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Proximal Tibia Resection with Endoprosthetic Reconstruction

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OVERVIEW

Resection is a limb-sparing option for low-grade bony sarcomas and most high-grade (Stage IIA or IIB) sarcomas (e.g. osteosarcomas) arising from the proximal tibia. In the past, several surgical and technical problems made it impossible to perform limb-sparing surgery for tumors at this site. These problems included anatomic constraints, a difficult surgical approach, inadequate soft-tissue coverage, vascular complications, and the need to reconstruct the patellar/extensor mechanism. Appreciating these challenges, most surgeons recommended above-knee amputation for these lesions.

The limb-sparing technique illustrated in this chapter allows a safe approach to the dissection of popliteal vessels and to the resection and replacement of the proximal one-third to two-thirds of the tibia. Preoperative evaluation of tumor extent requires a detailed understanding of the anatomy and careful evaluation by computerized tomography (CT), magnetic resonance imaging (MRI), bone scintigraphy, and biplane angiography. The major contraindications to limb-sparing are a pathologic fracture, neurovascular involvement, or contamination from a poorly positioned biopsy. One-half to two-thirds of the tibia is removed, along with a portion of all muscles inserting on the tibia and the entire popliteus muscle, in combination with an extra-articular resection of the proximal tibiofibular joint. The peroneal nerve is preserved. The surgical options for reconstruction are primary arthrodesis, prosthetic replacement, or allograft replacement. We prefer a prosthetic replacement; allograft replacements have a high rate of infection, fracture, and local tumor recurrence. One key to the success of this procedure is the use of a gastrocnemius muscle transfer to obtain reliable soft-tissue coverage that helps prevent skin flap necrosis and secondary infections, and provides for reliable extensor mechanism reconstruction. Most patients with low-grade sarcomas, and approximately half of those with high-grade sarcomas, of the proximal tibia can be treated by a limb-sparing resection.

INTRODUCTION

The proximal tibia is the second most common site for primary bony sarcomas.[1] Because of several unique surgical problems, and the difficulty of reconstruction, this site is a difficult area in which to perform a safe limb-sparing resection that preserves function. There have been only a few reports of limb-sparing resections for high-grade sarcomas of the proximal tibia.[2–6] Most surgeons still recommend above-knee amputations even though good results, widespread acceptance, and varied techniques for limb-sparing resections of bony sarcomas (distal femur[3,7–9] and of the tibia); and have been reported for giant cell tumors and low-grade sarcomas, (i.e. chondrosarcomas) (Figure 31.1).[5,10–12]

The difficulty in performing a successful resection for a high-grade sarcoma of the tibia arises from the local anatomy, rather than from any inherent properties of the tumor. In fact, persons with osteosarcomas of the proximal tibia have higher survival rates than those with tumors of the distal femur.[13–15] The surgical and technical problems include intimate anatomic relationships, a difficult surgical approach, inadequate soft-tissue coverage, and vascular complications. In addition, unique to an arthroplasty of the proximal tibia is the need to reconstruct the patellar tendon (extensor mechanism). Finally, one must deal with a second adjacent joint, the proximal tibiofibular joint. These difficulties have often led to a high rate of early postoperative complications, foremost among which is failure of reconstruction. The ultimate result was a poor functional outcome and/or secondary amputations.

This chapter describes a technique developed by the senior author during the past 20 years, that permits safe and easy access to the popliteal vessels, resection and replacement of a large segment of the tibia and knee joints, and a method of patellar/extensor mechanism reconstruction and soft-tissue coverage that utilizes a transferred medial gastrocnemius muscle (Figures 31.2 and 31.3). The unique anatomic considerations, as well as the staging studies that are necessary to determine resectability, are emphasized.[6,16–18]

INDICATIONS

Indications for proximal tibia resections include low-grade bony sarcomas (usually chondrosarcomas), recurrent aggressive benign tumors (especially giant-cell tumors), and carefully selected high-grade sarcomas.[4,5,11,12] The most common high-grade bony sarcoma is osteosarcoma; malignant fibrous histiocytoma and fibrosarcoma are less common.[6,16] Round-cell sarcomas (e.g. Ewing's sarcoma of bone) were traditionally treated by resection combined with chemotherapy (Figure 31.4).

In recent years Ewing's sarcoma (Figure 31.5) has been treated by induction chemotherapy and resection with a prosthesis replacement; no postoperative radiation is used. Candidates for resection are selected on the basis of a careful evaluation of the local tumor extent, placement of any previous biopsy sites, and the patient's functional demands. The preoperative assessment must include an evaluation of the length of bone resection that would be required (usually not more than one-half to two-thirds of the tibia); the degree of soft-tissue, capsular, and patellar tendon involvement; and the tumor-free status of the popliteal trifurcation (Figures 31.6 and 31.7).

Contraindications to resection include a pathologic fracture, extensive contamination from a poorly positioned biopsy, tumor penetration through the skin, and local sepsis. Relative contraindications include a large posterior extraosseous component and immature skeletal age. Expandable prostheses are used in younger patients in the hope of avoiding future problems related to leg-length discrepancy (Figure 31.5).

UNIQUE ANATOMIC CONSIDERATIONS

Popliteal Trifurcation

Surgical procedures of the popliteal space require extremely careful preoperative planning, beginning with an evaluation of the vascular pattern around the knee. The popliteal artery divides into the anterior tibial artery, the posterior tibial artery, and the peroneal artery at the inferior border of the popliteus muscle. The popliteal trifurcation is actually two bifurcations. The first is found at the place where the anterior tibial artery arises from the popliteal artery, which then continues as the tibioperoneal trunk. The anterior tibial artery is the first branch and arises at the inferior border of the popliteus muscle. The second bifurcation is found where the peroneal artery and the posterior tibial artery arise from the tibioperoneal trunk; thus, the second bifurcation is distal to the anterior tibial takeoff. It is almost always essential to ligate the anterior tibial artery at the time of resection, and other vessels must be identified before ligation. A unique and fortunate occurrence is the popliteus muscle that covers the posterior surface of the tibia, which affords an excellent boundary between posterior soft-tissue extension from the tibia and protects the popliteal artery and its branches. This is in contrast to the distal femur, in which the posterior aspect is covered only by the popliteal fat.

Tibiofibular Joint

The proximal tibiofibular joint is in close proximity to the posterolateral aspect of the proximal tibia. Histologic

Figure 31.1 Plain radiographs of osteosarcoma of the proximal tibia. (**A**) Small sclerosing osteosarcoma of the lateral aspect of the proximal tibia. (**B**,**C**) Anteroposterior and lateral radiographs of an infiltrative mixed osteoblastic and osteolytic osteosarcoma of the proximal tibia. Proximal tibial resections up until 1984 were rarely performed. Following that date the development of the surgical technique of resection and medial gastrocnemius transposition permitted limb-sparing surgery to be performed safely with minimal postoperative morbidity.

