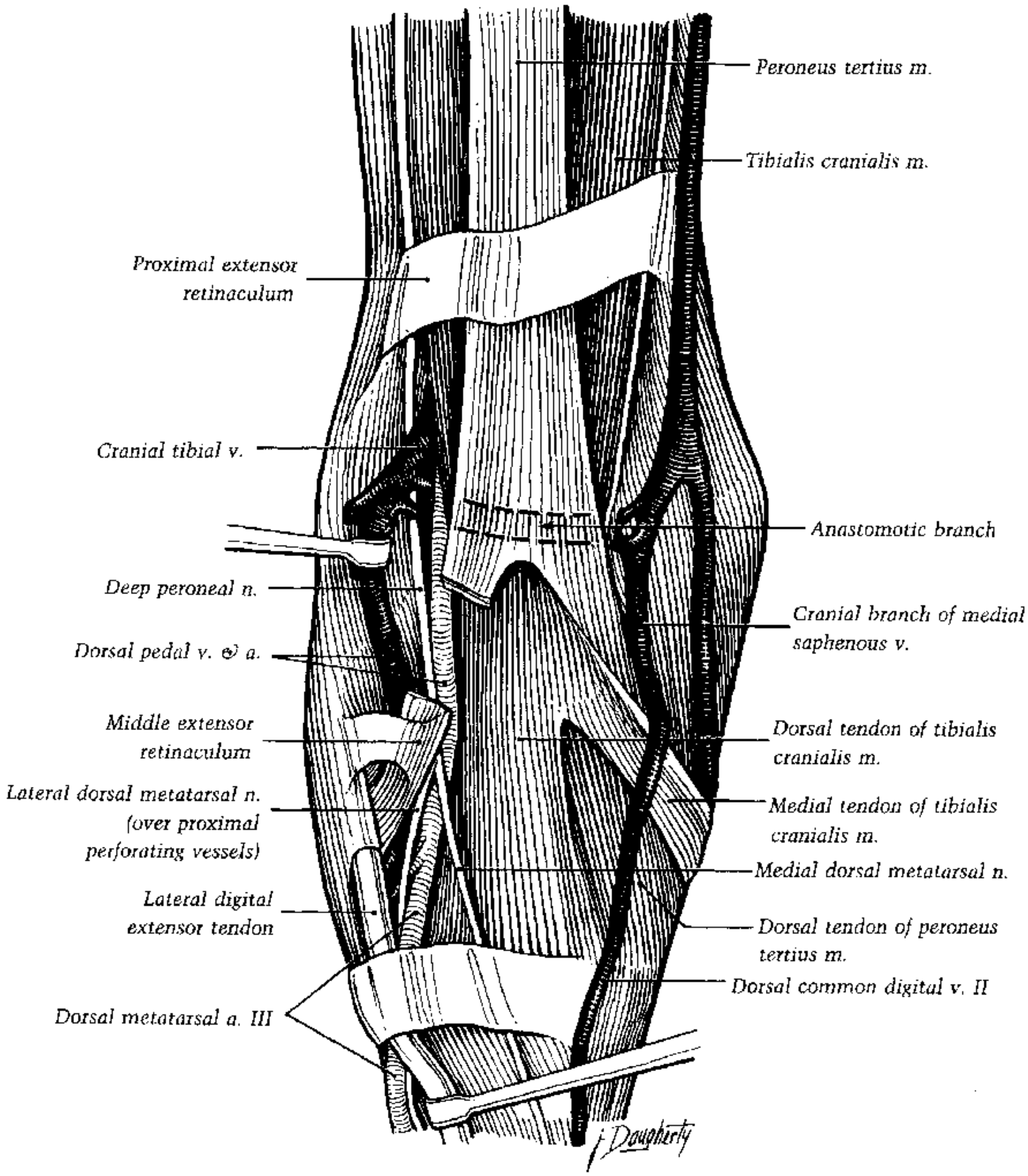

Fig. 1–31. Dorsal dissection of the right tarsus. The long digital extensor and short digital extensor muscles have been removed. The lateral tendon of the peroneus tertius is sectioned. Note its junction with the middle extensor retinaculum. m., muscle; n., nerve; a., artery; v., vein.

