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Comprehensive lower extremity anatomy

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SYNOPSIS

- Success in lower extremity reconstruction is dependent on a comprehensive understanding of structural and functional anatomy. An anatomic- and defect-specific approach to lower extremity reconstruction enables the surgeon to provide tailored solutions for both the preservation and restoration of a functional limb.
- A comprehensive appreciation for normal lower extremity anatomy and anatomical variants is critical to functional limb salvage when treating lower extremity pathology.
- The reconstructive surgeon may be also be called upon to harvest tissue for transfer from the many potential donor sites in the lower extremity.
- This chapter aims to provide a comprehensive review of the three-dimensional anatomy of the lower extremity to facilitate operative and clinical decision-making.
- A detailed description is given of each region of the lower extremity with respect to skeletal support, musculofascial anatomy, vascularity, lymphatic drainage, peripheral nerves, and skin and soft-tissue elements.
- A broad overview of available soft-tissue donor sites from each region, donor sites for bone grafts, anatomic basis of common lower extremity flaps, surgical approaches to lower extremity recipient vessels, and common points of nerve injury and entrapment are included to provide a clinically relevant discussion for anatomy of the lower extremity as a framework for common challenges in reconstructive surgery.

The gluteal region

Gluteal skeletal structure

The pelvis consists of the two paired hip bones and the midline sacrum, articulating together at the two sacroiliac joints. The hip bones are formed by the fusion of the ilium, pubis, and ischium. These three bony regions of the pelvis coalesce to form the acetabulum. The large thick bony prominences of the pelvis serve as attachments for the muscles of the hip and thigh (Fig. 1.1). These prominences also become clinically relevant in contributing to the formation of pressure ulcers, most commonly over the ischial tuberosity, sacrum, and greater trochanter. Dense ligaments stabilize and distribute the numerous opposing forces acting on the pelvis. The sacrospinous ligament runs from the sacrum to the ischial spine, bounding the greater sciatic foramen. The sacrotuberous ligament attaches the sacrum to the ischial tuberosity and encloses the lesser sciatic foramen. Running from the anterior superior iliac spine (ASIS) to the pubic tubercle is the inguinal ligament. The action of the multiple flexors, extensors, and internal and external rotators on the hip joint serves to stabilize and position the torso during the complex process of ambulation.

Clinical correlation – iliac crest bone graft

The iliac crest serves as a versatile source of autogenous bone graft to reconstruct a variety of defects. Bone grafts can be cortical, cancellous, or corticocancellous in composition. Cortical bone is structurally stable with osteoconductive properties and ideally suited for structural defects requiring immediate mechanical stability. Cancellous bone is osteoinductive, osteogenic, and osteoconductive, undergoes rapid remodeling and vascularization, and is ideally suited for non-unions and bony fusion. Cancellous bone can be obtained between the inner and outer table of the ilium. The anterior and posterior iliac crest are common donor sites for cancellous and corticocancellous bone grafts, with 13 cm^3 and 30 cm^3 average graft volumes available from the anterior and posterior crest, respectively (Fig. 1.2).[1] Anteriorly, bone graft is most commonly harvested from the iliac tubercle, 3–4 cm posterior and parallel to the ASIS to maximize available bone and minimize risk to the lateral femoral cutaneous nerve. The iliac crest lies deep to a musculofascial layer from the external oblique and the iliacus muscle. The ilioinguinal nerve runs along the medial surface of the iliacus muscle and is at risk during harvest from the anterior crest. The anterior iliac crest provides