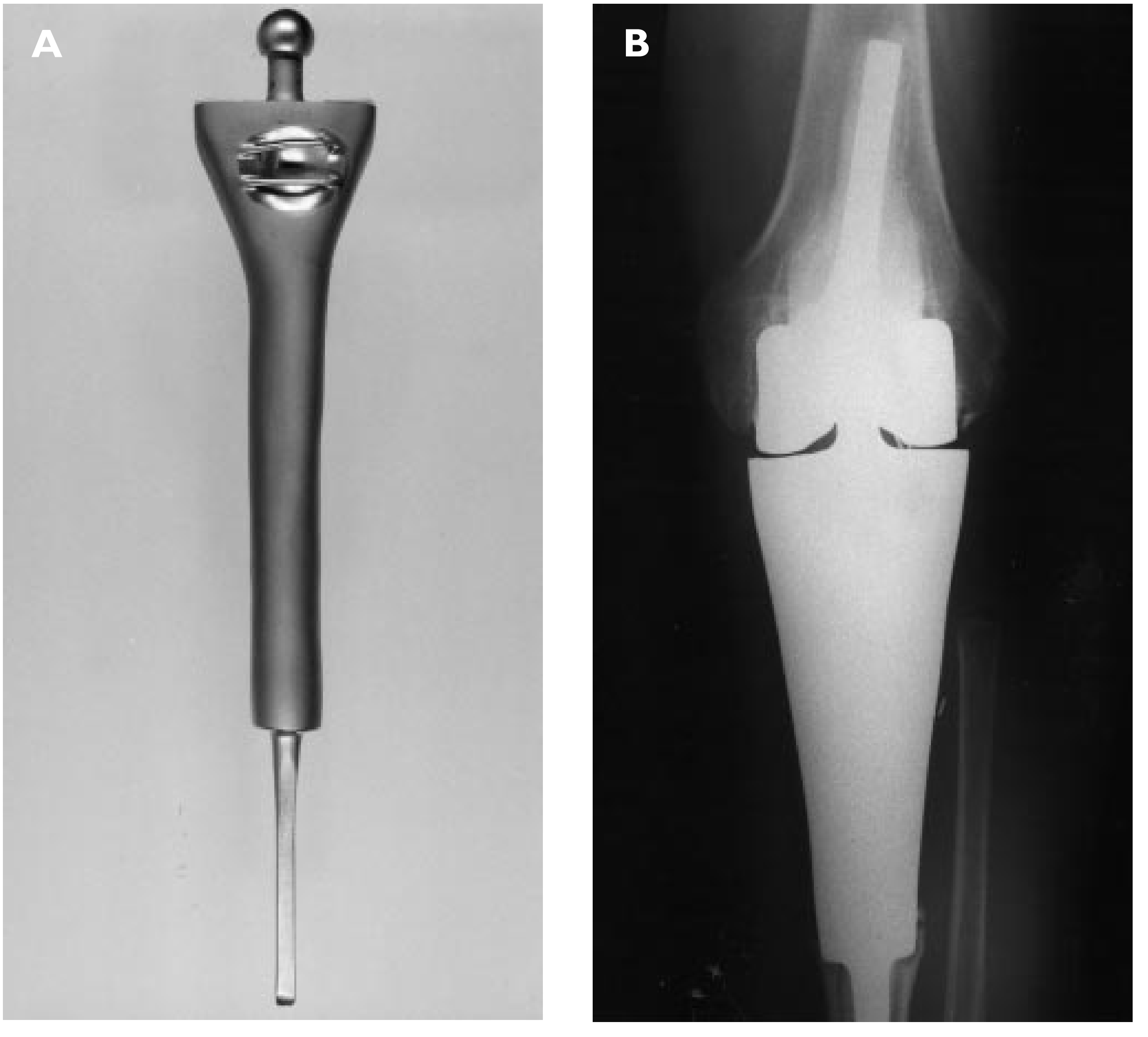

Figure 31.2 *(see above and following pages)* Different proximal tibial prostheses utilized over a 25-year period. (**A**) Photograph of the original custom proximal tibial replacement with a spherocentric knee component. (**B,C**) Anteroposterior and lateral radiographs of a similar prosthesis implanted. (**D**) Composite photograph of a custom and a present-day modular segmental proximal tibial replacement. Proximal tibial replacements with a modular design (Howmedica) began in 1988. (**E**) The first proximal tibial component with porous coating along the entire body to permit soft-tissue attachments of the adjacent muscles as well as attachments of the patellar extensor mechanism. (**F**) Plain lateral radiograph of a similar prosthesis as in (**D**). Note that no body was utilized between the stem and the tibial component. In general, resections of the proximal tibia are best performed when less than one-third of the length must be resected.

studies show that tumors involving the proximal tibia have a high incidence of extension and involvement of the periscapular tissues of the tibiofibular joint. To obtain a satisfactory surgical margin while performing a resection of the proximal tumor, it is necessary to remove this joint en-bloc, i.e. perform an extra-articular resection. This is routine procedure for all high-grade sarcomas of the proximal tibia.

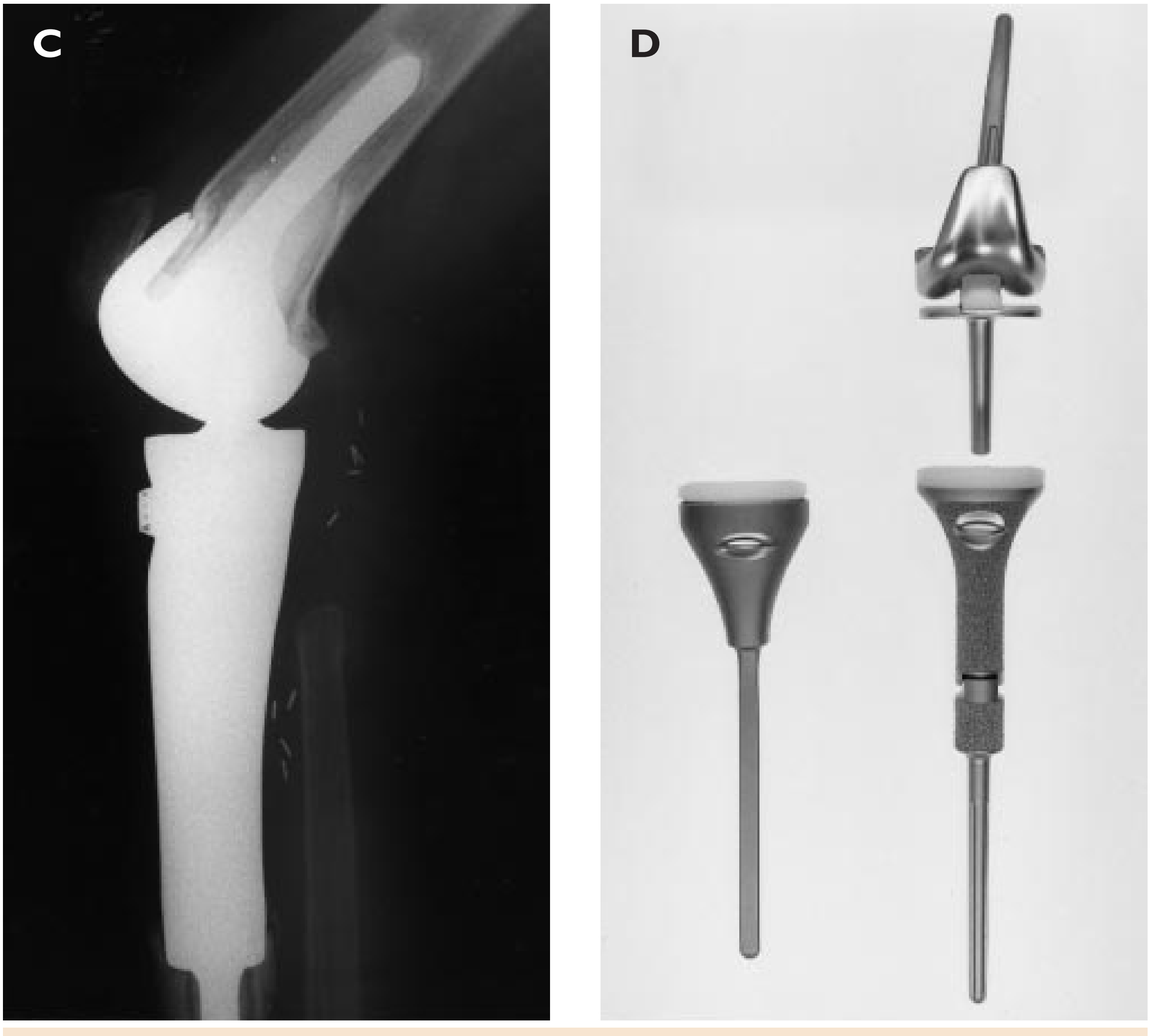

Figure 31.2C,D

Knee Joint and Cruciate Ligaments

The knee joint is rarely directly involved by tumors of the proximal tibia unless there has been a pathologic fracture or a biopsy has contaminated the knee joint. A hemarthrosis is suggestive of intra-articular disease. MRI is the most reliable means of determining cruciate ligament involvement. If nodules are seen on the cruciate ligaments a partial extra-articular resection (i.e. a proximal tibial resection with removal of the femoral condyles en bloc with the proximal tibia) may be performed. Amputationis not required. Involvement of the cruciate ligaments is often not determined until the time of surgery.

