22

Above-knee Amputation

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OVERVIEW

Above-knee amputation is most often performed for advanced soft-tissue sarcomas of the distal thigh and leg, or for primary bone sarcomas of the distal femur and proximal tibia. It is usually indicated because of major involvement of the main neurovascular bundle or the presence of an extensive involvement of the soft tissues. Above-knee amputations may be performed through the distal aspect of the femur (supracondylar), the middle section of the femur (disphyseal), or just below the lesser trochanter (high above-knee).

The clinical and surgical considerations surrounding above-knee amputations, as well as details of the surgical technique, are described in this chapter. Emphasis is on flap design and meticulous dissection, use of continuous epineural analgesia, myodesis of the major muscle groups to the distal femur, meticulous wound closure, and application of a rigid dressing.

INTRODUCTION

Until recent decades, lower-extremity amputation was the standard method of treatment for most soft-tissue and bone sarcomas. Since then, better understanding of the biological behavior of these tumors and advances in surgical technique, bioengineering, radiographic imaging, radiotherapy, and chemotherapy have led to the advent of limb-sparing surgery. Preoperative chemotherapy, given via the intravenous or intra-arterial route or using isolated limb perfusion, has been found to reduce tumor size, cause significant tumor necrosis, and make previously unresectable tumors amenable to limb-sparing procedures. Limb-sparing surgery is now the standard of care for bone and soft-tissue sarcomas of the extremities and is performed in approximately 90% of all cases (Figure 22.1). All patients must be considered and evaluated for limb-sparing surgery, and the decision to proceed with an amputation should be made on a case-by-case basis. Such decisions are based on local anatomic considerations, tumor grade and stage, and consideration of the functional and psychological impact of the procedure.

GENERAL INDICATIONS FOR LOWER EXTREMITY AMPUTATION

Considerations and indications to be borne in mind when deciding whether amputation is advisable are as follows:

1. *Local recurrence* was once considered a primary indication for amputation; however, local recurrence of a soft-tissue sarcoma has now been shown to have a minimal impact on patient survival.[1] The capability to resect the recurrent tumor without compromising the function of the extremity should, therefore, be the determining factor on which the decision to amputate is based. Although the applicability of these findings to primary bone sarcomas is questionable, most orthopedic oncology centers treat local recurrence of a primary bone sarcoma in the same manner, and the mere presence of a recurrent tumor is not an indication for an amputation (Figure 22.2).
2. *Major vascular involvement*. Invasion of a major blood vessel by a sarcoma is generally indicative of a poor prognosis. In the past the increased morbidity of a limb-sparing surgery with a vascular graft made amputation the procedure of choice in most of these cases. Because of the availability of reliable vascular grafts, vascular involvement *per se* is no longer an indication for an amputation. It is the concomitant involvement of a major nerve and the expectation that function of the extremity will be poor that rule out the possibility of limb-sparing surgery.
3. *Major nerve involvement* often occurs within the popliteal space. In general, one nerve may be removed, but a two-nerve deficit results in a poorly functioning extremity. Most patients with such a deficit who have undergone a limb-sparing procedure report that a useless extremity is worse than no limb at all. Nerve involvement is usually combined with a major vascular involvement, and the combination of the two makes amputation the recommended treatment.

   Amputations are rarely performed for extensive, neglected benign lesions. In these cases it is the extensive bone destruction, lack of soft tissues for reconstruction, and neurologic compromise that indicate the need for amputation (Figure 22.3).
4. *Soft-tissue contamination* as a result of pathologic fracture through a bone sarcoma or of a poorly performed biopsy was also once considered an indication for amputation. The efficacy of the current chemotherapy regimens makes the limb-sparing procedure a safer option in minor cases of contamination; however, the extent of soft-tissue resection and flap design often have to be modified. Magnetic resonance imaging (MRI) allows one to evaluate the full extent of a hemotoma and plan a limb-sparing procedure. Amputation is usually inevitable in extensive hematomas.
5. *A poorly planned biopsy* can interfere with limb-sparing surgery. The biopsy incision and tract are assumed to harbor tumor cells, and therefore have to be excised en-bloc with the primary tumor and with the same wide margins. The diameter of the biopsy tract and the associated hematoma determine the extent of soft-tissue resection. Amputation is indicated if, following excision of the biopsy tract, the viability of the muscle flaps or function of the extremity would be significantly impaired. Core needle biopsies are strongly recommended in the evaluation of soft-tissue and bone lesions. The hazards of the recommendations for execution of a musculoskeletal tumor biopsy are discussed in Chapter 2.
6. *Infection*, either superficial or deep, is usually the result of tumor ulceration through the skin or infection at the biopsy site. It may negate the possibility of limb-sparing surgery, especially if prosthetic materials will be used. In addition, an infection will impair the ability to administer adequate preoperative and postoperative chemotherapy. Limb-sparing surgery is feasible only if the infection is completely controlled prior to surgery, or if the infected tissues can be completely removed at surgery.
7. *Skeletal immaturity* is still considered a major problem because significant leg-length discrepancy may occur following limb-sparing surgery that involves a