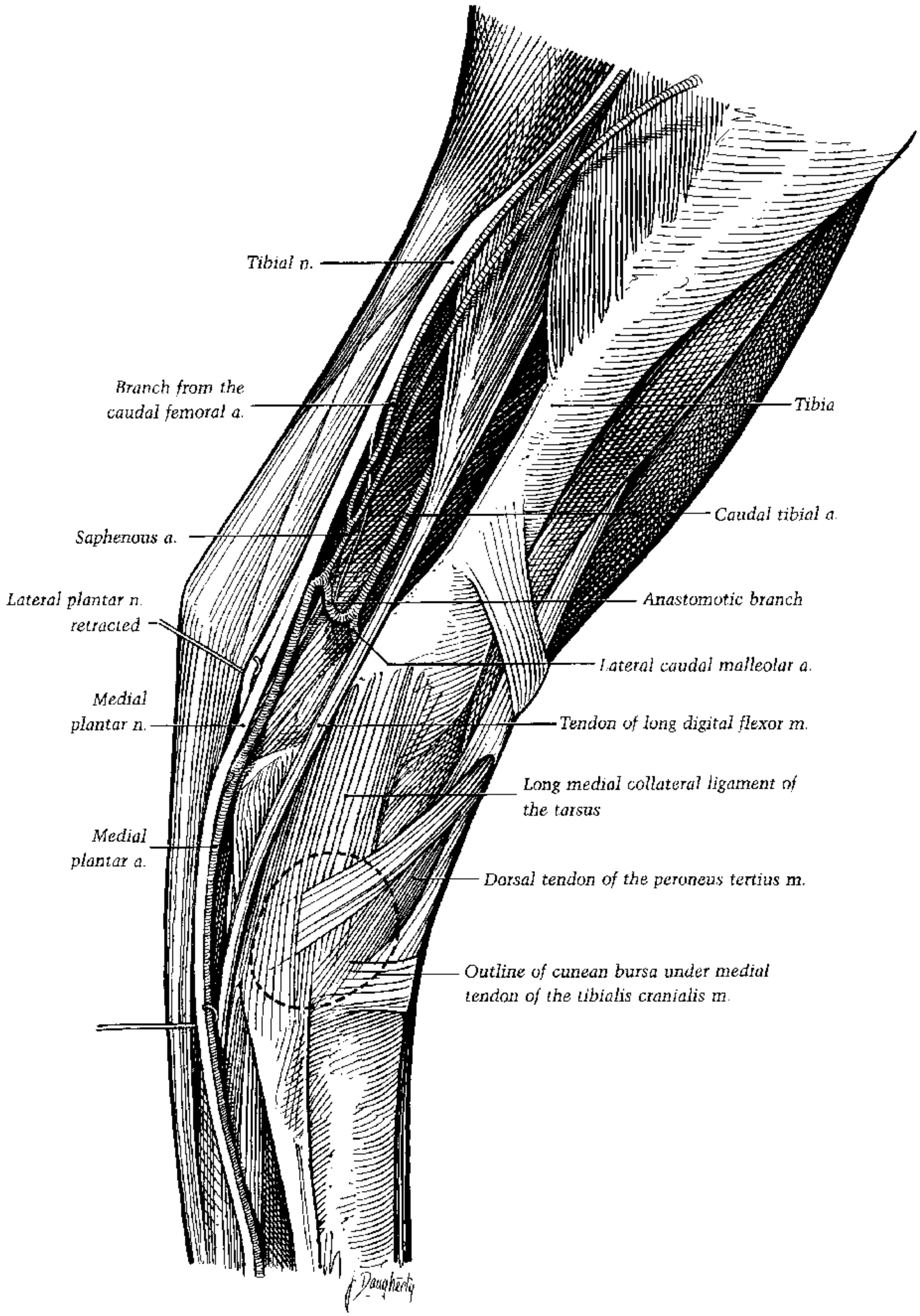

FIG. 1–32. Medial view of the left hock region. m., muscle; n., nerve; a., artery.

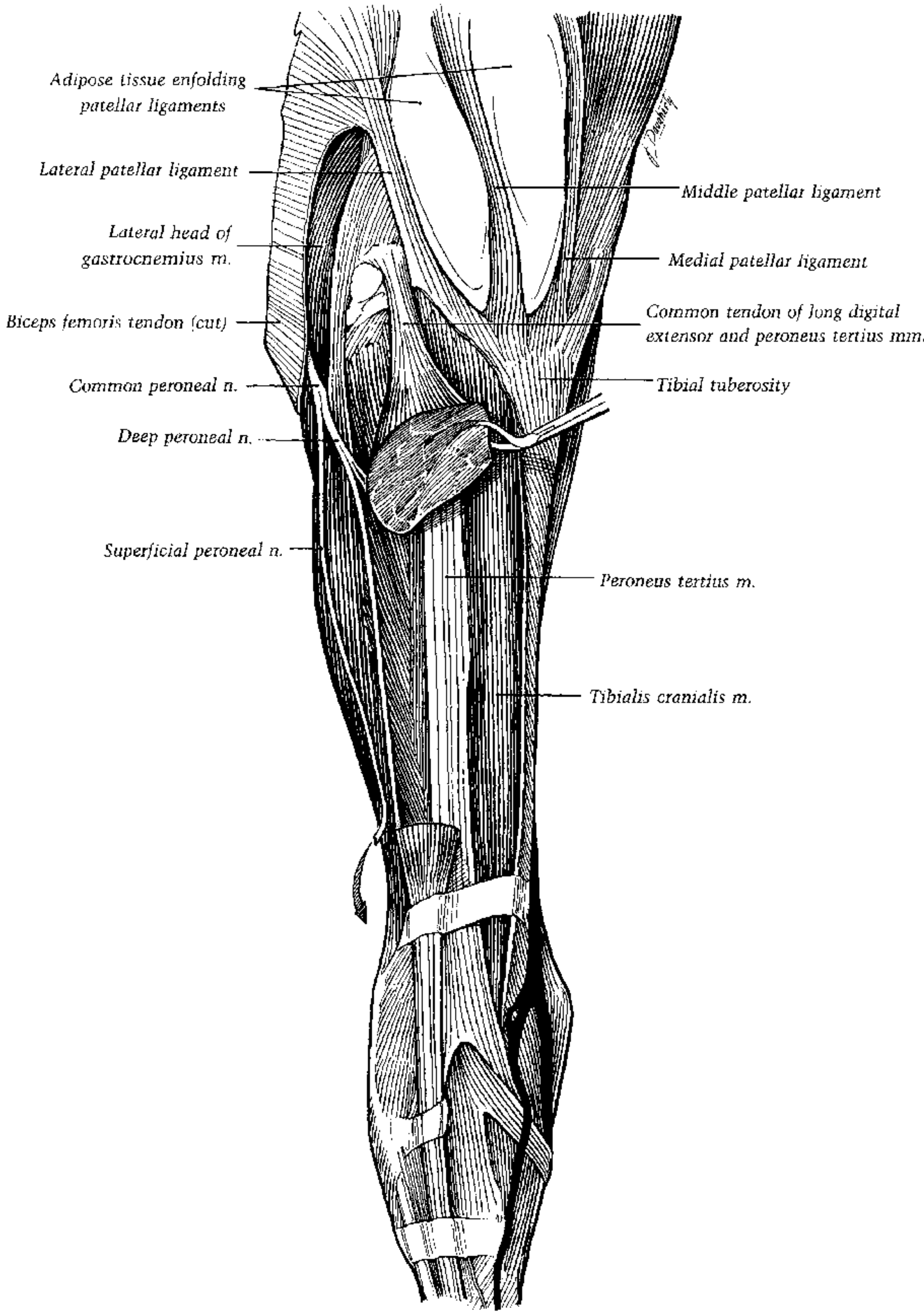

Fig. 1–33. Dorsal view of a dissection of the right stifle, crus, and tarsus. Long digital extensor muscle belly has been removed and a portion of the superficial peroneal nerve has been removed with the fascia (arrow). m., muscle; n., nerve.