Extensor Mechanism

The patellar tendon and capsular mechanism insert onto the proximal tibia and patellar tubercle. Reconstruction of this mechanism is essential for a functioning extremity. Traditionally, such reconstruction has been extremely difficult; as a result the surgical choices were to perform an arthrodesis or an amputation. Over the past 20 years several techniques of extensor mechanism reconstruction have been developed. The technique described by Malawer utilizes the medial gastrocnemius muscle, which provides for a soft-to-soft tissue reconstruction of the extensor mechanism and has proven to be quite reliable.

Figure 31.2E,F

Subcutaneous Location of the Tibia

The entire medial aspect of the tibia lies in a subcutaneous location. Resection and reconstruction by any technique leave the reconstructed area in a subcutaneous position. This has been a major source of primary and secondary infections, which, in turn, have necessitated an above-knee amputation. Today the routine transfer of the medial gastrocnemius muscle anteriorly, to cover the prosthesis, is a reliable method of prosthetic coverage. This transfer also provides a method of extensor mechanism reconstruction. It is a simple and reliable means of decreasing the incidence of infection, flap necrosis, and secondary amputation.

STAGING STUDIES

Detailed radiographic analysis is necessary before surgery.

Bone Scintigraphy

Bone scintigraphy is done to rule out skip lesions and to determine the extent of local intraosseous tumor. The

Figure 31.3 Gross specimen of an osteosarcoma following resection. (**A**) Posterior aspect of a proximal tibial resected specimen. Note the extra-artciular resection of the tibiofibular joint (arrows). The proximal fibula is resected with the proximal tibia due to the high risk of extension along the tibiofibular joint capsule and joint space. The popliteus muscle (P) covers the posterior aspect of the proximal tibia. This muscle permits proximal tibial resections and often permits a safe margin between the tumor and popliteal trifurcation. Note the hemaclip at the lower border of the popliteus muscle (curved arrow). This indicates the level of the anterior tibial artery that traverses from the posterior to the anterior compartment. This artery is routinely ligated to permit mobilization of the popliteal trifurcation during the initial steps of resection (see below). (**B**) A sagittal section through an osteosarcoma involving the proximal one-half of the tibia. Note, there is some tumor permeation of the epiphyseal cartilage. The tibiofibular joint was resected extra-articularly (arrow).

Figure 31.4 *(see following page)* Intraoperative photograph of the surgical technique of reconstruction with a modular segmental prosthesis following a proximal tibia resection and prosthetic replacement. A gastrocnemius transposition flap is the key to soft-tissue coverage and reconstruction of the extensor mechanism. (**A**) Intraoperative photograph of exposure and exploration of the proximal tibia and popliteal vessels prior to resection. The vessel loop is on the anterior tibial artery, which is routinely ligated. (**B**) Intraoperative photograph demonstrating the segmental defect following resection of the proximal tibia. The vessel loop is around the popliteal and the tibial peroneal vessels. (**C**) A Modular Segmental Prosthesis cemented into place with the patellar tendon being advanced through the loop on the prosthesis. (**D**) The patellar tendon is sutured to the loop of the prosthesis with a 3-mm Dacron tape with a cancellous bone graft within the loop to re-create a bone-tendon junction. This is later reinforced by the medial gastrocnemius muscle transposed anteriorly. (**E**) Transposition of the medial gastrocnemius muscle to cover the prosthesis as well as to aid in the soft-tissue reconstruction of the extensor mechanism. The muscle is sutured down to the transferred patellar tendon as well as sewn circumferentially to the medial and lateral capsules of the knee joint. (**F**) Medial gastrocnemius muscle is partially transposed. Note the posterior aspect of the muscle has been denuded of its deep thick fascia that permits the muscle to expand to cover a larger area. In addition, if a skin graft is necessary, it will readily take on a muscle belly in lieu of the deep fascia. (**G**) Soft-tissue reconstruction completed. The medial gastrocnemius muscle covers the entire prosthesis as well as reinforcing the patellar mechanism (GM = medial gastrocnemius muscle; arrows = level of the knee joint).