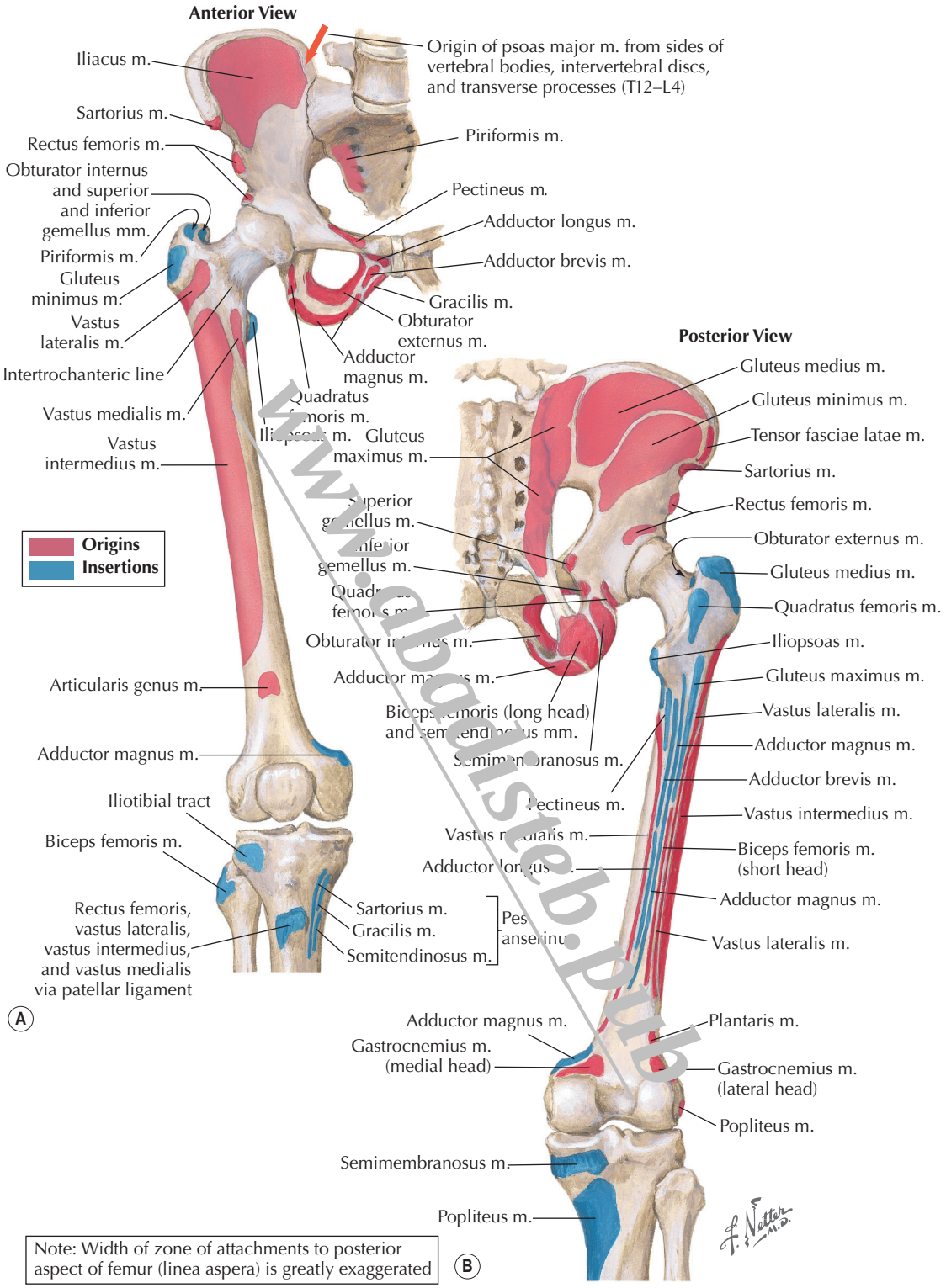

Figure 1.1 Bony attachments of buttock and thigh muscles. (*Netter illustration from www.netterimages.com. Copyright Elsevier Inc. All rights reserved.*)

twice the volume of packed cancellous bone compared to the distal radius or olecranon. Alternatively, tricortical bone grafts can be harvested from the inner and outer table of the anterior ilium and corticocancellous bone grafts can be harvested to include either the inner or outer table. Posteriorly, the bone is thickest and best harvested in the area superior to a line connecting the posterior superior iliac spine (PSIS) and the apex of the sacroiliac joint. Harvesting from an area approximately 4 cm distal to the PSIS prevents violation of the sacroiliac joint.[2] Unicortical and corticocancellous bone grafts can be obtained from the outer table of the posterior ilium and additional cancellous bone harvested from the inner table of the ilium. The iliac crest can also provide vascularized bone for a variety of composite soft-tissue and bone