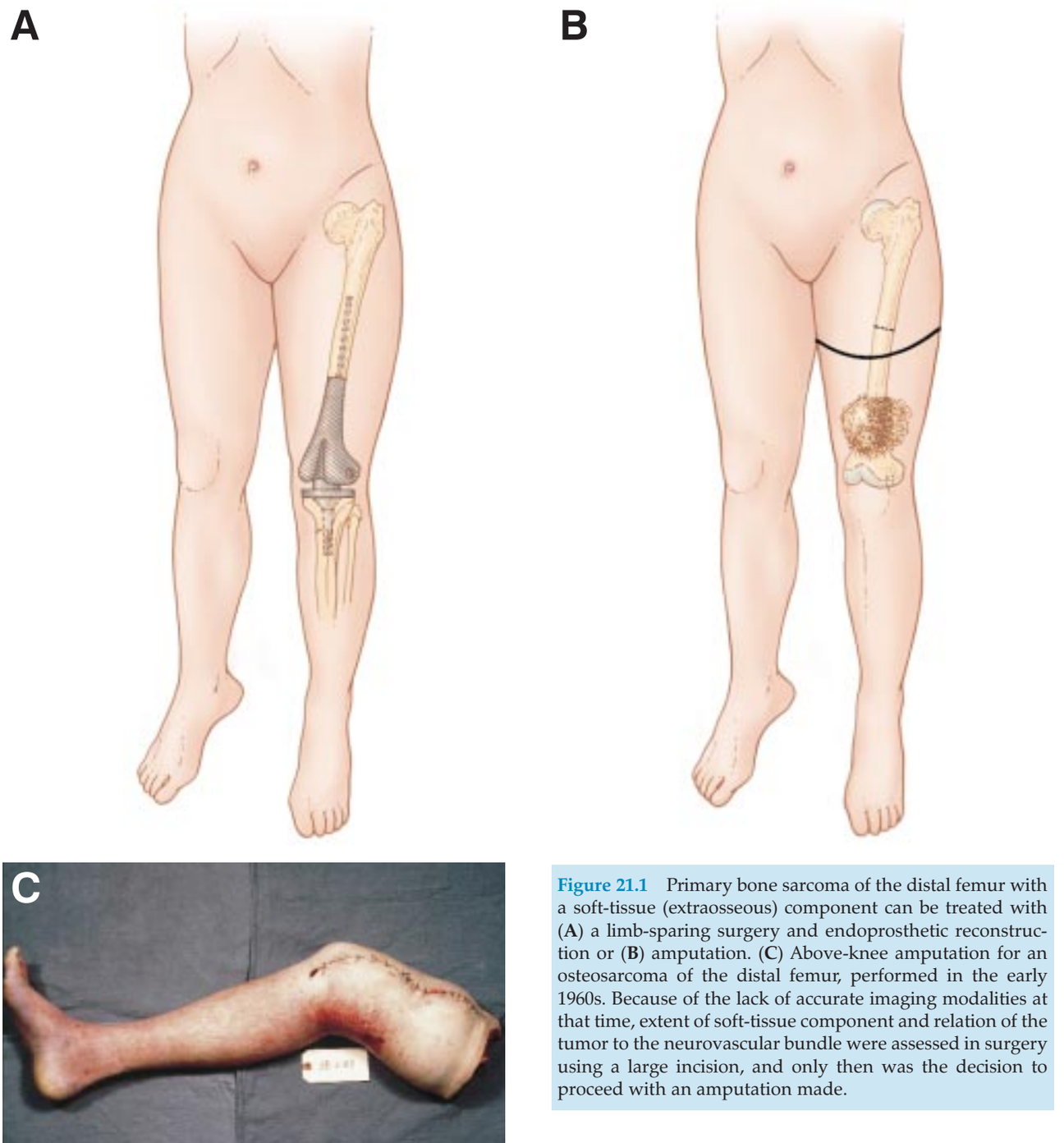
