

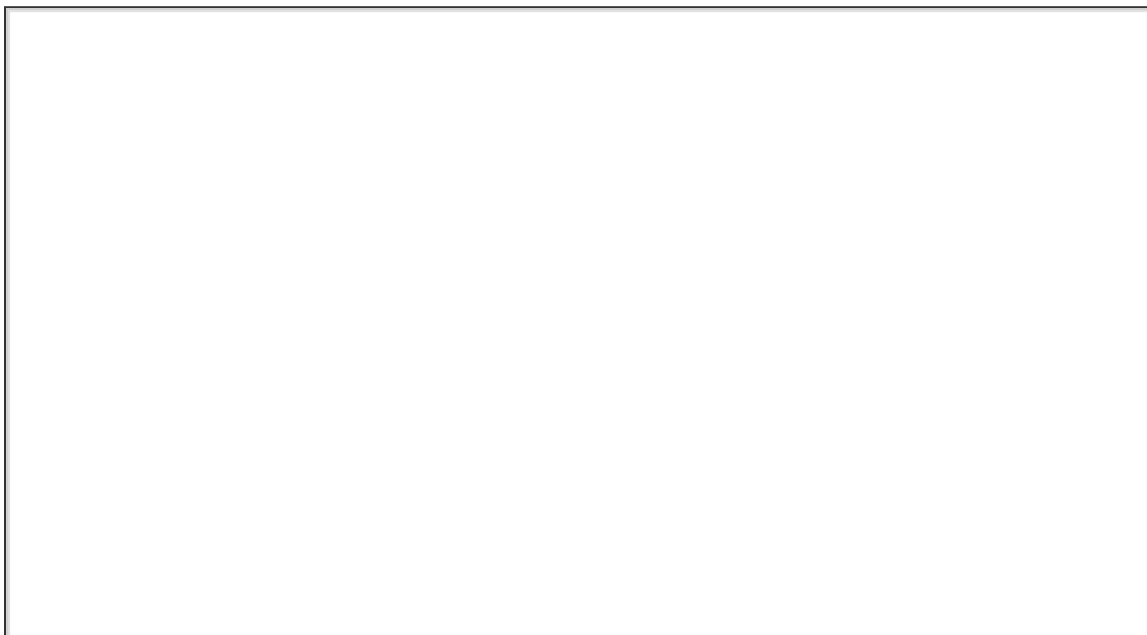
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Bucholz, Robert W., Heckman, James D.
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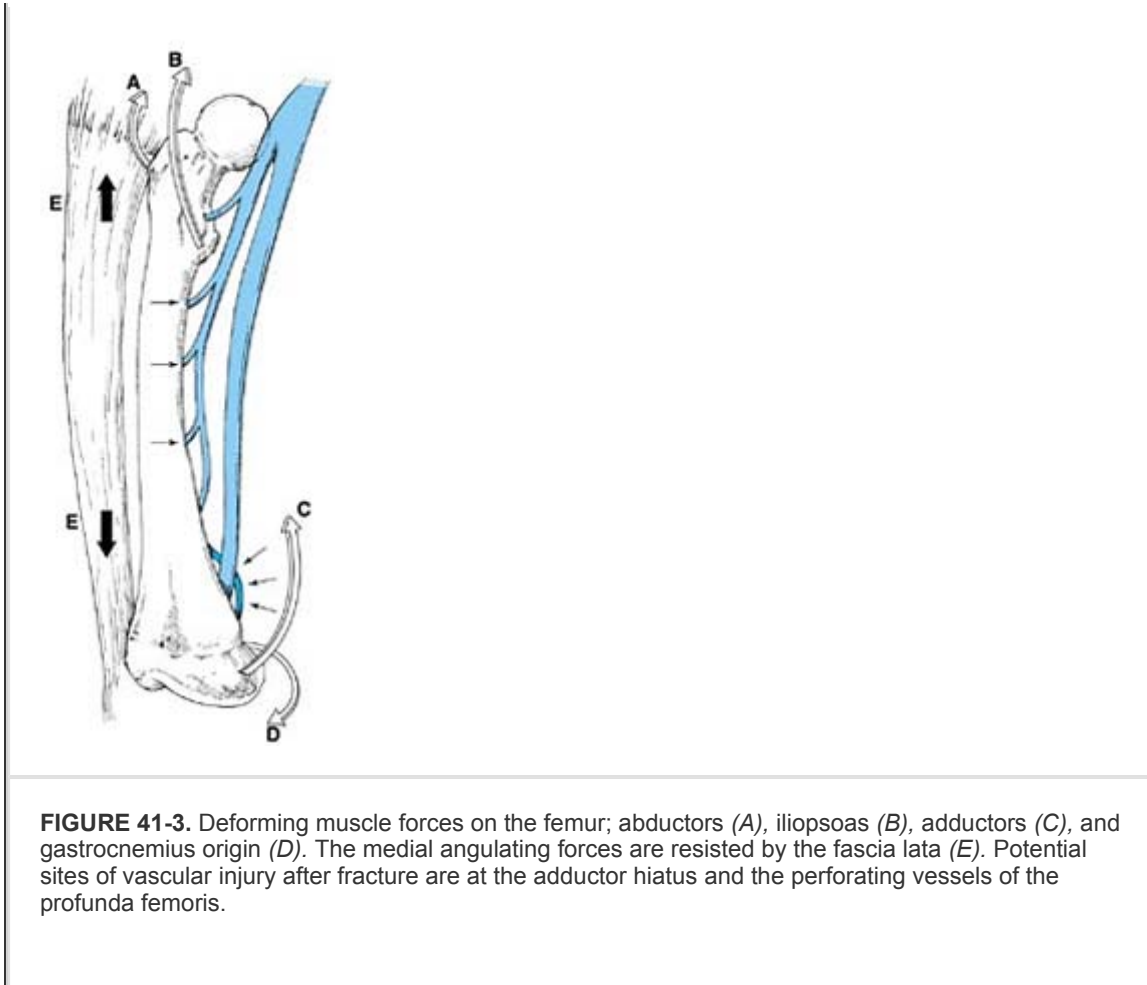
SURGICAL ANATOMY