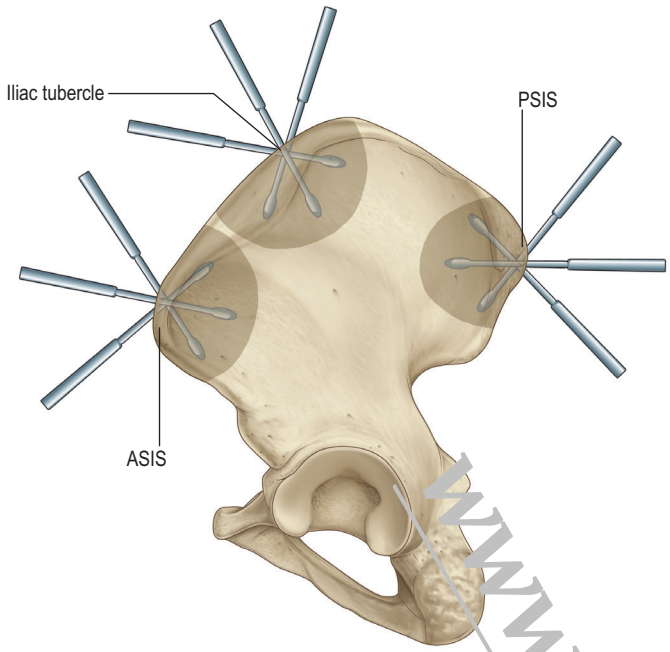

Figure 1.2 Harvest sites for iliac crest bone graft. (*Redrawn from Ebraheim NA, Elgafy H, Xu R. Bone-graft harvesting from iliac and fibular donor sites: techniques and complications.* J Am Acad Orthop Surg. *2001;9(3):210–218.*)

defects. Corticocancellous, vascularized bone can be obtained from the outer cortex of the ilium on the lateral half of the iliac crest, supplied by the ascending branch of the lateral femoral circumflex system.[3] The inner cortex of the ilium, supplied through nutrient branches off the deep circumflex iliac artery, is another common source of vascularized iliac bone.

Gluteal fascial anatomy

The fascial system of the gluteal region and the lower extremity contains various permutations of a nearly continuous superficial fascial and a deep fascial layer. The superficial system is located in the subcutaneous fat. The deep fascial layer is thicker and frequently can be seen as a dual-layered fibrous band. It usually lies directly over the underlying limb musculature and its proper fascia. The superficial fascia of the gluteal region is contiguous with that over the lower back and continues inferiorly into the proximal thigh. The deep fascia covering the gluteal muscles varies in thickness. Over the maximus it is thin, but over the anterior two-thirds of the medius it thickens and forms the gluteal aponeurosis. This is attached to the lateral border of the iliac crest superiorly, and splits anteriorly to enclose the tensor fasciae latae and posteriorly to enclose the gluteus maximus.

Muscles of the buttocks

The gluteus maximus is the largest muscle in the body and lies most superficially in the gluteal region, originating from the posterior gluteal line of the ilium and the dorsal portion of the sacrum (Fig. 1.3). The superficial fibers coalesce into a thick tendinous expansion which contributes to the iliotibial band of the fascia lata, while the deep fibers insert on the gluteal tuberosity of the femur. The gluteus maximus acts as a hip extensor when the hip is in a flexed position. In a standing position, the gluteus maximus dorsally rotates the pelvis and torso, maintaining stability. The vascular supply is primarily derived from the inferior gluteal vessels, which supply the inferior two-thirds of the muscle. The superior gluteal vessels supply the superior portion and the first perforator branch of the profunda femoris contributes to the vascular supply of the muscle laterally. For ease of description, the Mathes–Nahai classification system is used when discussing muscle vascularity (Table 1.1).[4] The gluteus maximus has a type III vascular supply, with two dominant pedicles from the superior and inferior gluteal arteries. Innervation to the gluteus maximus is provided by the inferior gluteal nerve. Underneath the gluteus maximus lie three bursae: the trochanteric, gluteofemoral, and ischiofemoral bursae, which allow frictionless movement over its underlying structures.

Table 1.1 Mathes–Nahai classification system for muscle vascular supply

Muscle vascular supply type	Description
I	Single vascular pedicle
II	Dominant vascular pedicle and one or more minor pedicles
III	Two dominant pedicles
IV	Segmental vascular pedicles
V	Single dominant vascular pedicle and secondary segmental pedicles

The gluteus medius, situated immediately deep to the gluteus maximus, arises from the outer surface of the iliac wing and inserts on the greater trochanter of the femur. It is innervated by the superior gluteal nerve and functions to abduct the hip and medially rotate the femur. Blood supply to this muscle is from the deep branch of the superior gluteal artery and from the trochanteric connection.

The gluteus minimus lies deep to the gluteus medius and arises from the outer surface of the ilium. Its fibers join the aponeurosis of the gluteus medius to insert on the greater trochanter, and the two muscles function together to abduct the hip. The gluteus minimus is innervated by the superior gluteal nerve and receives blood supply from the superior gluteal artery and trochanteric connection. Several small muscles arise from the medial pelvis and insert on the greater trochanter of the femur, functioning collectively to rotate the hip externally. These muscles include piriformis, superior and inferior gemellus, quadratus femoris, obturator internus, and obturator externus.