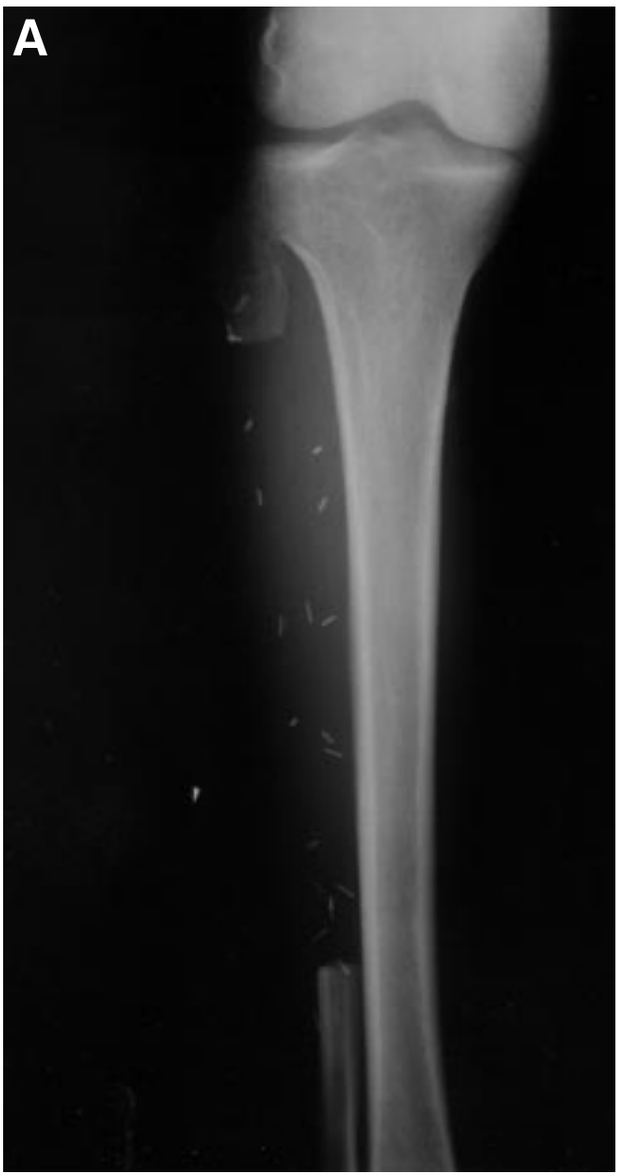