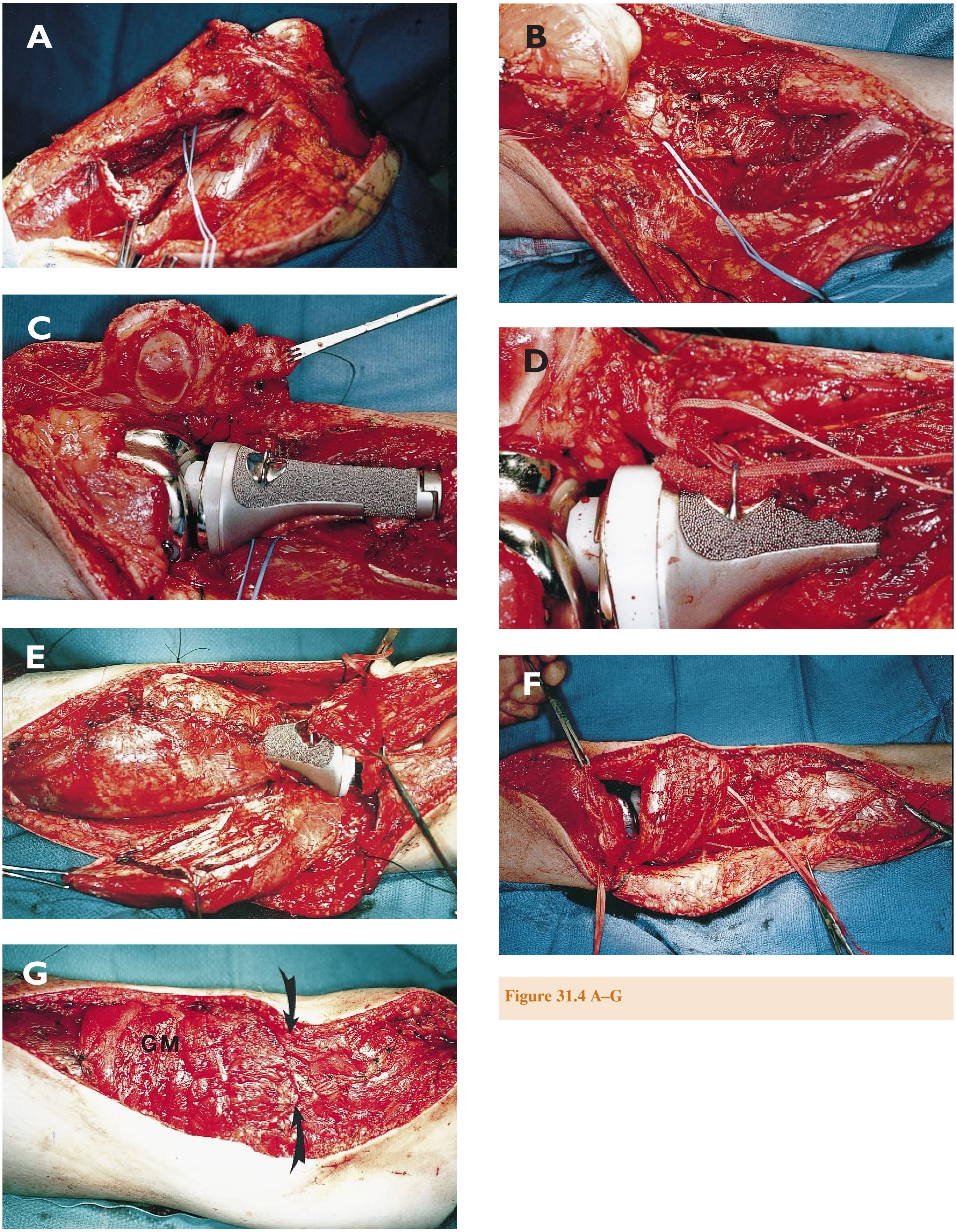

Figure 31.4 A–G

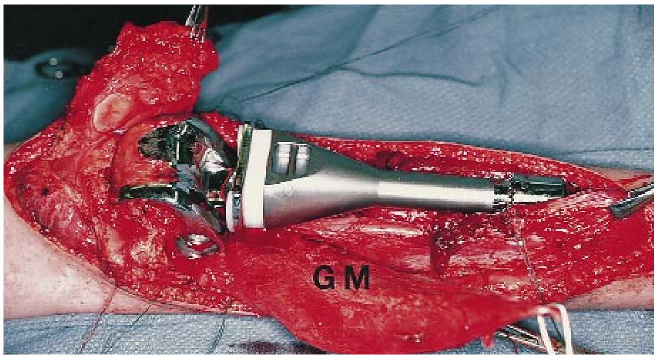

Figure 31.5 Intraoperative photograph of an expandable proximal tibial prosthesis. The patellar tendon and medial gastrocnemius muscle (GM) is utilized for soft-tissue reconstruction.

Figure 31.7 Various proximal tibial prostheses utilized during the 1980s showing a common mode of failure. The custom prosthesis on the left with porous coating shows stress fracture of the stem and similarly both expandable prostheses by different manufacturers show fracture of the stem. This was a common occurrence in the older design intramedullary stems that were often too short and narrow. In general, stems of greater than 9-mm are now utilized and rarely fracture.

Figure 31.6 Allograft replacement. Plain radiograph 4 years following a proximal tibial allograft replacement. Note the allograft failure with collapse of the articular surface and resorption of the proximal tibial component. This patient was salvaged by a proximal tibial prosthetic replacement. In general, the authors do not recommend allograft replacements and prefer prosthetic reconstruction.

site of resection is 3–5 cm distal to the area of abnormality. At least one-third of the remaining distal tibia must appear normal.

CT and MRI

CT and MRI are useful to determine intraosseous and extraosseous extension of the primary tumor. MRI can also reveal skip lesions and soft-tissue extension. Attention is paid to the possibility of posterior extension and tibiofibular joint and intra-articular knee involvement.

Angiography

Biplane angiography (Figure 31.8) is used for local arterial evaluation, especially if CT has revealed posterior soft-tissue extension. The anteroposterior view is used to evaluate the popliteal bifurcation; of particular relevance is the presence or absence of the posterior tibial artery, which may be the sole blood supply to the leg after resection. The lateral view is required to evaluate the interval between the tibia and the neurovascular bundle. The popliteus muscle often separates a posterior tumor mass from the vessels.[2,19] This is seen as a clear interval on the lateral angiogram and is an indication that an adequate resection margin exists. Ligation of the anterior tibial artery is almost always required. The peroneal artery may be involved by tumors with a large posterior compartment. Two of the major vessels may be ligated in a young patient, without jeopardizing the possibility of a viable and functional extremity. The posterior tibial artery is almost never involved by tumor.

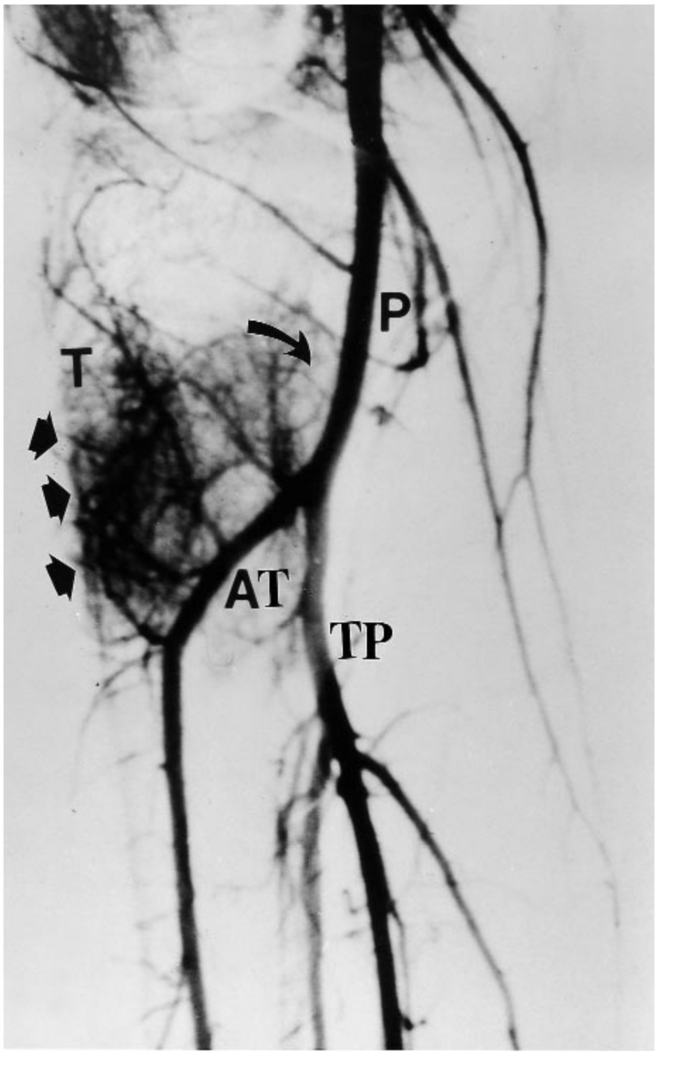

Figure 31.8 Angiogram showing lateral view of the popliteal artery. The space between tumor in the proximal tibia and the popliteal bifurcation is best appreciated by this study. The popliteal artery (P), tibioperoneal trunk (TP), and anterior tibia (AT) arteries are all visualized. It is essential that the soft tissue posterior to the tumor mass (curve arrow) be free of cancer along the popliteal artery and tibioperoneal trunk. The popliteus muscle covers the bone in this interval and usually protects the vessels from tumor invasion. A tumor (T) blush (small arrows) is seen anteriorly.

BIOPSY

Extreme caution must be taken to minimize contamination of the anterior muscles, peroneal nerve, patella tendon, and knee joint when the biopsy is performed. The biopsy site must be placed along the line of the definitive incision (i.e. the anteromedial aspect of the tibia). A small core biopsy of the extraosseous tumor component is optimal. The biopsy is performed under CT or fluoroscopic guidance. There is no need to open the cortex unless no extraosseous component is easily accessible. If the cortex must be opened, a tourniquet is used to decrease local contamination, and the cortical window is plugged with a small amount of polymethyl methacrylate (PMMA).

SURGICAL GUIDELINES (Figure 31.4)

There are three major steps involved in successful resection and reconstruction of tumors of the proximal tibia: (1) resection of the tumor, (2) reconstruction of the skeletal defect and knee joint with a modular prosthesis, and (3) reconstruction of the extensor mechanism and soft-tissue coverage of the prosthesis with the medial gastrocnemius flaps.

Key issues to be considered during the various phases of surgery include the following:

1. *Incision*. A long medial incision is made from the medial peripatella to the distal one third of the leg

posteriorly and medially. Thick fasciocutaneous flaps must be developed to avoid skin necrosis.