Part of "41 - FRACTURES OF THE SHAFT OF THE FEMUR"

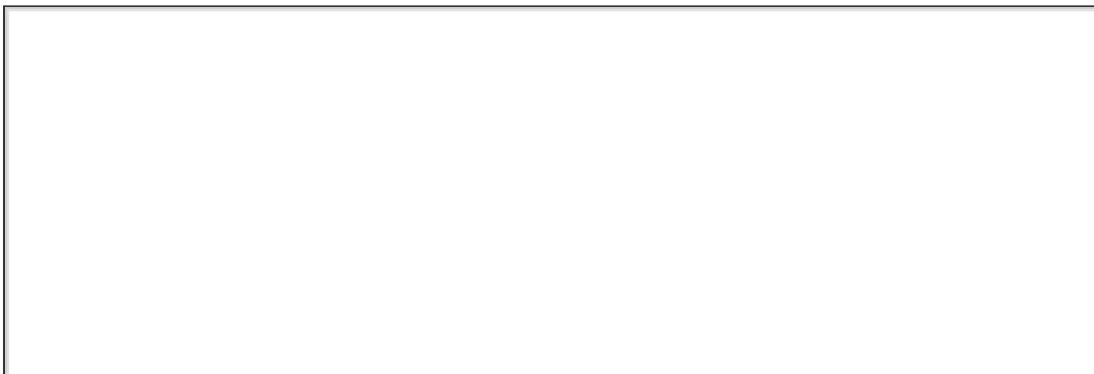
The shaft of the femur is essentially a tubular structure. It is slightly bowed anteriorly, and distally it flares outward toward the medial and lateral condyles of the supracondylar region. The shaft of the femur is smooth along its anterior, medial, and lateral surfaces. However, posteriorly there is a prominent longitudinal ridge, the linea aspera. This "roughened line" serves as a site of attachment for many of the muscle groups that surround the femur. The linea aspera is divided into two labia, or "lips." The medial and lateral labia of the linea aspera are situated close to one another near the middle of the femoral shaft. Proximally, however, the labia diverge. The medial labium courses toward the lesser trochanter, whereas the lateral one spirals upward to end in the gluteal tuberosity. Similarly, the labia diverge distally, coursing downward toward the femoral condyles. The space between the diverging labia is called the popliteal surface.