Figure 21.1 Primary bone sarcoma of the distal femur with a soft-tissue (extraosseous) component can be treated with (**A**) a limb-sparing surgery and endoprosthetic reconstruction or (**B**) amputation. (**C**) Above-knee amputation for an osteosarcoma of the distal femur, performed in the early 1960s. Because of the lack of accurate imaging modalities at that time, extent of soft-tissue component and relation of the tumor to the neurovascular bundle were assessed in surgery using a large incision, and only then was the decision to proceed with an amputation made.



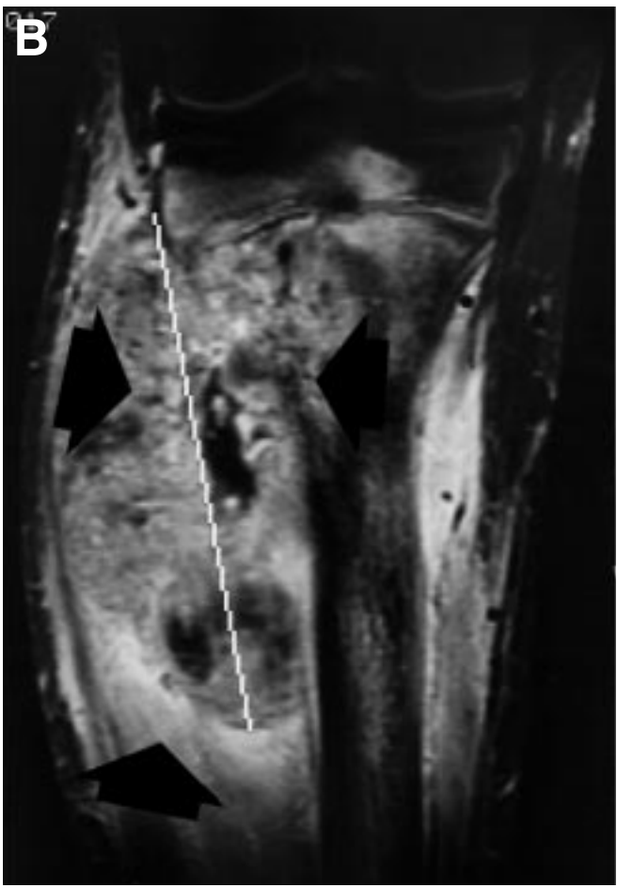


Figure 22.2 A 45-year-old patient who initially presented with dedifferentiated, high-grade osteosarcoma of the fibula. (**A**) Following neoadjuvant chemotherapy the patient underwent intercalary fibular resection. Approximately a year after the surgery the patient presented with a rapidly enlarging, extensive tumor recurrence. (**B**) As shown in the MRI, the tumor extensively invaded the superficial posterior, deep posterior, and lateral compartments of the leg. Wide excision of the tumor would necessitate removal of the neurovascular bundle and all three compartments. Above-knee amputation was therefore performed.

major bone resection in young patients. Intercalary resection of long bones does not have a major impact on limb length, but resection of the epiphyses does. Since most primary bone sarcomas occur in the second decade of life, after the majority of skeletal maturation has been achieved, and because expandable prostheses are commonly available, amputation for these indications is rare.

CLINICAL CONSIDERATIONS

Staging and Level of Amputation

Patients requiring an above-knee amputation for a soft-tissue or primary bone sarcoma must undergo complete staging in order to allow the surgeon to determine the level of amputation and extent of soft-tissue resection. The type of flaps to be used is also determined at this time. The combined use of plain radiography, computerized tomography (CT), and MRI is necessary to determine the proximal extent of the medullary and extraosseous components of the tumor. In general, the more proximal of the two levels of involvement (i.e. medullary or extraosseous) determines the level of amputation. The level of bone transection should be at least 5–10 cm proximal to this point.

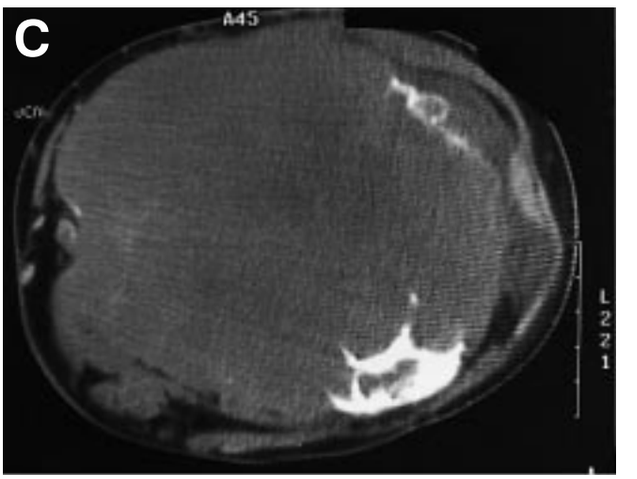


Figure 22.3 (**A**) A 23-year-old patient with a few years' history of a neglected benign giant-cell tumor of the distal femur with an extensive soft-tissue component. (**B**) A plain radiograph of the distal femur showing extensive bone destruction. The knee joint is in flexion contracture due to intractable pain. (**C**) Computerized tomography shows that only a thin rim of muscles is left. Adequate soft-tissue coverage of a prosthesis was there not feasible, and above-knee amputation was performed.

Level of Amputation

Above-knee amputations may be performed through the distal femur (supracondylar), the midfemur (diaphyseal), or just below the lesser trochanter (high above-knee amputation) (Figure 22.4). Above-knee amputations performed for tumors of the distal femur or sarcomas of the distal thigh tend to be performed at a higher level than standard above-knee amputations. By contrast, tumors of the leg are treated with the standard above-knee amputation. As a rule, any length of femur makes prosthetic fitting easier than none. Even amputations at the subtrochanteric level are preferred to hip disarticulation; if 3–5 cm of bone distal to the lesser trochanter remain, the patient can be fitted with a prosthesis in a manner used for above-knee amputation.