2. *Early popliteal exploration*. The popliteal trifurcation must be explored early to determine if the tumor is operable, especially if it is in a posterior location. The popliteal space and trifurcation are exposed by detaching the medial gastrocnemius muscle and splitting the soleus muscle. A key to a successful approach to the popliteal trifurcation, especially when there is a large posterior mass displacing the vessels, is to first expose the popliteal space by identifying and detaching the origin of the medial gastrocnemius muscle and the insertion of medial hamstring muscles. The popliteal artery can be easily identified in normal tissue and be traced distally around the popliteus muscle.
3. *Tibiofibular joint resection*. This resection is performed through the same incision; a lateral flap is developed to permit exposure to the proximal fibula. The peroneal nerve must be exposed and retracted prior to resection.
4. *Exposure of the knee joint*. The capsule is transected circumferentially approximately 1 cm away from the tibia and the patellar tendon, to avoid contamination. The cruciate ligaments are visually explored. If there is any evidence of tumor nodules, the femoral condyle is later resected en-bloc with the proximal tibia, and a trans- or intra-articular resection is not performed.
5. *Soft-tissue and extensor reconstruction*. The medial gastrocnemius muscle is used for reconstruction. This provides a safe and reliable method of reconstructing the extensor mechanism as well as coverage of the prosthesis, which is essential to prevent early or late infections.
6. *Doppler examinations*. Doppler is utilized to check the pulses distally and at ankle level after the prosthesis is cemented. To prevent any spasm, the vessels are protected throughout the operative procedure with a papaverine-soaked sponge.

TECHNIQUE OF MEDIAL GASTROCNEMIUS TRANSFER AND PATELLAR MECHANISM RECONSTRUCTION

The technique for reconstruction of the patellar mechanism and coverage of the proximal tibia is based on the anterior transfer of the medial gastrocnemius muscle. Originally described by Malawer in the mid-1980s, this technique has proven to be successful and reliable.[16,17] The medial gastrocnemius muscle is not developed until the prosthesis has been cemented into position. It is then detached distally from the midline and rotated anteriorly to cover the body of the prosthesis as well as the knee joint.

The medial gastrocnemius muscle is based in the medial sural artery, which must be protected during the popliteal exploration and ligation of the geniculate vessels. The medial sural artery takes off from the popliteal artery in a medial and posterior direction, whereas the geniculate vessels arise from the popliteal artery and traverse anteriorly to the distal femur and knee joint. The medial gastrocnemius muscle can be rotated both transversely and proximally to cover large defects in either direction. Approximately a 20-cm area can be covered. The medial gastrocnemius muscle is sutured to the lateral aspect of the remaining muscles of the leg circumferentially, and the capsular mechanism is sutured to the transferred muscle. The patellar tendon is sutured directly to the muscle as well as to the loops or the holes on the tibial prosthesis. Dacron tape is utilized to close the patellar tendon to the prosthesis as well as to reinforce the suture line along the gastrocnemius muscle. The reconstruction of the extensor mechanism is both dynamic (patellar tendon to gastrocnemius muscle) and static (Dacron tape fixation of the patellar tendon). This reconstruction reliably permits full knee extension and approximately 90–100° of knee flexion.

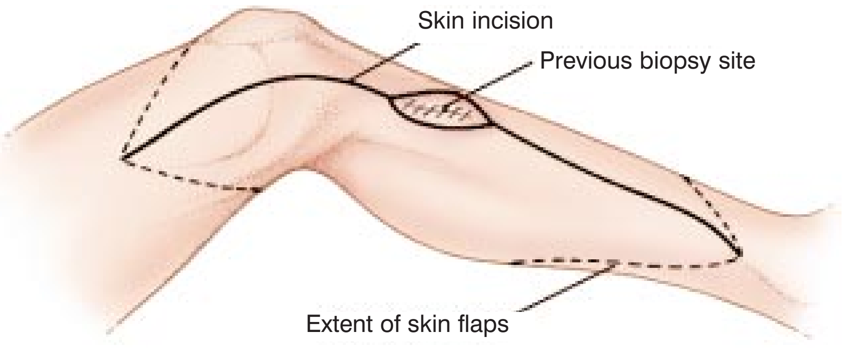

Figure 31.9 Incision. A single anteromedial incision is made, beginning proximally at the distal one-third of the femur and continuing to the distal one-third of the tibia. The approach includes excision of biopsy sites with at least a 2-cm margin. Medial and lateral flaps of skin and subcutaneous tissue are developed. Uninvolved flaps are raised with the underlying fascia to decrease flap ischemia.

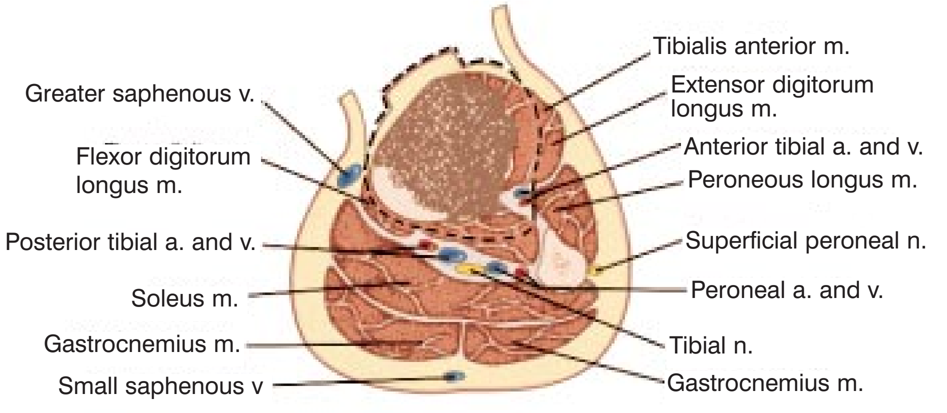

Figure 31.10 Cross-section of leg through the proximal tibia showing the planes of dissection.

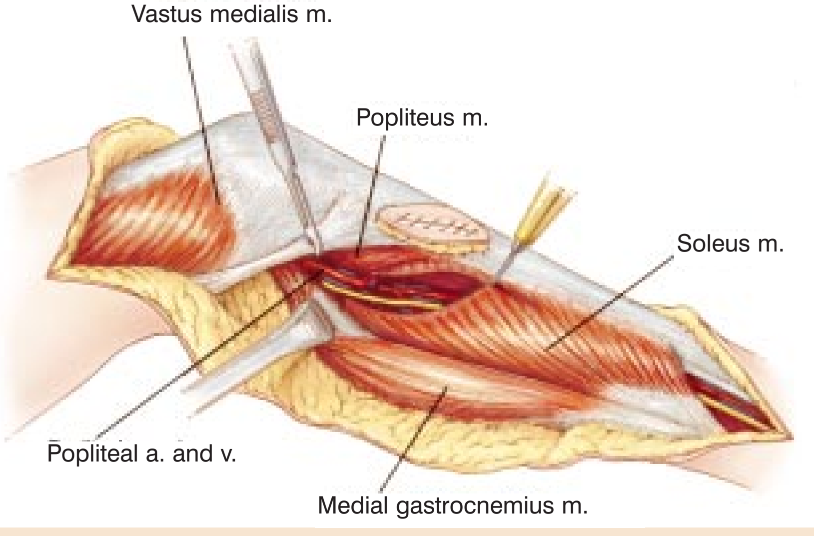

Figure 31.11 Exploration of popliteal artery trifurcation. Careful exploration of the popliteal fossa is needed to determine resectability. The medial flap is continued posteriorly, and the medial hamstrings are released at 2–3 cm proximal to their insertion to expose the popliteal fossa. The popliteal vessels are identified, and the trifurcation is initially explored through the medial approach. The medial gastrocnemius is partially mobilized, and the soleus muscle is split to expose the neurovascular structures. Care is taken to preserve the medial sural artery, which is the main pedicle to the medial gastrocnemius muscle. If the interval between the posterior aspect of the tibia and the tibioperoneal trunk (separated by popliteus muscle) is free of tumor, resection can proceed.