Gluteal vasculature

The superior gluteal artery (SGA) is the last branch of the posterior trunk of the internal iliac artery. It exits the pelvis through the greater sciatic foramen superior to the piriformis, dividing into two branches (Fig. 1.4). The deep branch runs deep to the gluteus medius, dividing into superior and inferior branches. The superior branch travels laterally to the anterior superior

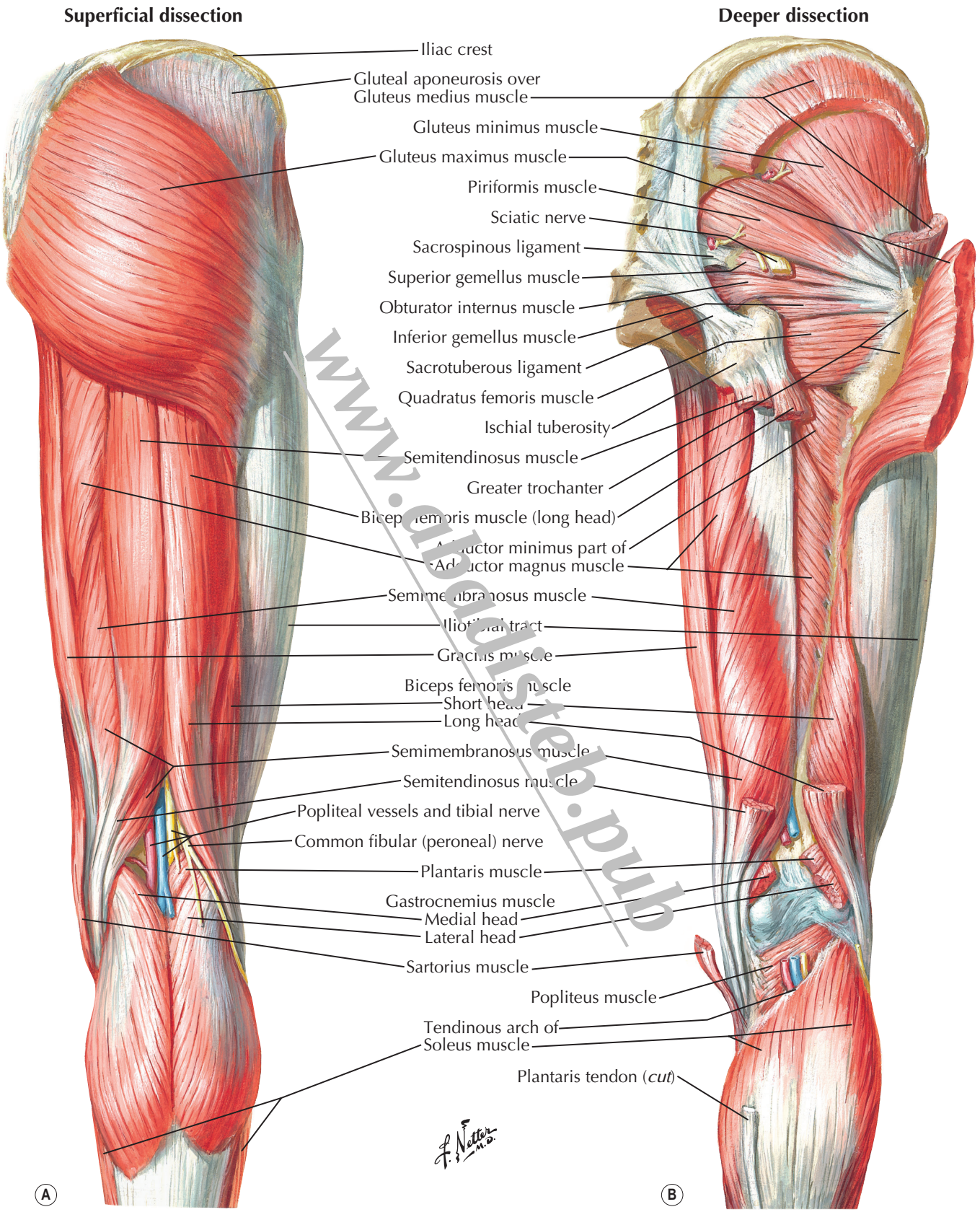

Figure 1.3 Muscles of hip and thigh: posterior views. (*Netter illustration from* www.netterimages.com. *Copyright Elsevier Inc. All rights reserved.*)