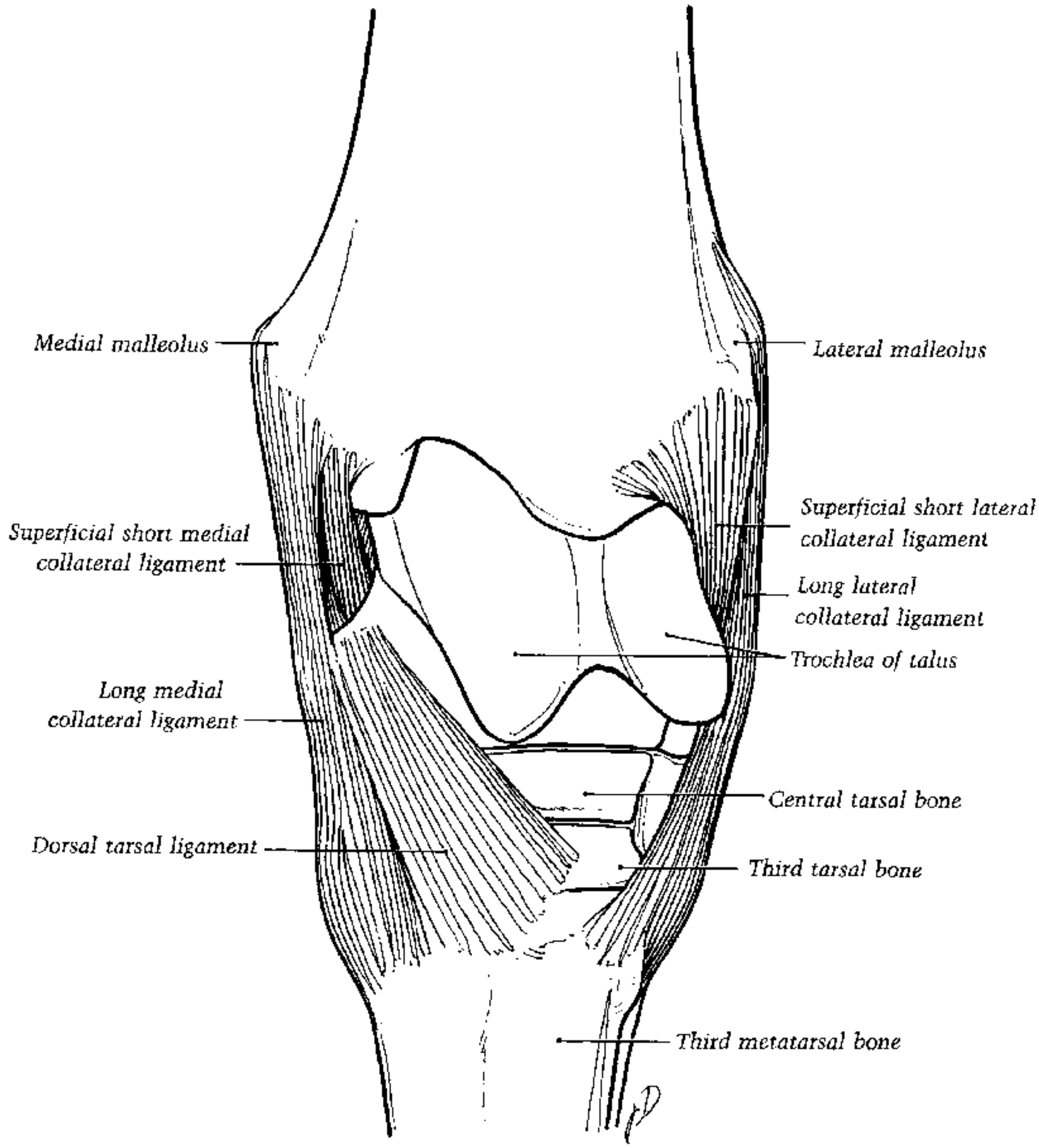

FIG. 1–34. Dorsal view of tarsal ligaments; right hock.

Movements of the Stifle Joint

In the standing position, the quadriceps femoris muscle is relatively relaxed. Extension of the stifle joint through action of the quadriceps femoris, tensor fasciae latae, and cranial division of the biceps femoris muscles plus passive traction exerted by the peroneus tertius is limited by tension from the collateral and cruciate ligaments. There is minimal lateral rotation of the gaskin during full extension. During flexion, the gaskin is rotated slightly medially.

When a horse shifts its weight more to one hind limb, the relaxing limb flexes slightly and rests on the toe. The pelvis is tilted so that the hip of the supporting limb is higher. The stifle on the supporting limb is locked in position due to a slight medial rotation of the patella as the medial patellar ligament and parapatellar cartilage slip farther caudally on the proximal part of the medial trochlear ridge. The locked position achieved by this configuration together with the support rendered by the other components of the stay apparatus minimizes muscular activity in the supporting limb while the relaxed hind limb is resting. When the position is shifted, the patella snaps off the proximal part of the medial trochlear ridge.

