BACKGROUND

- The fibula is a rare anatomic location for both primary and metastatic bone tumors. When tumor does occur, it most commonly involves the proximal fibula, followed by the fibular diaphysis and the distal fibula.
- Primary bone sarcomas of the fibula have traditionally been treated with above-knee amputations. Increased use of limb-sparing procedures stimulated an interest in the surgical anatomy in this area and the possibility that tumors of the fibula might be safely resected.

ANATOMY

Proximal Fibula

- The proximal fibula is the attachment site for the lateral collateral ligament (LCL) and biceps femoris tendon and therefore has a role in determining lateral knee joint stability.
- The peroneal nerve turns around the base of the fibular head to enter the peroneus longus tunnel (FIG 1).

Fibular Diaphysis

- The fibular diaphysis is circumferentially surrounded by muscle origins at all aspects and anatomic levels.

Distal Fibula

- The distal fibular is a subcutaneous structure with minimal soft tissue coverage.

- It is the attachment site for the tibiofibular and calcaneo-fibular ligaments and therefore has a role in determining lateral ankle joint stability.

INDICATIONS

- Benign-aggressive tumors
- Primary sarcomas of bone
- Metastatic lesions of the fibula are usually treated with radiation therapy and rarely require surgery. This is because the fibula is not a major weight-bearing structure and bone destruction at that site does not compromise the mechanical stability of the lower extremity.
- Above-knee amputation is considered when a malignant tumor grossly invades the tibia or there is extensive multi-compartmental involvement, especially the posterior deep compartment.

IMAGING AND OTHER STAGING STUDIES

- In staging fibular tumors, emphasis is placed on the extent of bone destruction, intramedullary involvement, and soft tissue extension. Special attention is also given to the relation of the tumor to the peroneal nerve, blood vessels, and tibia.
- Plain radiographs and computed tomography are required to assess the extent of bone involvement and cortical destruction. These data are completed by magnetic resonance imaging (MRI), which shows the extent of medullary and extrasosseous extension (FIG 2).
SURGICAL MANAGEMENT

Positioning

- A semisupine position (45-degree elevation of the operated side) is used to permit easy access to the anterior and lateral compartments and allow dissection of the popliteal space. The entire extremity, from the inguinal ligament to the foot, is included in the sterile field to allow evaluation of the distal foot pulses and execution of an above-knee amputation, if indicated.
- The utilitarian fibular incision, which allows exposure and resection of tumors at all levels of the fibula, extends from the biceps above the knee joint, over the midportion of the fibula, anteriorly to the crest of the tibia, and then curves posteriorly and distally to the ankle. This permits the development of large anterior and posterior fasciocutaneous flaps.
- The anterior compartment, the lateral compartment (peroneal musculature), and the superficial posterior compartment consisting of the lateral gastrocnemius and soleus muscle are exposed, and the popliteal space and trifurcation can be explored through this incision. The biopsy site is removed en bloc with the tumor mass (FIG 3).
PROXIMAL FIBULA RESECTION

- Three types of tumor resections are practiced around the proximal fibula: curettage and type I and II resections of the proximal fibula. Tumor curettage is done in benign-aggressive tumors and low-grade sarcomas associated with minimal cortical destruction and extraosseous extension (TECH FIG 1A). The types of proximal fibular resections have been previously described by Malawer. Type I resection includes the proximal fibula, a thin muscle cuff in all dimensions, and the LCL attachment site. The peroneal nerve and its motor branches are preserved and the tibiofibular joint is excised intra-articularly (TECH FIG 1B–D,H). This resection type is used for the management of benign-aggressive tumors and low-grade sarcomas that have caused considerable cortical destruction of the proximal fibula.
- Type II resection includes an en bloc removal of the proximal fibula and the tibiofibular joint, the anterior and lateral muscle compartments, the peroneal nerve, and the anterior tibial artery (TECH FIG 1E–H). It is used for the management of high-grade sarcomas, which usually have considerable cortical destruction with extraosseous extension.
- All type II resections necessitate anterior tibial artery ligation: in contrast, type I resections usually allow...
preservation of that artery. A type II resection may also require sacrifice of the peroneal artery. Table 1 summarizes the anatomic structures removed en bloc with the various resection types of the proximal fibula.