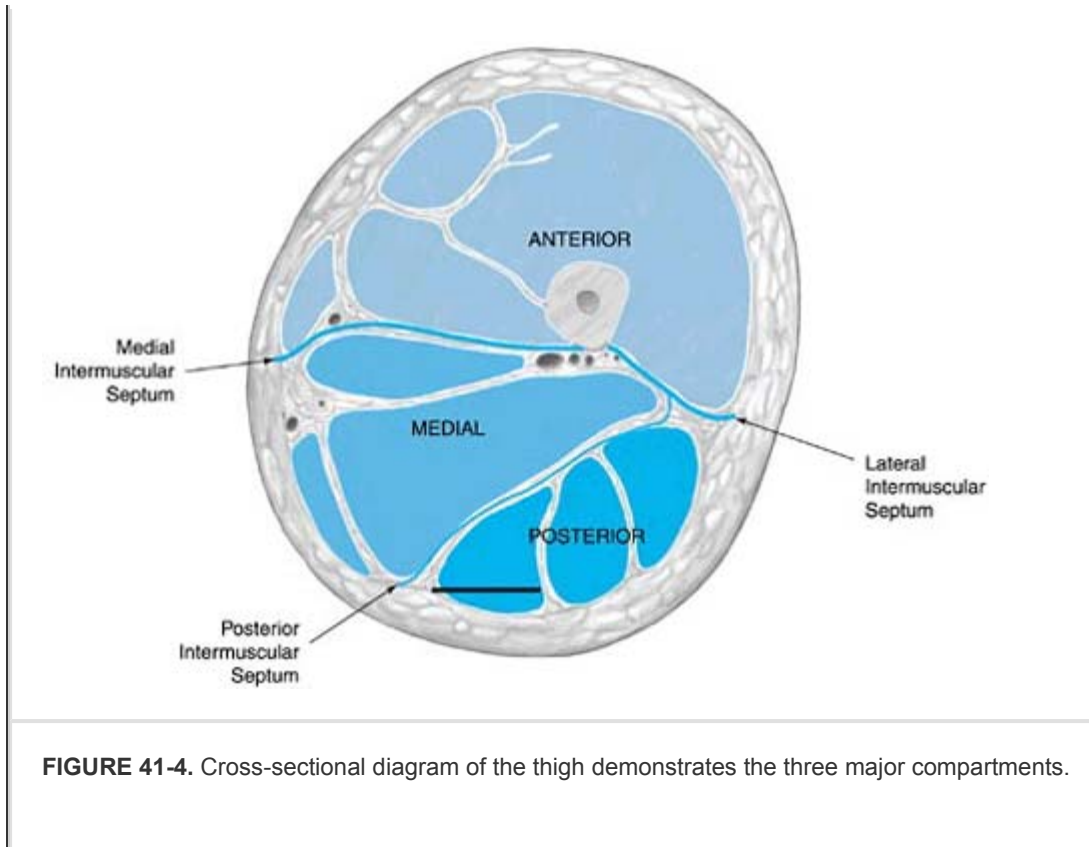
The femoral shaft is subjected to major muscle forces that can deform the thigh after a fracture (Fig. 41-3). The action of the gluteal musculature that inserts on the greater trochanter abducts the proximal femur after subtrochanteric and proximal shaft fractures. These proximal-third shaft fractures are also flexed and externally rotated by the pull of the iliopsoas muscles on the lesser trochanter. The adductor muscles span most shaft fractures, and exert a strong axial and varus load along the bone. Fractures of the distal shaft can be angulated into flexion through the pull of the gastrocnemius muscle. Adjustments to traction devices or fracture tables are necessary to counteract these deforming forces, and to obtain a reduction of the fracture.