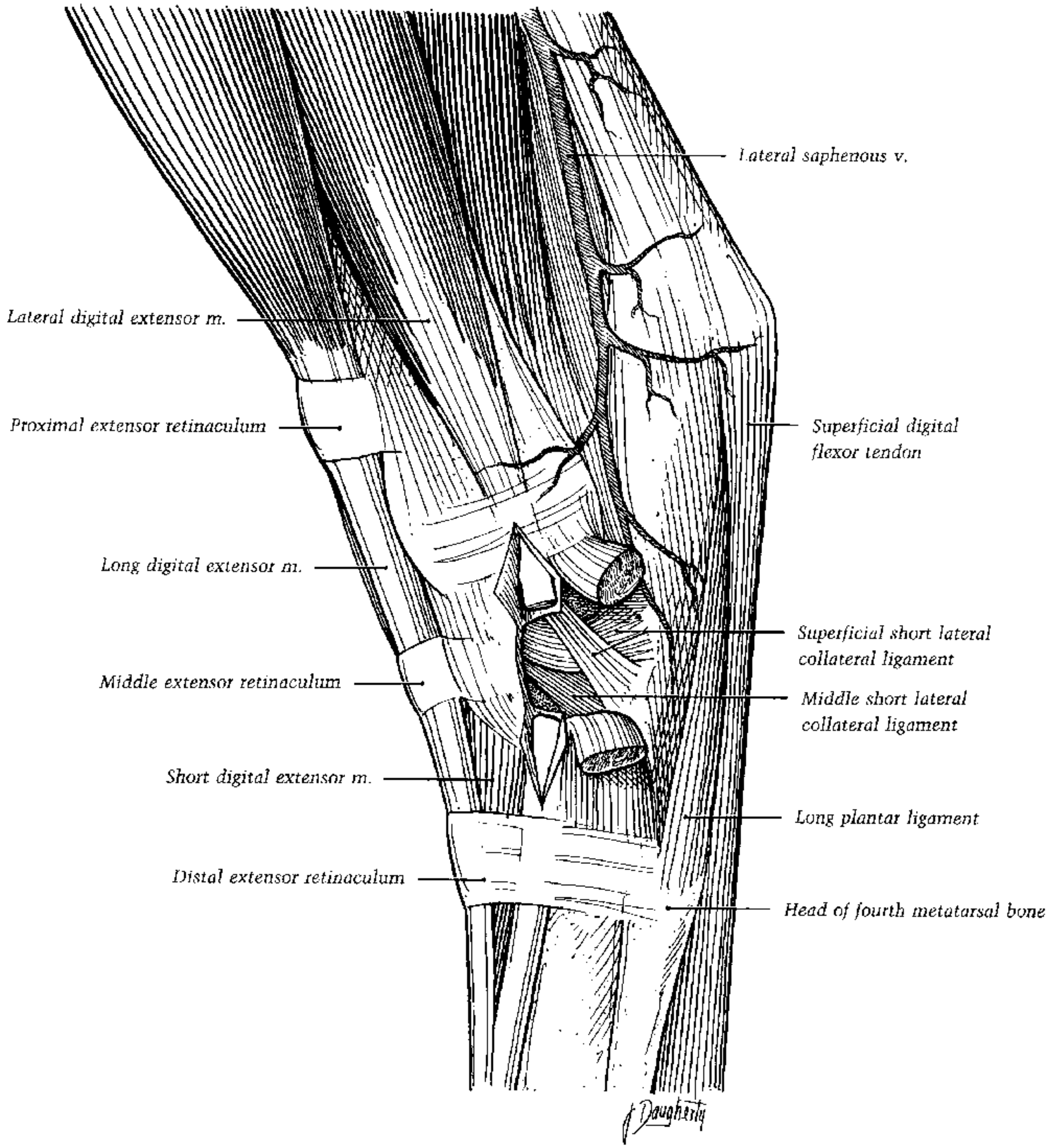

FIG. 1–35. Lateral view of left hock. The long lateral collateral ligament has been cut and reflected. To the left of it, a section of lateral digital extensor tendon has been removed. m., muscle; v., vein.

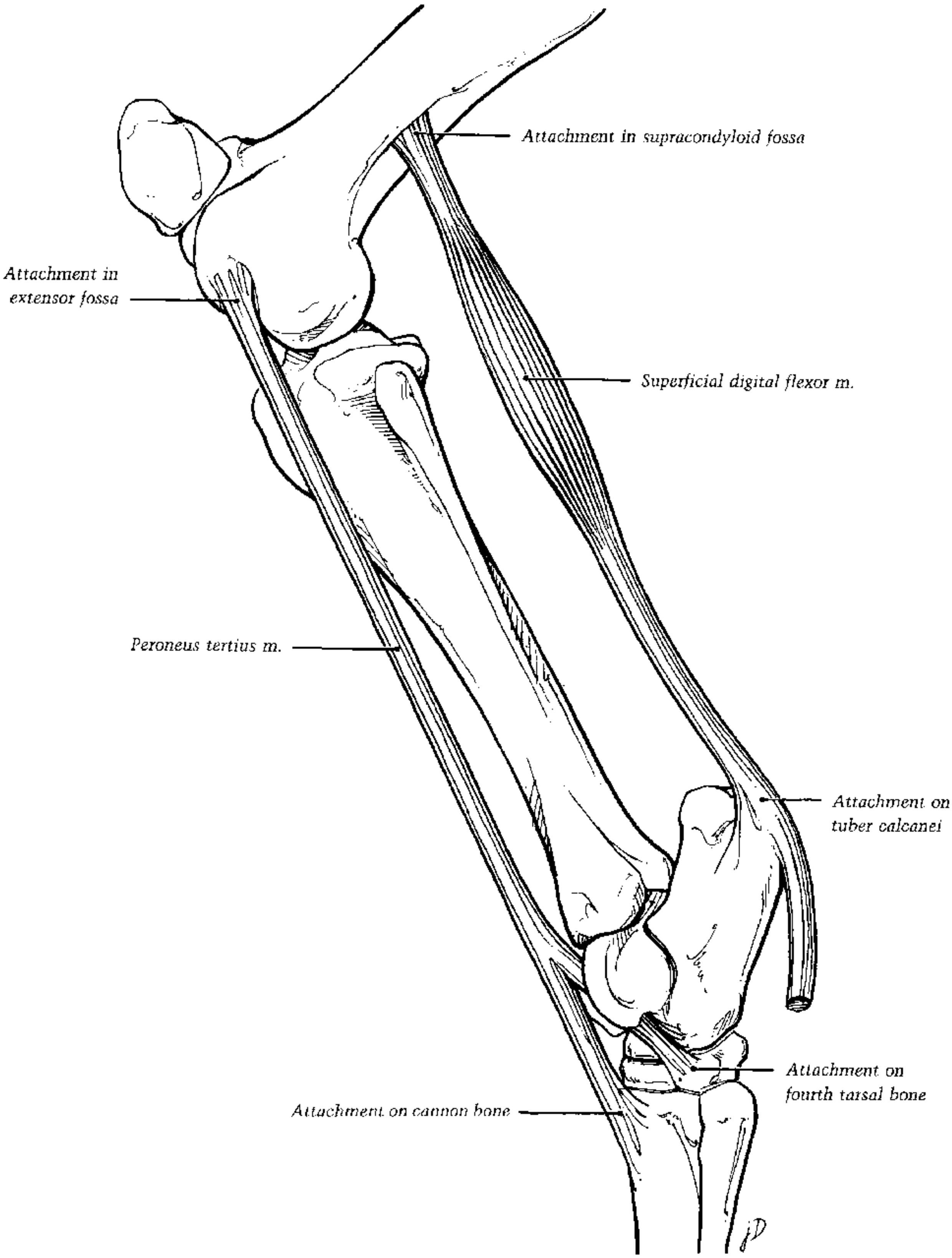

FIG. 1-36. Dissection of the reciprocal apparatus; lateral view, left hind limb.