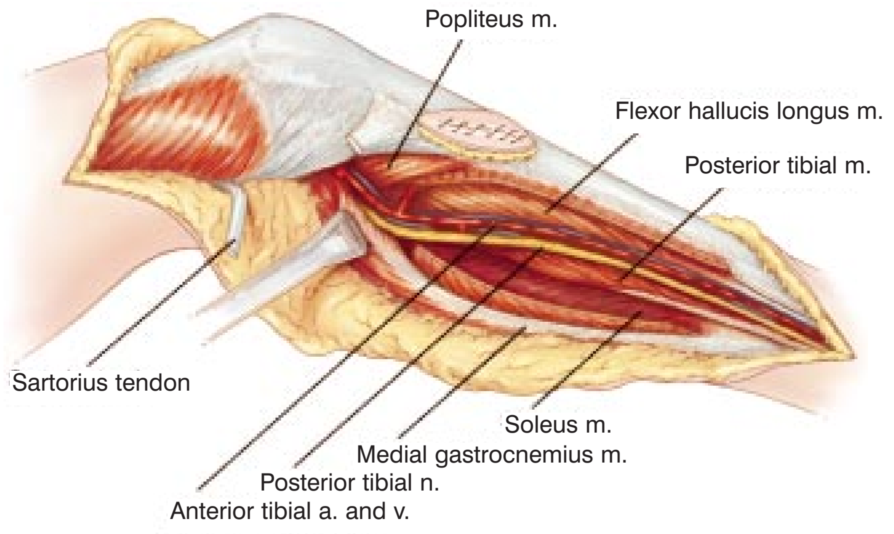

Figure 31.12 Dissection and exposure of the neurovascular bundle. Identification and mobilization of the major vessels are often difficult because the tumor has distorted the normal anatomy. Care should be taken to identify all major vascular branches to any ligation. The anterior tibial artery, which is the first takeoff of the popliteal artery, is located at the inferior border of the popliteus muscle. As this artery passes directly anterior through the interosseous membrane, this artery ties down the entire neurovascular bundle.

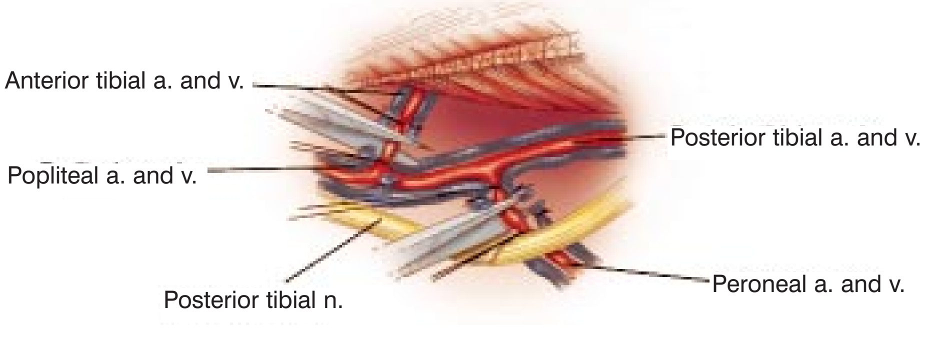

Figure 31.13 Ligation of the anterior tibial and peroneal artery and vein. Applying posterior traction proximal to the popliteal artery permits visualization of the takeoff of the anterior tibial artery and its accompanying veins. The anterior tibial vessels are individually ligated, allowing the entire neurovascular bundle to fall away from the posterior aspect of the tibia and/or tumor. If the mass is large, the peroneal artery must occasionally also be ligated.

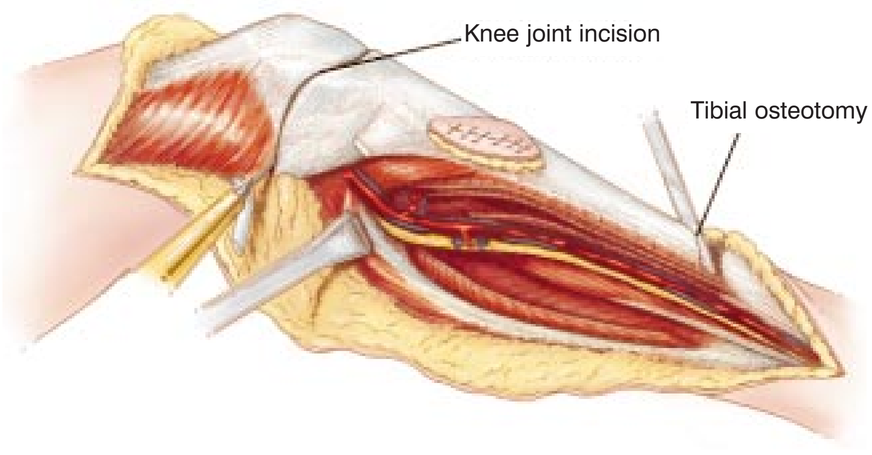

Figure 31.14 Knee joint incisions, capsular incision, and osteotomy. A small arthrotomy is performed. The meniscus and cruciate ligament are carefully evaluated. If there is no evidence of hemarthrosis (indicating tumor contamination) or direct tumor extension, an intra-articular resection is performed. The patellar tendon is sectioned 1–2 cm proximal to the tibial tubercle, and the entire capsule of the knee is detached circumferentially by electrocautery 1–2 cm from the tibial insertion. The posterior capsule is dissected carefully under direct vision after the popliteal vessels have been mobilized by ligation of the inferior geniculate vessels. The cruciate ligaments are sectioned close to the femoral attachments, and frozen sections of the proximal stumps are obtained. The capsular excision is done to the distal tibial osteotomy.

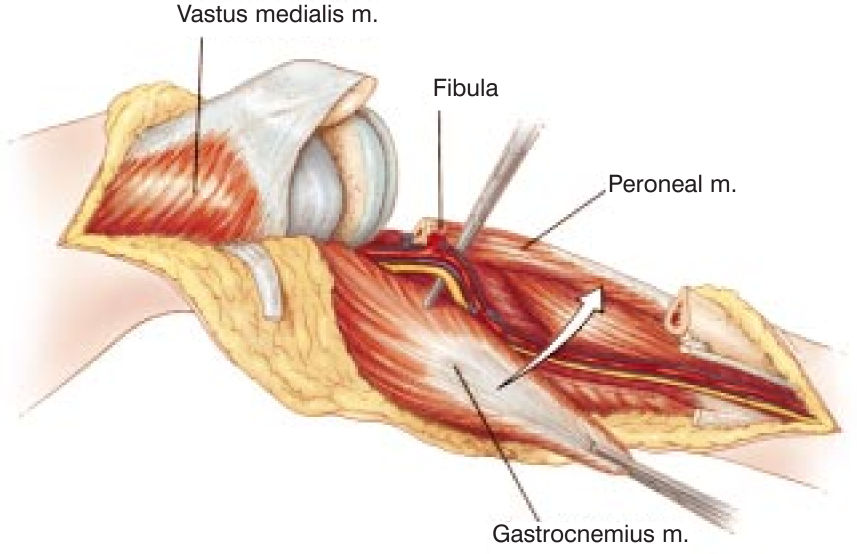

Figure 31.15 Exposure of the peroneal nerve and resection of the tibiofibular joint. A portion of the anterior tibialis muscle is routinely removed along with the tibia. The remaining anterior compartment muscles are preserved. Care must be taken to protect the branches of the peroneal nerve that enervate the anterior muscles. Posteriorly, a portion of the soleus origin and the entire popliteus muscle are left on the tibia.

The peroneal nerve is identified proximal to the fibular head and below the fascia of the biceps tendon. The biceps is transected 2 cm proximal from insertion. The peroneal nerve is freed from the proximal fibula, and the fibula is osteomized approximately 6–8 cm from its head. An extra-articular resection of the proximal tibiofibular joint is routinely performed. A sleeve of muscle is left on the joint in order to avoid inadvertent contamination by tumor. Care must be taken not to place tension on the peroneal nerve.

To release the specimen, the tibia is osteomized 5–6 cm distal to the lesion, as determined by bone scintigraphy, MRI, and CT. The intermuscular septum is released under direct vision. An intra-articular resection of the knee joint is then completed. (From Malawer and McHale.[17]; reprinted with permission.)