The muscles that surround the femur are separated into three distinct compartments (Fig. 41-4). The anterior compartment contains the quadriceps femoris, sartorius, psoas, iliacus, and pectineus muscles, as well as the femoral artery and vein, the femoral nerve, and the lateral femoral cutaneous nerve. The medial compartment contains the gracilis, adductor brevis, adductor longus, adductor magnus, and obturator externus muscles, the profunda femoris artery and vein, along with the obturator artery and vein, and the obturator nerve. The posterior compartment contains the semitendinosus, the semimembranosus, the biceps femoris, and portions of the adductor magnus muscle, as well as branches of the profunda femoris artery, the sciatic nerve, and the posterior femoral cutaneous nerve.





The volume of the three compartments in the thigh is quite large. Thus, compartment syndrome of the thigh is not as common as it is in the leg (125). Compartment syndrome in the thigh is more common after severe, high-energy fractures or in patients with multiple injuries in the same extremity (29,85). Prolonged periods of traction on a fracture table may also increase the risk of compartment syndrome because compression of the femoral or saphenous veins by the perineal post may impede venous return, and thus increase edema. Compartment syndrome of the thigh should be addressed by immediate fasciotomy. The anterior and posterior compartments can be reached

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through a lateral incision, whereas the medial compartment requires a separate, medial approach.

The femur has a rich blood supply. Like most long bones, it can derive blood flow from periosteal vessels, but normally the major source of blood supply is a single nutrient vessel. The first or second branches of the profunda femoris artery usually supply the nutrient vessel to the femur. Laing (66), in his study of adult cadavers, found a single nutrient vessel in six of ten adult femurs. In three of the femurs with two nutrient vessels, both vessels entered the upper half of the femur. In only one specimen did a nutrient vessel enter the lower half of the femur. These nutrient arteries were found to enter the bone near the linea aspera. Once inside the bone, the vessel arborizes proximally and distally to form the endosteal circulation of the shaft.

Similarly, the small periosteal vessels that enter the femur do so along the linea aspera. At

the linea, the periosteal vessels wrap around the surface of the femur and send small penetrating vessels into the cortical bone (Fig. 41-5). These vessels align themselves perpendicularly to the cortical surface, with few, if any, traversing longitudinally along the periosteum. These small periosteal vessels supply the outer one third to one fourth of the cortical bone, whereas the endosteal vessels supply the inner two thirds to three fourths (102,103). Inside the cortex, there are direct communications between the periosteal vessels and the endosteal vessels (Fig. 41-6). The normal blood flow is centrifugal, although some blood returns to the large venous sinusoids of the medullary canal.



FIGURE 41-5. Lower portion of the femoral shaft from a 60-year-old man (arterial injection with Micropaque, tourniquet applied proximal to the site of injection). The venae comitantes are engorged with blood. The linea aspera is on the left. A long branch of the perforating artery descends adjacent to the intermuscular septum on the linea aspera; from it, four periosteal ring arteries take origin. Anteriorly, arterial branches from the periosteal network pass into the overlying muscles. (From Crock H. *Atlas of vascular anatomy of the skeleton and spinal cord*. St. Louis: Mosby, 1996:215, with permission.)