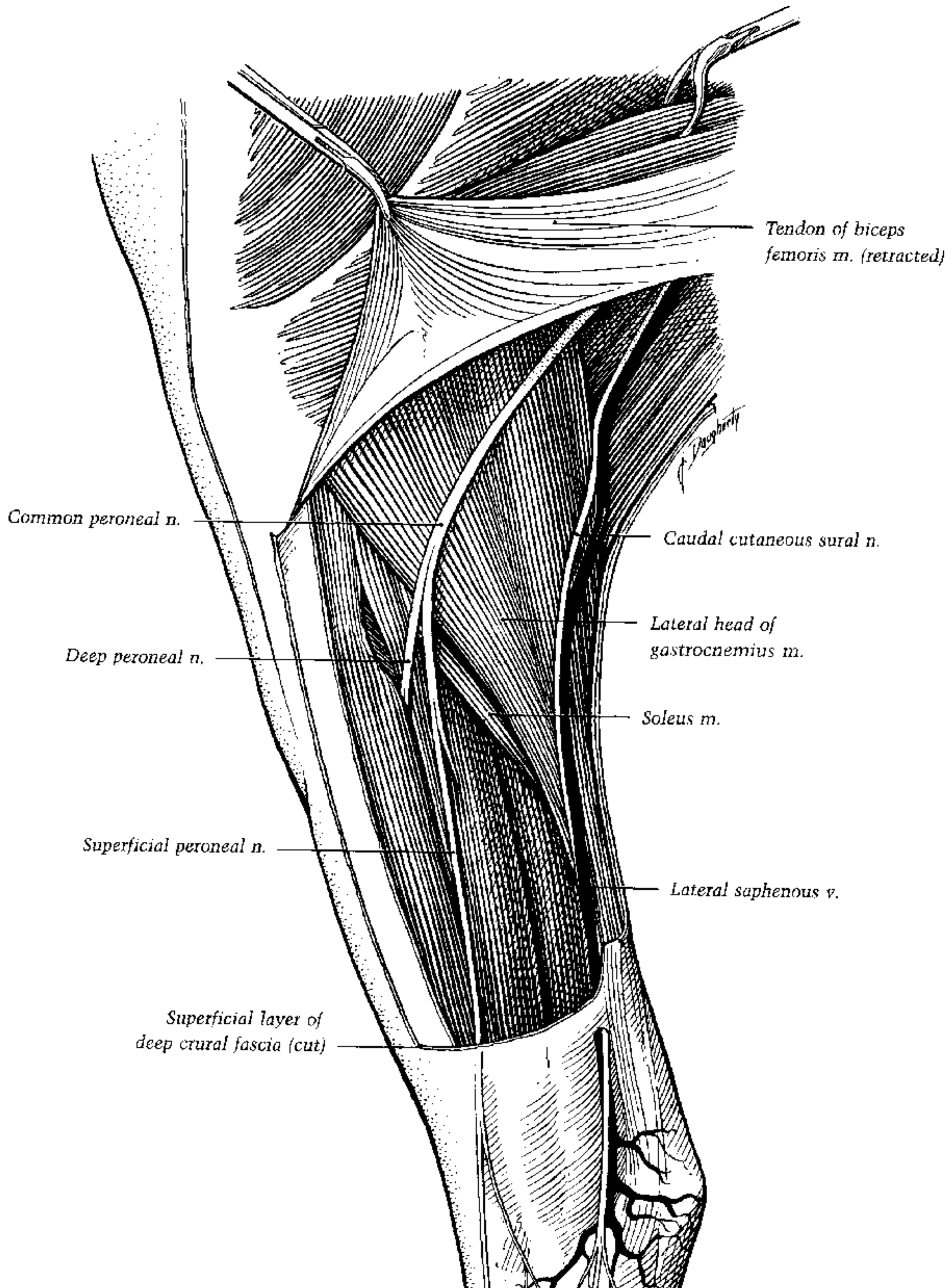

FIG. 1–37. Superficial dissection of the lateral aspect of the left stifle, gaskin, and hock. m., muscle; n., nerve; v., vein.