The main factors that determine the type of flaps to be constructed are the soft-tissue extent of the tumor, areas of prior irradiation, and previous scars. The aim is

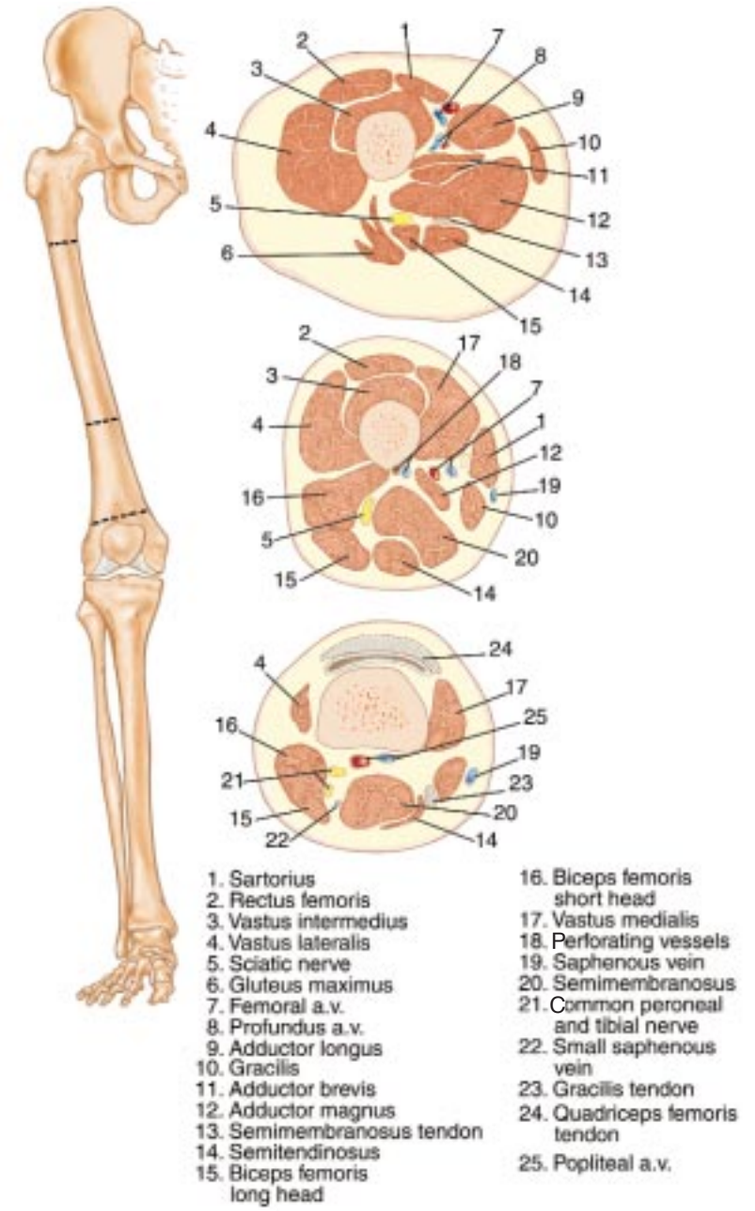


Figure 22.4 Level of osteotomy and cross-sectional anatomy for supracondylar, diaphyseal, and high above-knee amputation. Higher above-knee amputations are generally used for primary bone sarcomas of the distal femur. Low above-knee amputations are used for bone sarcomas of the leg, especially those involving the popliteal fossa or arterial trifurcation. High above-knee amputation is preferable to hip disarticulation, even though the osteotomy is only a few centimeters below the greater trochanter. With the hip joint intact, movement of the prosthesis is greatly facilitated.

to avoid local recurrence and no attempt is made to adhere to standard flaps. At this level a skin or muscle flap of almost any length will heal in the young patient. Furthermore, it is not necessary to use equal flaps; long posterior, anterior, or medial flaps will all heal rapidly.

SURGICAL TECHNIQUE

Figures 22.5–22.12 illustrate the execution of an above-knee amputation. Each step is described in detail. Emphasis is on flap design and meticulous dissection, use of continuous epineural analgesia, myodesis of the major muscle groups to the distal femur, meticulous wound closure, and application of a rigid dressing.

The patient is supine, and the operated extremity should be abducted and flexed (Figure 22.5). Most amputations are performed without compressive tourniquet because it is easier to locate the bleeding edges of blood vessels and perform an adequate hemostasis under such circumstances. The most common type of flap is the anterior and posterior "fish-mouth" flap, and the skin incision should be planned accordingly (Figure 22.6). It is recommended to draw the incision line prior to surgery.

Transection of muscle and bone is shown in Figure 22.7. Major muscle groups should be carefully dissected and tacked for their further use in soft-tissue reconstruction. The femoral edge should be beveled and smooth (Figure 22.8). Cytologic examination and a frozen section of the proximal marrow canal must be performed to ascertain that there is no occult medullary extension of the tumor. A frozen section of any questionable site should be performed.