**Exposure**

**Curettage**

- The common peroneal nerve is identified around the inferior border of the biceps femoris. If the nerve is to be preserved, as in tumor curettage or type I resection, its course under the peroneus longus is identified, the peroneus longus tunnel is unroofed, and the nerve is mobilized posteriorly away from the proximal fibula and marked with a vessel loop (TECH FIG 2).
- A longitudinal cortical window with oval edges is made above the lesion.

**Type I and II Resections**

- Large tumors of the proximal fibula may reach the midline posteriorly and push and distort the popliteal vessels. The major vessels are exposed by reflecting the lateral gastrocnemius muscle through its length and, if necessary, releasing the proximal tendinous origin from the lateral femoral condyle. This exposes the underlying soleus muscle, which is similarly detached through its substance near its fibular origin.
- The neurovascular bundle can be easily identified at the level of the popliteus muscle: the anterior tibial artery is positioned 2 to 3 cm distal to its inferior border. The peroneal artery lies close to the posterior aspect of the tibia and along the flexor hallucis longus muscle.
- The posterior tibial nerve is closest to the surface and the popliteal veins course between the nerve and the posterior tibial artery, which can be identified in the midline. The interval between the posterior fibular head and the posterior tibial and popliteal arteries must be explored.
and evaluated early to determine whether a high-grade sarcoma is resectable or a vascular graft will be required.

- The anterior tibial artery passes directly anteriorly through the interosseous septum, tying down the vascular complex and preventing mobilization. Applying traction on the popliteal artery, a simple maneuver, permits visualization of the anterior tibial artery origin. The anterior tibial artery and the two accompanying veins may then be ligated and transected, allowing the popliteal and posterior tibial arteries to fall away from the posterior surface of the mass. Completion of the vascular dissection proceeds distally.

**Tumor Removal**

**Curettage**

- Gross tumor is removed with hand curettes (TECH FIG 3A,B). Curettage should be meticulous and should leave only microscopic disease in the tumor cavity. Curettage is followed by high-speed burr drilling of the walls of the tumor cavity (TECH FIG 3C,D).

**Type I Resection**

- The LCL and biceps tendon are released at their fibular insertion. Muscle origin is transected by electrocauterization from the proximal shaft of the fibula. The anterior tibiofibular capsule can then be identified: its posterior aspect lies under the popliteus muscle.

- The capsule is incised and the joint opened, after which an intra-articular resection of the proximal fibula is carried out by performing an osteotomy 1 cm below the lower edge of the lesion (TECH FIG 3E).

**Type II Resection**

- The anterior and lateral musculature and the overlying deep fascia are excised. The origin of the anterior muscles from the shaft of the tibia is transected by electrocauterization. The distal level of the transaction is at the musculotendinous junction. The lateral collateral ligament, biceps tendon, and peroneal nerve are released 2.5 cm proximal to their fibular insertion. The anterior tibiofibular capsule can then be identified.

- A semicircular cut is made directly through the popliteus muscle toward the posterior aspect of the lateral tibial condyle. A fibular osteotomy is done 2 to 3 cm below the lower edge of the tumor (TECH FIG 3F). It is important to inspect the condyle after osteotomy and removal of the specimen. If the knee joint capsule had been exposed and opened, it should be repaired to prevent a synovial fistula.

![TECH FIG 3](continued)

TECH FIG 3 • **A.** Macroscopic tumor is removed with hand curettes. **B.** Curettage of low-grade chondrosarcoma of the proximal fibula. **C,D.** Curettage is followed with high-speed burr drilling of the walls of the tumor cavity.
Part 4  ONCOLOGY  •  Section IV  LOWER EXTREMITIES