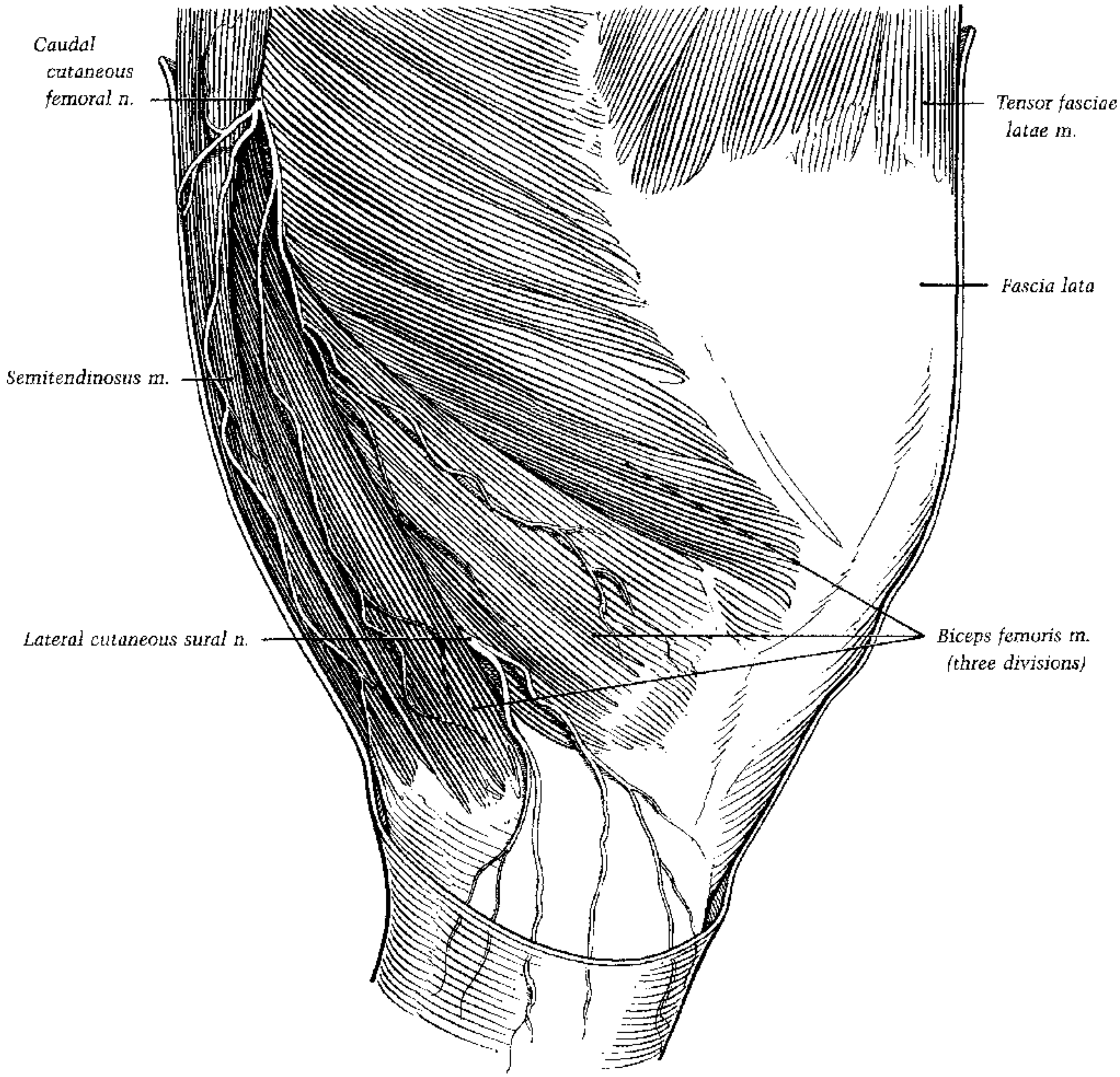

FIG. 1–38. Lateral view of the right stifle and thigh, deep to the skin. m., muscle; n., nerve.

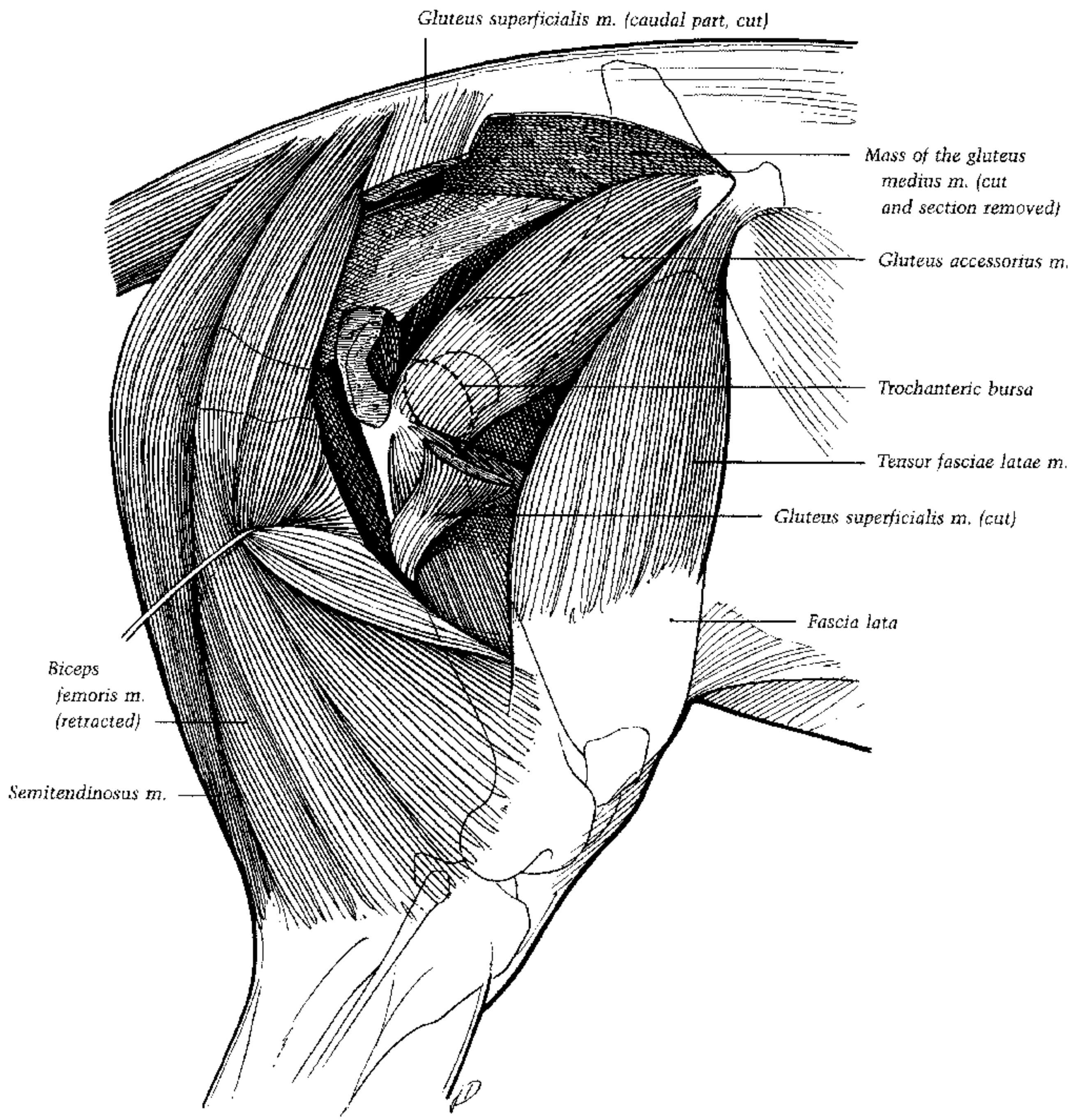

Fig. 1–39. Dissection of the right thigh and hip. Most of the gluteus superficialis and gluteus medius have been removed; lateral view. m., muscle.