Sciatic and Femoral Nerves

The cut ends of the nerves may form neuromata, which can be extremely painful when exposed to pressure from the prosthesis or direct trauma. Therefore, the nerve endings must be positioned, and even sutured, with muscles. Malawer *et al*.[2] described the use of continuous infusion of bupivacaine into the epineural space to control postoperative pain. That method was found to significantly reduce the need for intravenous and oral narcotics, and it is now routinely used in limb-sparing resections and amputations. As shown in Figure 22.9, the epineural catheter is placed under the nerve sheath, in the epineural space. The catheter is sutured to the nerve sheath, pulled through a muscle flap, and secured to the skin. A bolus of 10 ml of bupivacaine 0.25% is injected into the epineural space, and an additional 10 ml are given before the patient leaves the operating room. This is followed by a continuous infusion of 4 ml/h. Boluses of 10 ml can be given as required. The epineural catheter is generally removed after 5 days of treatment, following gradual weaning.

Muscle Reconstruction

Muscle reconstruction around the femur is essential to ensure a functional extremity. In addition, the bone end must be adequately covered and padded with muscles in order to avoid pressure from the prosthesis. The quadriceps and the hamstrings are tenodesed to each other by covering the bone end (Figure 22.10). The hip flexors are stronger than the extensors; thus, the hamstrings should be cut longer than the quadriceps and

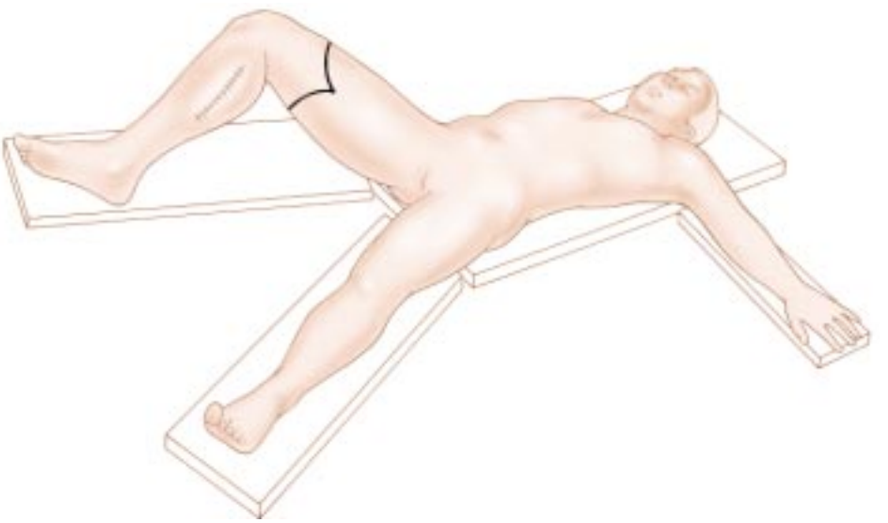


Figure 22.5 Position. The patient is supine; the operated extremity is in flexion and abduction.

Figure 22.6 Incision. The skin flaps are marked. The main factors that determine the type of flaps are the extent of the soft-tissue tumor, areas of prior radiation, and previous scars. The greatest priority is to avoid local recurrence and no attempt is made to adhere to standard flaps; at this level a skin or muscle flap of almost any length will heal primarily in a young patient. It is not necessary to utilize equal flaps; long posterior, anterior, and medial flaps will heal.

attached to one another, with the hamstrings somewhat tighter. In addition, the adductors should be tenodesed to these muscles and the femoral stump using drill holes and 3 mm Dacron tapes. This is especially important in the short proximal femoral stump, which has a tendency to go into flexion and abduction.

Closed suction drains are brought out of the medial and lateral aspects of the incision, and the superficial fascia is tightly closed (Figure 22.11). Special attention should be given to wound closure; it is important to avoid large folds of skin. Skin sutures must be positioned by halving the incision, especially if unusual skin flaps have been utilized.

As soon as the surgery is completed, a rigid dressing is applied (Figure 22.12); it is used to reduce the swelling and, if positioned proximally enough, prevent flexion contracture around the hip joint. Contractures are more common with short stumps; to prevent this problem the cast should be continued up to the groin and held in place with a belt. With early ambulation, patients tend to have less pain and experience fewer psychological difficulties. Patients with a rigid cast invariably mobilize earlier than those who have a standard soft dressing. Preoperative or early postoperative chemotherapy is not a contraindication to a rigid dressing and early ambulation. Drains are usually removed on the third or fourth day after the surgery or when each drains less than 50 ml/day. The patient should keep compression on the stump at all times; this is best accomplished with an elastic stump shrinker. As soon as the wound is healed and the stump is not significantly swollen (usually around 4 weeks after surgery), the patient can have the first prosthetic fitting.