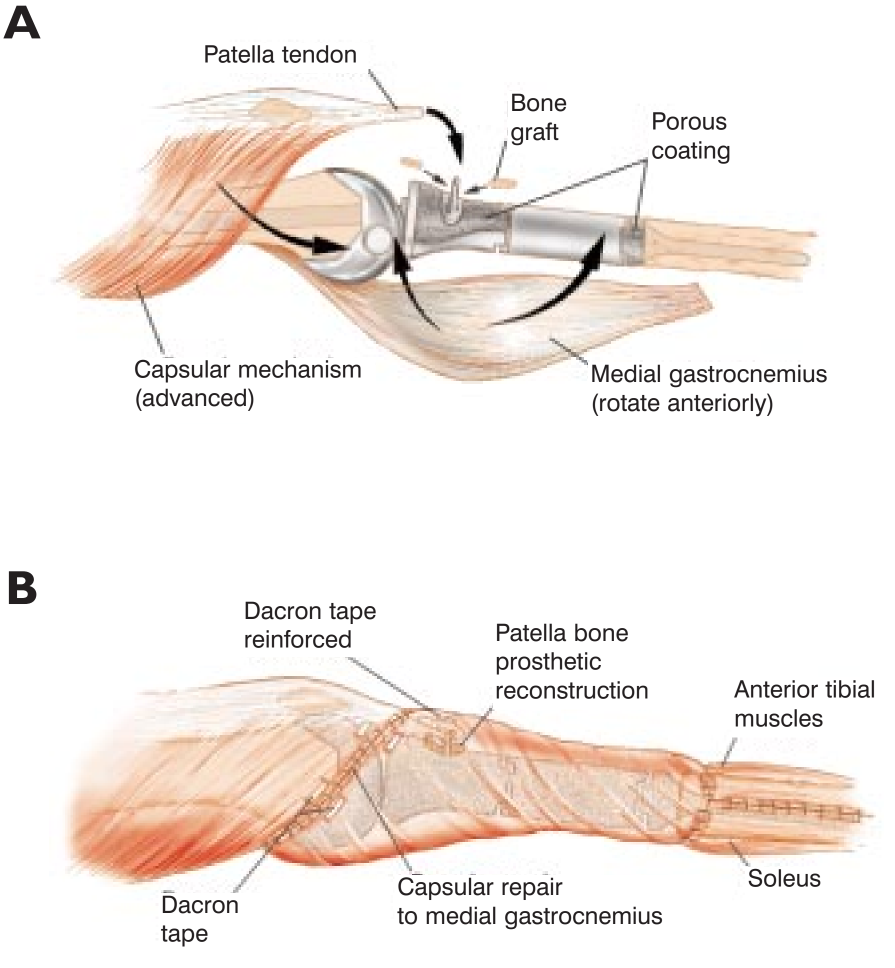

Figure 31.16 Extensor mechanism and patellar tendon reconstruction. (**A**) Schematic showing the reconstruction of the extensor mechanism. The remaining patellar tendon is sutured to the loop or the holes on the proximal tibia prosthesis with Dacron tape. Bone graft (from a portion of the resected bone from the distal femoral cuts) is placed tightly between the porous coating and the tendon. The bone graft is wedged into place. This will re-create a new "bone–tendon" junction. The medial gastrocnemius muscle is mobilized and rotated anteriorly to cover the prosthesis. The remaining medial and lateral capsular structures are advanced distally. (**B**) Completion of the extensor repair. The medial gastrocnemius muscle is now covering the prosthesis. The medial and lateral knee capsular structures are tenodesed to the superior border of the rotated medial gastrocnemius muscle. This repair is reinforced with 3 mm Dacron tape both medially and laterally. The patella tendon and bone graft are held tightly in place. The inferior border of the rotated medial gastrocnemius muscle is sutured to the soleus muscle to close over the distal end of the prosthesis. The soleus muscle may be mobilized and rotated anteriorly to close this distal corner. The soleus muscle is then sutured to the anterior leg muscles to cover the exposed tibial shaft.

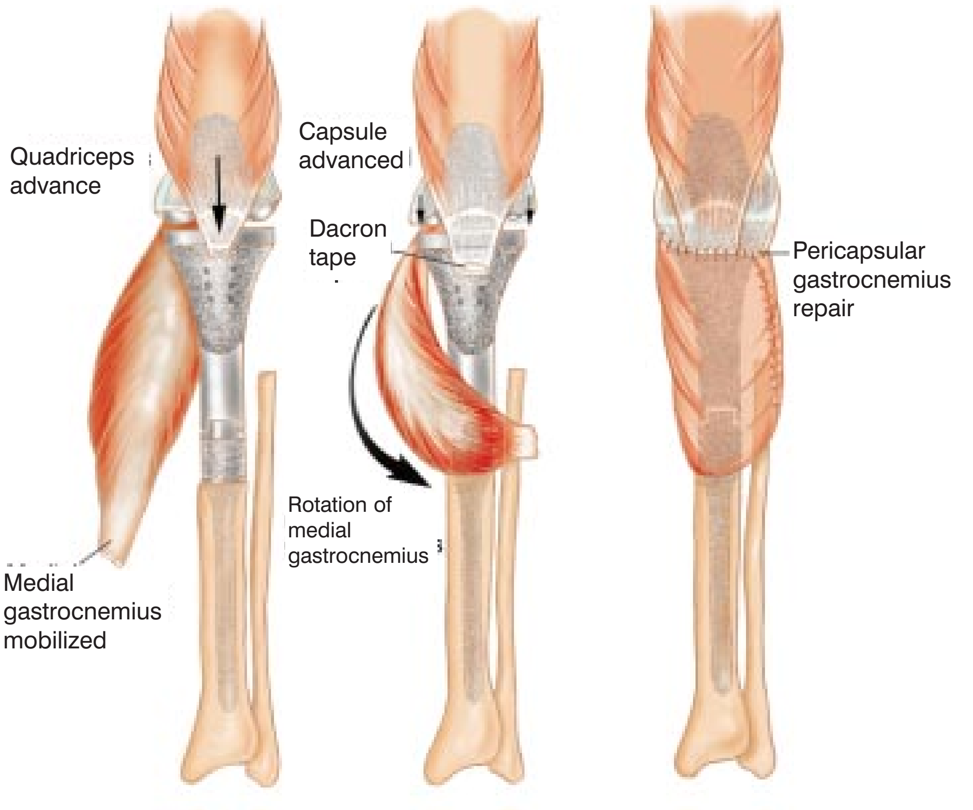

Figure 31.17 Soft-tissue reconstruction and gastrocnemius transposition. Irrespective of the type of skeletal reconstruction, a medial gastrocnemius transposition flap (GTF) is used to provide soft-tissue coverage.[21] The medial sural artery is carefully preserved to the medial gastrocnemius muscle. The muscle graft is spread out, rotated anteriorly over the defect, and sutured to the border of the anterior muscles, forming a complete soft-tissue envelope around the prosthesis. Dacron tapes sewn into the patellar tendon are tied to a highly polished loop on the prosthetic tibia.