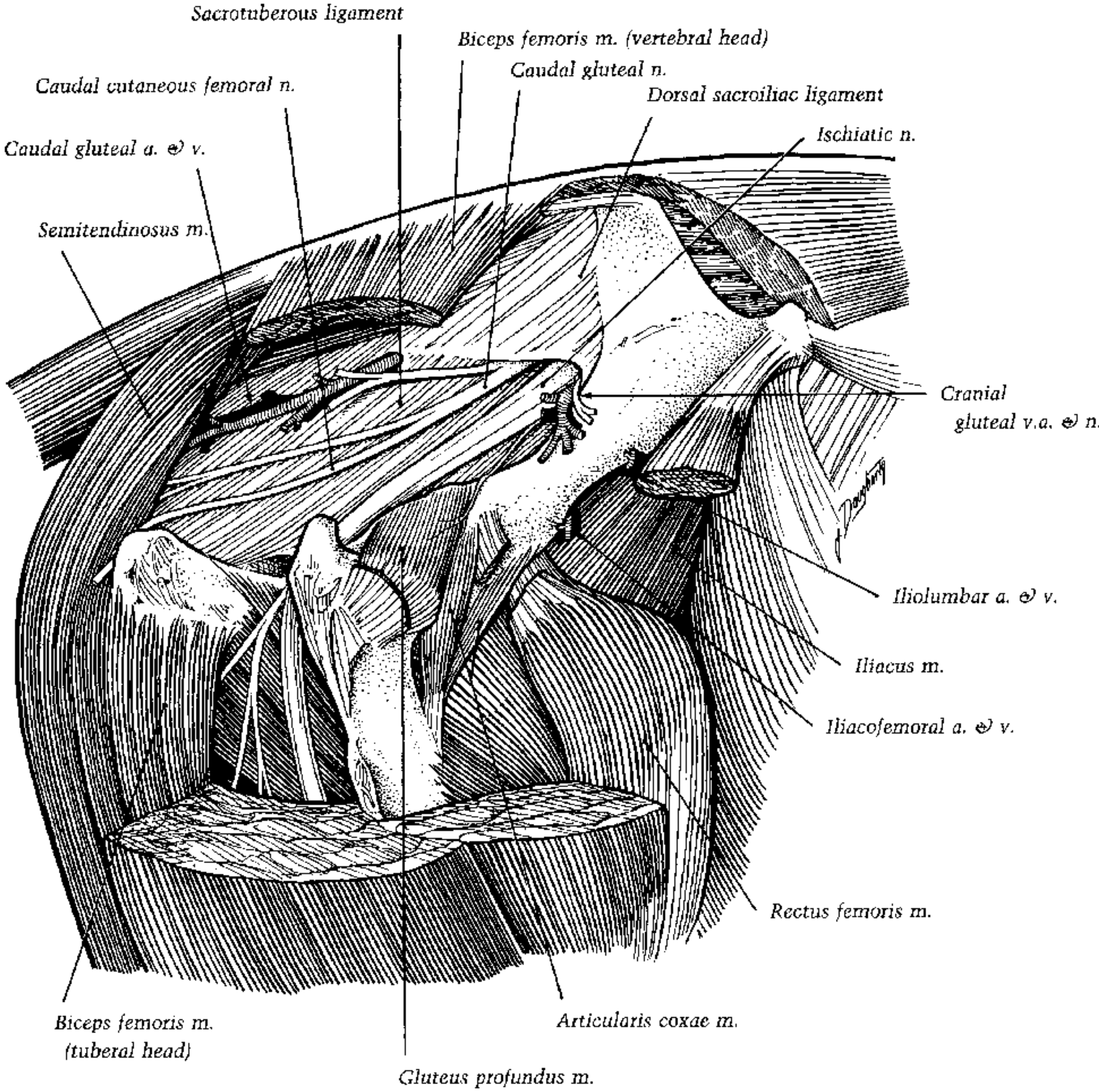

FIG. 1–40. Deep dissection of the right hip; lateral view. m., muscle; n., nerve; v., vein; a., artery.

Thigh and Hip (Femur and Coxal Joint)

Extending from the hip to the stifle, the thigh includes the femur and the structures around it. The region adjacent to and the muscles acting upon the coxal joint comprise the hip (Figs. 1–38, 1–39, and 1–40).

A prominent longitudinal groove evident when viewing a horse from the rear marks the site of the intermuscular septum between the semitendinosus and the biceps femoris muscles.

The hip joint is formed at the junction of the ilium, ischium, and pubis. The acetabulum articulates with the head of the femur. (Fig. 1–28).

Whereas the hip joint is a ball-and-socket joint capable of very limited rotation, the principal movements are flexion and extension. The range of motion between extreme flexion and extension is only 60°.

Flexor muscles of the hip joint are the gluteus superficialis, tensor fasciae latae, rectus femoris, iliopsoas, sartorius, and pectineus. Extensor muscles of the hip joint are the gluteus medius, biceps femoris,

FIG. 1–41. Photograph of the sacroiliac joint (large arrow) and intertransverse joints (small arrows). Dorsocranial view.

semitendinosus, semimembranosus, adductor, and quadratus femoris.

Pelvis

Sacroiliac Joint

Because it is provided with a joint capsule and because the roughened articular surfaces of the sacrum and ilium are covered with a minimal layer of hyaline cartilage, the nearly immovable sacroiliac joint is classified as a synovial joint (Fig. 1–41). However, the joint cavity is just a slit, and it may be crossed by bands of dense white fibrous connective tissue. As the animal ages, the apposed surfaces become even rougher. The joint is stabilized by the surrounding strong fibrous bands of the ventral sacroiliac ligament.

Symphysis Pelvis

The medial borders of pubis and ischium from each side meet ventrally at the symphysis pelvis. In the young animal, fibrocartilage joins the bones. Later in life, the cartilage ossifies.

Stay Apparatus of the Pelvic Limb (see Fig. 1–42)

The quadriceps femoris muscle and the tensor fasciae latae act to pull the patella, parapatellar cartilage, and medial patellar ligament proximally to the locked position over the medial trochlear ridge of the femur when the limb is positioned to bear the weight of the caudal part of the trunk and the hip. Through the restraint of the components of the reciprocal apparatus, the hock is locked correspondingly. Minimal muscular activity assures continuation of this locked configuration, preventing flexion of the stifle and hock joints. Distal to the hock, the digital flexor tendons support the lower limb. Prevention of overextension of the fetlock joint during the fixed, resting position is accomplished through the support rendered by the digital flexor tendons on the way to their digital attachments, the two extensor branches of the suspensory ligament extending from the proximal sesamoid bones to the long digital extensor tendon, and the sesamoidean ligaments, particularly the three distal sesamoidean ligaments.