REHABILITATION

Successful rehabilitation of the patient who has undergone an above-knee amputation requires a coordinated effort that should start at the time of the staging studies. The health-care team must develop an honest relationship with the patient and family and include them in the decision-making process from the very beginning. Building upon this basis the patient will be better able to accept the amputation and set realistic goals for recovery. The patient should be told that phantom limb sensations might occur following surgery. These sensations should be presented as a normal part of the recovery process. Phantom limb pain is generally controlled by the judicious use of analgesics and the passage of time.

The requirements of above-knee amputees are somewhat different from those of below-knee amputees. Their energy requirements are almost 100% greater, and it is not unusual for the above-knee amputee to require an assistive device (i.e. a cane) for community ambulation, and be less able to participate in sports than a patient who has undergone below-knee amputation. Younger and motivated patients can have a good functional outcome, but older patients can find the energy cost difficult to overcome.

The first stage of recovery is dedicated to proper wound healing and conditioning of the stump. Prevention of flexion contracture of the hip can be achieved with rigid dressing, prone positioning, a physical therapy program and, in most cases, a combination of all three modalities. The use of immediate postoperative prosthesis is more practical and better

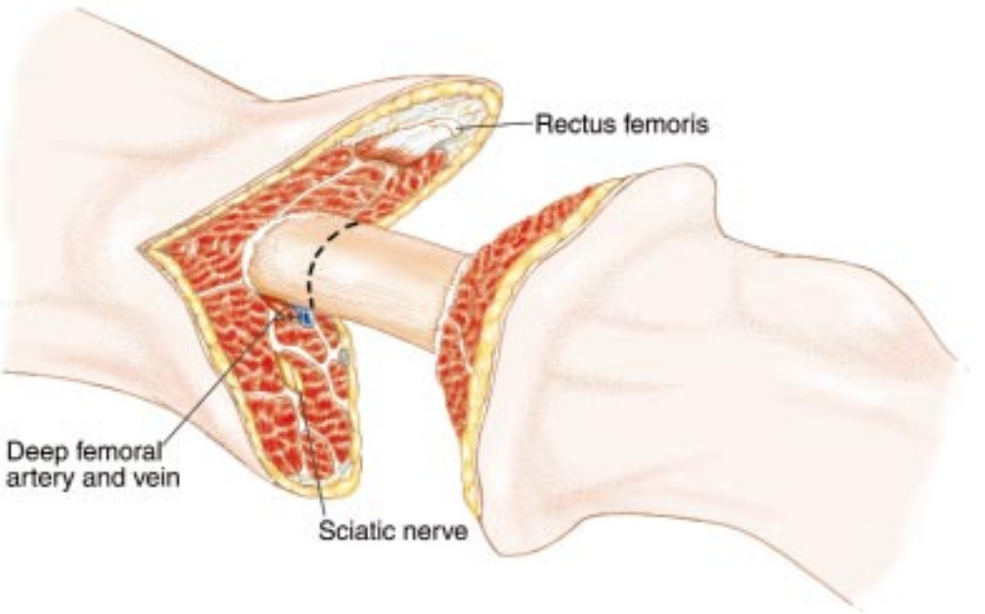


Figure 22.7 Transection of muscle and bone. Incision is performed through the skin, superficial fascia, and subcutaneous tissue vertical to the skin edges. Using electrocautery, muscles are beveled in their transection down to bone. Large vessels are dissected, suture-ligated in continuity, and transected in a bloodless fashion. Nerves should be gently pulled down from their muscular bed approximately 2 cm, ligated with nonabsorbable monofilament sutures, transected with a knife and allowed to retract back to the muscle mass. The bone is transected with an oscillating or Gigly saw without traumatizing the soft tissues.

tolerated by these patients than by below-knee amputees. A temporary prosthesis provides the patient the advantage of training with a simple and adaptable device. It also becomes a backup to the permanent prosthesis, which is fabricated when the residual limb has stabilized in volume and matured to allow full-time wear. Two critical elements are selection of the knee joint mechanism and suspension system. Many designs, with varying degrees of durability, gait parameters, weight, and stability, are available. Selection of an appropriate product is dependent on patient-specific factors such as age, weight, type of daily activities, and desired sports activities, and requires close consultation with the prosthesist.