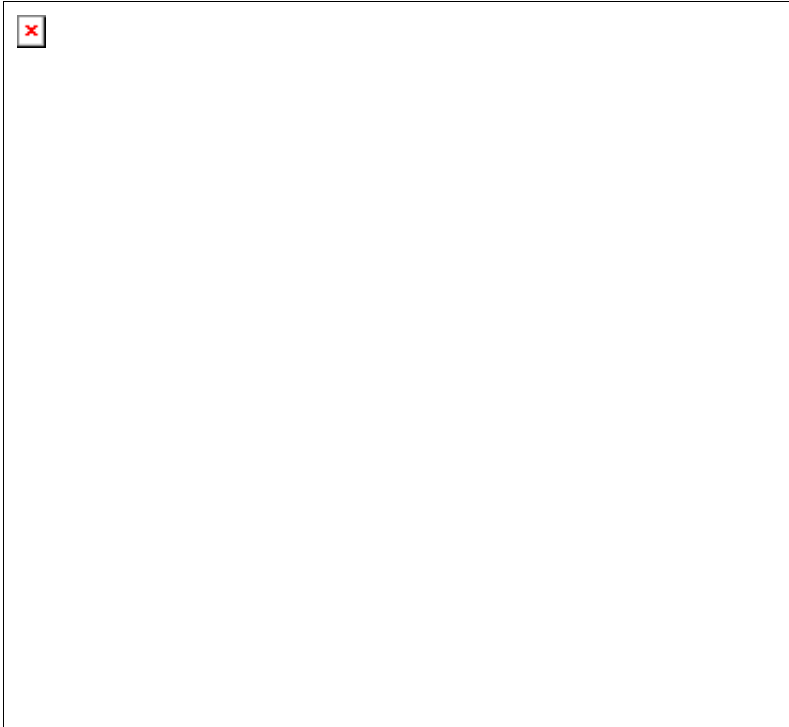


FIGURE 41-6. Thin transverse section from the mid-shaft of a femur of an adult (arterial injection; magnification approximately $\times 10$). The linea aspera is at the bottom. The relationship between radially penetrating branches of the periosteal arteries with branches of the nutrient artery system can be clearly seen. (From Crock H. *Atlas of vascular anatomy of the skeleton and spinal cord*. St. Louis: Mosby, 1996:222, with permission.)

After diaphyseal fractures, this circulatory pattern is radically altered. The endosteal blood flow is interrupted by fracture displacement, and the periosteal vessels must assume the dominant role. Proliferation of these periosteal vessels to meet the metabolic demands of the bone is the paramount vascular response to the fracture. Thus, preservation of the periosteal circulation is a high priority during any surgical procedure on the femur. Avoiding any soft tissue stripping of the linea aspera minimizes damage to these vessels. Severe traumatic or operative damage to the periosteal vessels results in delayed fracture healing.

The endosteal response to reaming and the placement of intramedullary nails has been studied extensively (91). Reaming of the intramedullary canal as preparation for placement of an intramedullary nail obliterates the endosteal circulation. However, it has been shown experimentally in goats that the endosteal vessels recover from this injury fairly rapidly, usually within 3 to 4 weeks (49,91). The intramedullary position of the nail does not appear to hamper the return of these endosteal vessels. As these endosteal vessels recover, the periosteal vessels proliferate, and, as stated previously, assume the dominant role in meeting the metabolic demands of the healing bone. The rapid healing and remodeling of fractures after closed intramedullary nailing attest to the abundant collateral circulation of