Growth Plate Closure

Table 1–2 summarizes the ranges of reported closure times for the growth plates of bones in the pelvic limb.

Axial Contributors to Locomotion

Certain muscles of the trunk (the psoas minor, quadratus lumborum, and the four abdominal muscles on each side) act to flex the vertebral column during the gallop. Other muscles of the trunk and neck (from lateral to medial, the iliocostalis system, the longissimus system, and the transversospinalis system) are extensors of the vertebral column. Acting unilaterally, muscles from both of these groups are responsible for lateral movement of the trunk and neck.

TABLE 1–2. ***Ranges of Growth Plate Closure Times in Equine Pelvic Limbs***

Ilium, ischium, pubis	10–12 mos.
Secondary centers for crest, tuber coxae, ischiatic tuber and acetabular part of pubis	$4\frac{1}{2}$–5 yrs.
Femur	
Proximal	36–42 mos.
Distal	22–42 mos.
Tibia	
Proximal	36–42 mos.
Distal	17–24 mos.
Fibula	
Proximal	$3\frac{1}{2}$ yrs.
Distal (lateral malleolus of tibia)	3–24 mos.
Calcaneus	19–36 mos.

Growth plate closure times for bones distal to the tarsus are similar to those distal to the carpus.

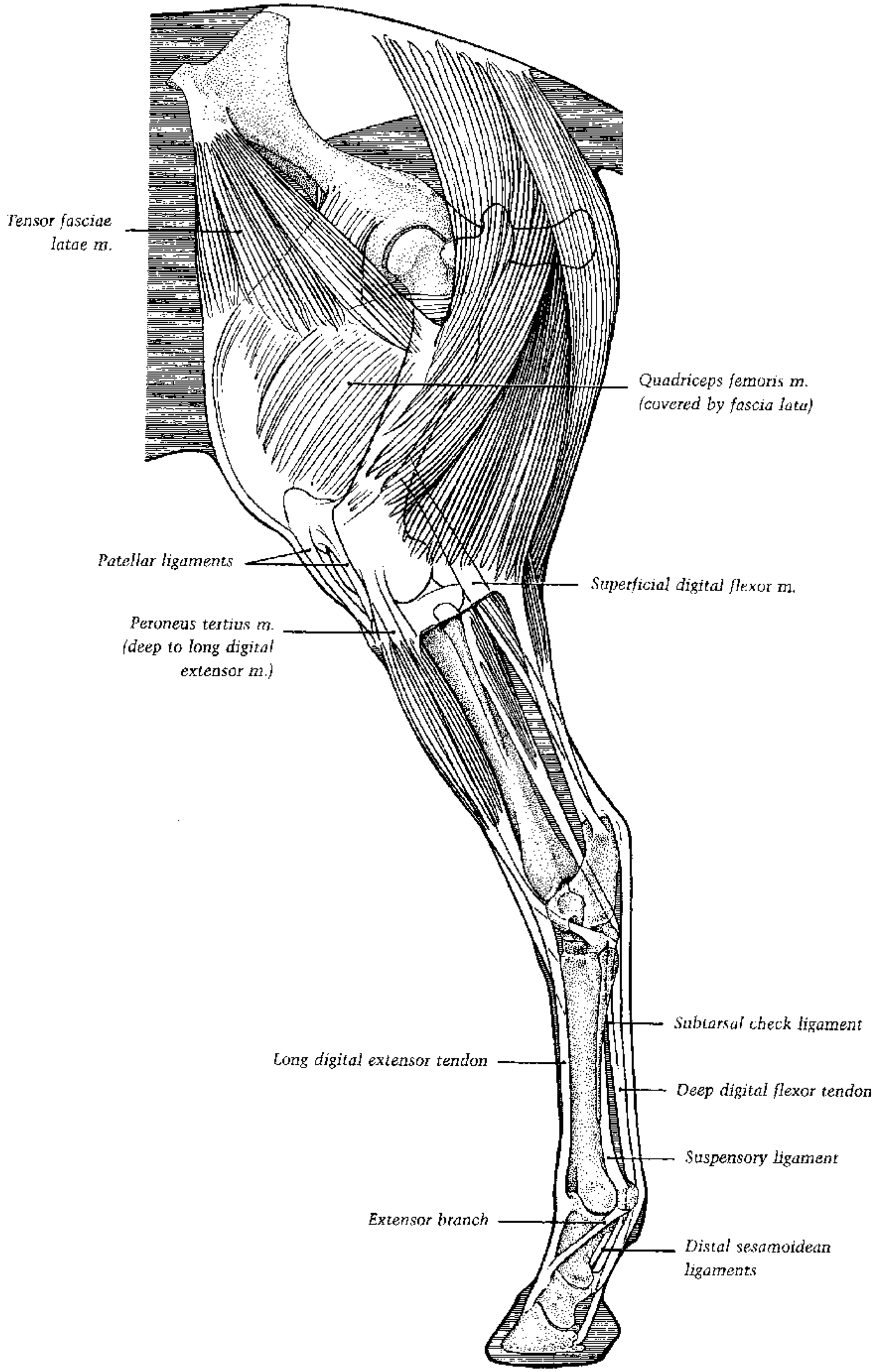

Fig. 1-42. Stay apparatus of the left pelvic limb. m., muscle.

Excluding the joint between the atlas and axis, the joints of the vertebral column all permit flexion, extension, lateral flexion, and even limited rotation. Whereas these movements are limited at each joint, taken as a whole, the movement is fairly extensive. Intervertebral discs of fibrocartilage are interposed between adjacent vertebrae. These are termed "symphysial joints." Joint cavities exist between the last cervical and first thoracic vertebral bodies and between the last lumbar and first sacral vertebral bodies. Articulations between articular processes on vertebral arches are true joints—arthrodial in the cervical and thoracic regions, and trochoid in the lumbar region. True joints also exist between the transverse processes of the fifth and sixth lumbar vertebrae and between the transverse processes of the sixth lumbar vertebra and the wings of the sacrum (see Fig. 1–41).