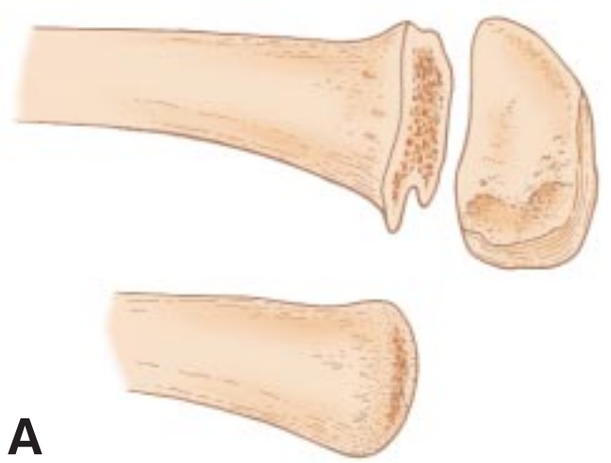


Figure 22.8 (**A**) The femoral edge should be beveled and smooth (**B**) A sharp edge can become extremely painful, especially when pressure from a prosthesis is applied.

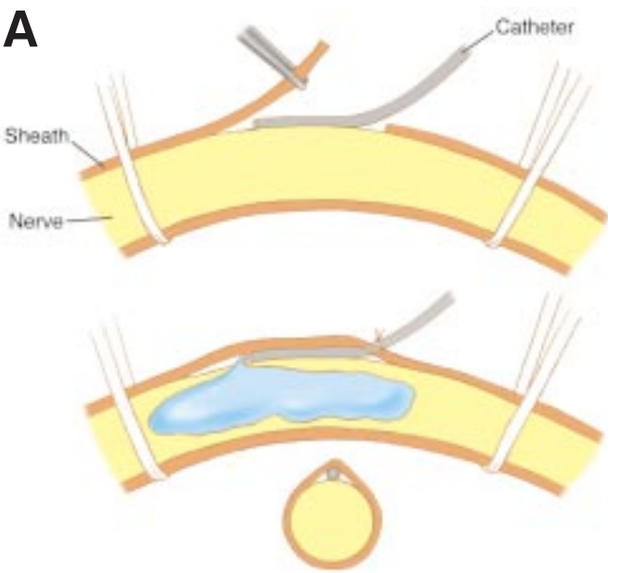


Figure 22.9 (**A**) Epidural catheter, flushed with bupivacaine 0.25%, is introduced to the epineural space. The catheter is advanced 5–7 cm proximally, and the neural sheath is sutured over the catheter with absorbable sutures. (**B**) Epineural catheter in the femoral nerve following above-knee amputation. Contrast dye was bolus injected to demonstrate the distribution of local anesthetics within the epineural space.

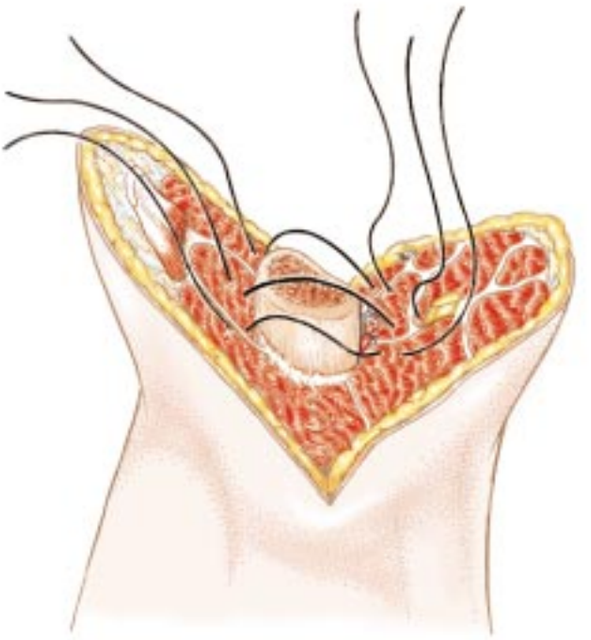


Figure 22.10 A two-layer myodesis is used over the end of the femur. Muscle stabilization of the femur is essential if strength of the limb is to be retained. The quadriceps and hamstrings muscles are myodesed to each other in covering the bony end of the femur, the and adductors are tenodesed to these muscles and the femoral stump using drill holes. This is especially important if there is a short proximal femoral stump, which has a tendency to go into flexion and abduction.

Figure 22.11 Closed suction drains are brought out of the medial and lateral aspects of the incision. It is important not to stitch these catheters to the skin, because they will be removed from inside the rigid dressing.

Figure 22.12 Application of a rigid dressing.

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