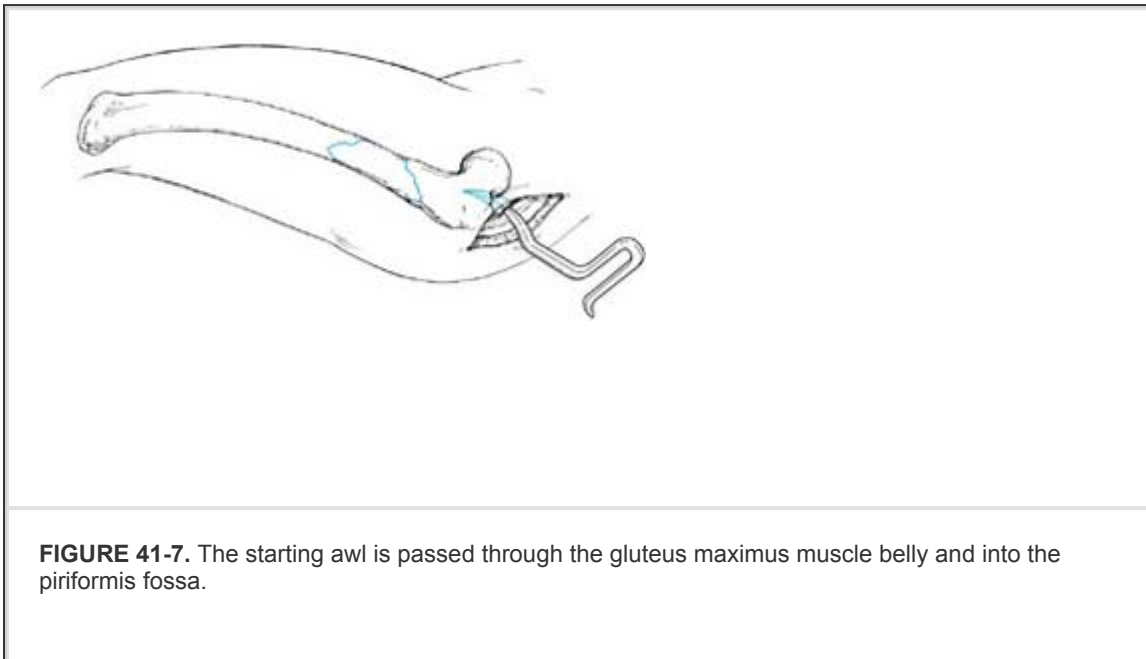
the femoral shaft.

Most fractures of the femoral shaft can be successfully treated using an intramedullary nail. These can be placed in an antegrade or retrograde fashion. For antegrade placement, an incision is made on the lateral aspect of the hip, just over the subcutaneous portion of the greater trochanter (Fig. 41-7). The gluteus fascia is split in line with the skin incision, and the underlying gluteus

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maximus muscle is separated longitudinally, in line with the incision. The surgeon's finger can then readily be placed in the piriformis fossa. The piriformis fossa will be the site of the starting hole for placement of the guide rod, the flexible reamers, and finally for the intramedullary nail. For retrograde intramedullary nailing of the femur, the starting portal is just above the intercondylar notch of the distal femur. It can be approached in several different ways. First, a standard medial parapatellar arthrotomy can be performed. This allows eversion of the patella, and easy, direct exposure of the notch. Alternately, a smaller incision can be made just medial to the patellar tendon, or the patellar tendon can be split longitudinally. Through this opening, a guide pin can be placed into the intercondylar notch. Placement of the guide pin requires fluoroscopic control. A cannulated drill can then be passed over the guide pin, and the starting hole can be made. Placement of the guide wire and passage of the flexible reamers is done in a manner identical to that used with antegrade nailing. If a smaller incision is used, the knee joint must be vigorously irrigated after intramedullary reaming because the reaming debris is trapped inside the knee joint.



For the few cases where a direct, open approach to the femur is required, a lateral incision can be used (Fig. 41-8). This approach follows a line from the greater trochanter to the lateral epicondyle. The fascia lata is incised in line with the skin incision, and the

underlying vastus lateralis muscle is lifted off the lateral intermuscular septum and the lateral lip of the linea aspera. A 1-cm cuff of vastus lateralis muscle may be left posteriorly. The perforating branches of the profunda femoris artery must be ligated as they are found. Once the vastus lateralis muscle is freed from the intermuscular septum and the linea aspera, anterior retraction of the muscle exposes the lateral aspect of the femoral shaft. This lateral approach limits scarring of the quadriceps, and can be reused in future surgery on the shaft if necessary.