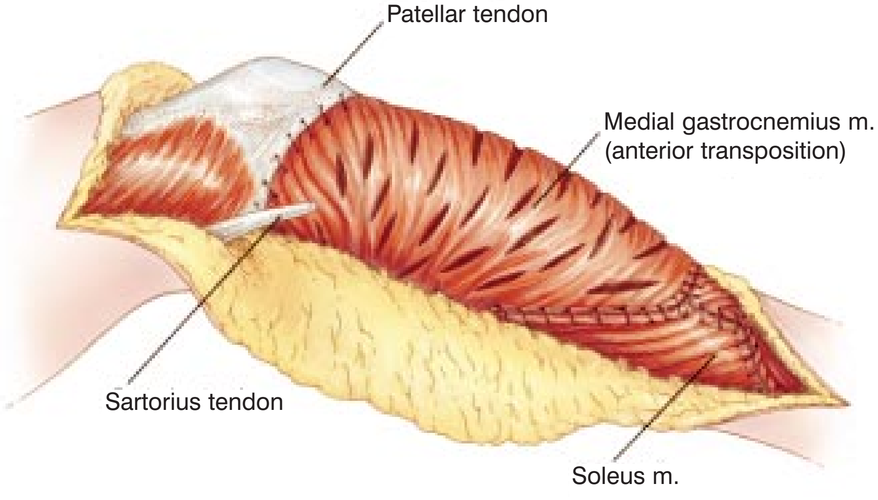

Figure 31.18 Muscular closure. The patellar tendon and anterior capsule are advanced and sutured to the transferred GTF with nonabsorbable sutures. The proper tension on the quadriceps mechanism is determined by bending the knee through a 30–40° range of motion. The medial hamstrings are reattached to the transferred medial gastrocnemius muscle. If possible, the soft tissue posterior to the prosthesis or arthrodesis should be closed to avoid direct contact of the neurovascular bundle with metal or allograft. At the level of the knee joint, the origins of the gastrocnemius heads are approximated; more distally, fibers of the posterior tibialis muscle and/or soleus are approximated.

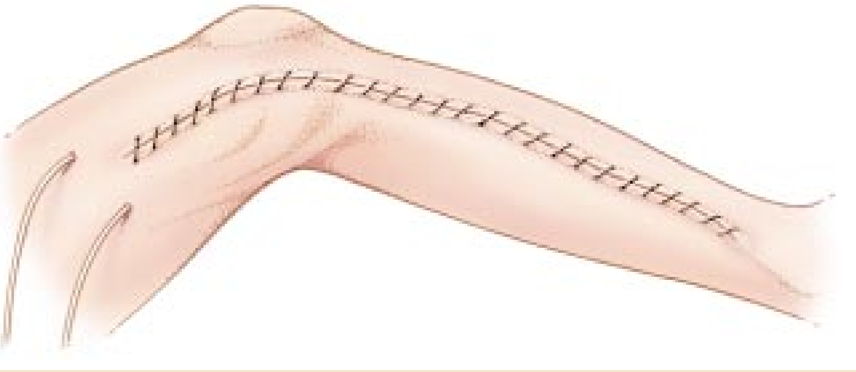

Figure 31.19 Closure of superficial fascia and skin.

FUNCTIONAL AND PROSTHETIC SURVIVAL DATA

Kaplan–Meyer prosthetic survival analysis, performed by Henshaw *et al.*,[20] was presented at the International Society of Limb-sparing Surgeons in 1998. Modular prostheses were shown to last longer than custom prostheses. The survival of the proximal tibial replacements at 10 years was approximately 78% (see Chapter 30, Figure 30.7). This is in marked contrast to reconstructions at other sites, specifically the proximal femur, distal femur, and proximal humerus, where survival of the device at 10 years approaches 95–100%. The lower survival data for prosthetic replacements at the proximal tibia are most likely attributable to the complexity of the surgical procedure and the soft-tissue reconstruction, breakage of the polyethylene component, and mechanical failure.

The incidence of infection has been dramatically decreased by the use of gastrocnemius muscle flap. The primary modes of failure are breakage of the polyethylene component within the body and aseptic loosening of the stem. Extracortical fixation is now routinely utilized for the proximal tibial replacements in the hope of creating a biological noose to prevent aseptic loosening.

POSTOPERATIVE MANAGEMENT

Large closed-suction drains are utilized to prevent hematoma. The extremity is elevated for 5–10 days to prevent edema of the flaps. If the flaps develop areas of ischemia they are allowed to demarcate and are excised at 10 days after surgery, and the underlying muscle is covered with a split-thickness skin graft. Patients with knee fusions are placed in a long-leg cast until there is radiographic evidence of bone healing (usually within 3–4 months). The patient is then fitted for a long-leg brace, which is worn for approximately a year. Patients with arthroplasty are immobilized for 3 weeks in a long-leg cast to permit healing of the extensor mechanism to the gastrocnemius transfer. A long-leg brace with the knee restricted to 0–30° is then fitted. Rehabilitation emphasizes extensor strength rather than flexion. Knee flexion is increased only after full active extension has been obtained.

Rehabilitation

The technique of rehabilitation following a proximal tibial replacement is the opposite of that following a distal femoral replacement or total knee joint replacements in general. The consideration is the ability to regain extensor function following patellar tendon reconstruction with the medial gastrocnemius muscle. We believe that full extension must be obtained before knee flexion is attempted. Therefore, we do not utilize continuous passive motion machines following tibial replacement, and we do not permit any knee flexion, passive or active, until the patient can fully extend the limb against gravity. We anticipate approximately 90–110° of knee flexion but are not willing to jeopardize full knee extension. An extension lag is extremely detrimental to the ability to ambulate normally, especially without a limp, whereas some loss of flexion is of relatively minimal consequence.

DISCUSSION

Patients with proximal tibial osteosarcomas generally have a higher survival rate than those with femoral tumors, probably because the former tumors are smaller and generally detected earlier.[13–15] Proximal tibial sarcomas tend to be smaller and have less of an extraosseous component than such lesions have in other locations. Posterior extension and vascular involvement are rare; when extension does occur, the popliteus muscle often acts as a barrier to involvement of the popliteal and tibioperoneal arteries.[19]

Between 1978 and 1985, 11 of 21 patients presenting with sarcomas of the proximal tibia at our institution underwent limb-sparing resection utilizing a custom rotating hinge or spherocentric prosthesis (Figure 31.4).[17] The remainder, most of whom were treated prior to 1980, underwent an above-knee amputation. Since 1988 the Modular Replacement System has been utilized for pre-excised tumors. No arthrodeses were performed. The technique and surgical approach described here are reliable and have decreased the previously high complication rates. They permit a choice of reconstructive procedures (i.e. arthrodesis, prosthesis, or allograft) (Figures 31.5–31.7). Contraindications to resection generally include sepsis or local contamination, significant posterior tumor extension, or the absence of a posterior tibial artery. We believe that all patients with tibial sarcomas should be considered as potential candidates for limb-sparing procedures and should undergo appropriate staging studies to determine resectability. Accurate radiographic studies are essential. Biplane radiography and angiography, in conjunction with CT, MRI, and bone scintigraphy, accurately depict local tumor extent.

Angiography (Figure 31.8) is particularly helpful in this anatomic location, where anomalies and vascular distortion make dissection difficult. Because the tibiofibular joint is at high risk for microscopic capsular involvement, we routinely perform an extra-articular resection and do not rely upon imaging studies for that determination.

The location and technique of the biopsy are major determinants of the outcome of a limb-sparing resection, especially in this location. Appropriate technique is essential to avoid contamination of the anterolateral muscles, peroneal nerve, popliteal space, and knee joint. To minimize contamination we recommend a small core biopsy of the medial flare of the tibia that is in line with the definitive incision.

The technique of quadriceps reconstruction described (see Figure 31.15) here has proven to be a reliable method of soft-tissue coverage and reconstruction of the extensor/patellar mechanism.[21,22] Reconstructing this mechanism has heretofore been a major barrier to a successful outcome of an arthroplasty. Several techniques of extensor mechanism reconstruction have been attempted, including direct suture to the prosthesis or allograft and osteotomy of the fibula with attachment to the lateral collateral ligament.[23] The muscle transfer technique described in this chapter uses muscle-to-muscle attachment to provide two important functions: first, it covers the prosthesis, which reduces the possibility of secondary infections; second, it provides a means for reconstruction of the extensor mechanism.

Following proximal tibial resections, intensive rehabilitation of the quadriceps is necessary. The postoperative rehabilitation following an arthroplasty of the proximal tibia is almost the opposite of that following a distal femoral arthroplasty. The aim is to avoid an extensor lag; thus, the patient is placed in a cast for 2–3 weeks to permit healing of the extensor mechanism to the transferred gastrocnemius. Immediate postoperative motion must be avoided. Active flexion exercises do not begin until extension is obtained.

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