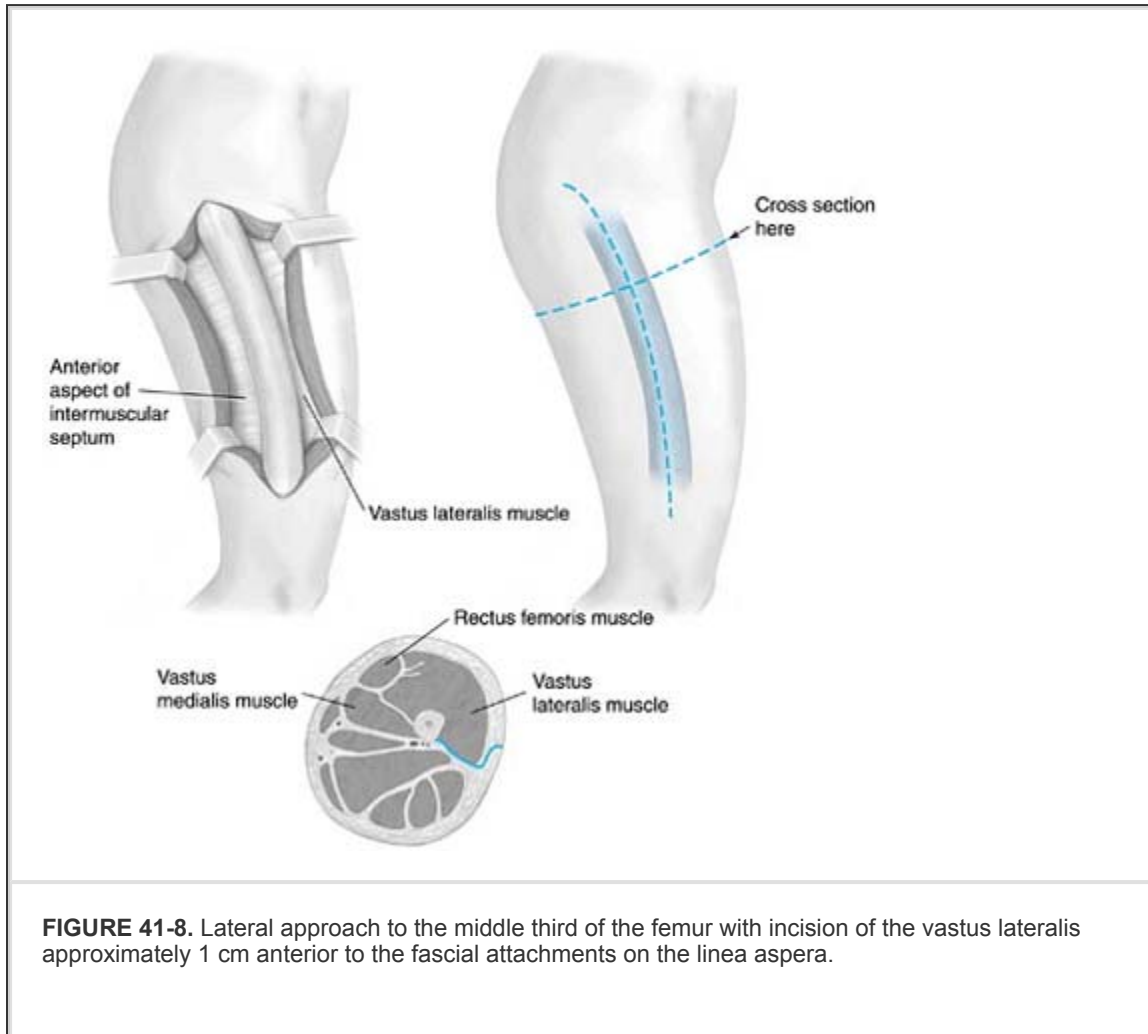


FIGURE 41-8. Lateral approach to the middle third of the femur with incision of the vastus lateralis approximately 1 cm anterior to the fascial attachments on the linea aspera.