**TECH FIG 3**  (continued) **E.** Type I resection of the proximal fibula. The tibiofibular joint is opened, the peroneal longus tunnel is unroofed to expose the peroneal nerve, muscle origins are transected from the proximal shaft of the fibula, and an osteotomy is performed 1 cm below the lower edge of the lesion. **F.** Type II fibular resection. The resection of the proximal fibula begins with exploration of the popliteal trifurcation posteriorly. The anterior tibial artery and often the peroneal vessels are ligated if there is a large posterior component to the tumor. A resection then proceeds, with release of all of the muscles attaching to the fibula posteriorly and preservation of the tibial nerve. The peroneal nerve is ligated before it enters the peroneus longus muscles. All of the tibialis muscles are released from the tibial border and are retained on the specimen side. The final step is an extra-articular disarticulation of the tibiofibular joint with a curved osteotome or a high-speed burr drill, removing a portion of the lateral tibial plateau with the joint en bloc. Care must be taken to avoid entering the knee joint. (**F:** Reprinted with permission from Clin Orthop Relat Res 1984;186:172–181.)

Reconstruction and Wound Closure

**Curettage**
- The tumor cavity is filled with bone graft or a bone substitute for benign-aggressive lesions in a young patient. Cement is used for reconstruction in adults, especially in low-grade sarcomas or metastatic lesions.

**Type I and II Resections**
- The LCL stump is attached to the lateral tibial metaphysis using a staple with the knee in 20 degrees of flexion after an osteoperiosteal flap has been formed (**TECH FIG 4A–D**). Fixation is reinforced with nonabsorbable sutures to the overlying iliotibial band and fascia.

- When the surgical field extends to the lower leg, the authors pull up the peronei and extensor digitorum longus tendons, thereby advancing the foot to a neutral position (to reduce the magnitude of foot drop and possibly avoid the need for an ankle–foot orthosis), and then tenodese the tendons to the tibial shaft using a 3-mm Dacron tape (**TECH FIG 4E,F**).
- The surgical defect is closed by rotating the lateral gastrocnemius muscle anteriorly to the deep fascia, covering the exposed tibia. The gastrocnemius muscle is sutured to the deep fascia and to the soleus muscle distally, as well as along the lateral capsule of the knee joint. The biceps tendon is then tenodesed to the gastrocnemius muscle (**TECH FIG 4G**).
TECH FIG 4 • (continued) E. Surgical defect after a type II resection, which usually is associated with a foot drop because of the need to resect the peroneal nerve. F. Tenodesis of the peronei and the extensor tendons to the tibial shaft with the foot in neutral position may prevent plantarflexion and obviate the need for an ankle–foot orthosis. G. After resection of the fibula, the surgical defect is closed by rotating the lateral gastrocnemius muscle anteriorly to the deep fascia, covering the exposed tibia. The gastrocnemius muscle is sutured to the deep fascia and to the soleus muscle distally, as well as along the lateral capsule of the knee joint. The biceps tendon is then tenodesed to the gastrocnemius muscle. (E,F: Courtesy of Martin M. Malawer; G: Reprinted with permission from Clin Orthop Relat Res 1984;186:172–181.)

FIBULAR DIAPHYSIS RESECTION

- Tumors of the fibular diaphysis, whether benign or malignant, are usually treated with intercalary resection of the affected diaphyseal segment. Tumor curettage is neither feasible nor effective due to the small diameter of the diaphysis. Furthermore, loss of an intercalary segment usually does not affect the stability of knee and ankle joints or the overall function of the lower extremity.

- Benign tumors require resection of bone only, while high-grade sarcomas require en bloc removal of the surrounding cuff of muscles.

Exposure

- Intercalary fibular resections are performed using the middle portion of the utilitarian incision with proximal
or distal extension, according to anatomic extent of the affected segment.

- To expose the fibular diaphysis, the fascia is opened in line with the utilitarian incision. The plane between the peronei and the soleus is defined by the septum separating the two compartments. The soleus is detached from its fibular origin and, along with the lateral gastrocnemius muscle, is retracted medially and proximally to reveal the posterior crest of the fibula (TECH FIG 5).

- The flexor hallucis longus can be spared or resected, depending on the grade and local extent of the underlying tumor. The peronei are mobilized anteriorly, and retractors are positioned underneath the fibula.

**Tumor Removal**

- Resection is performed at the level that had been determined before surgery. Care must be taken not to damage the peroneal vessels, which are posterior and parallel to the fibula.

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**TECH FIG 5**• A. Plain radiograph showing fibrous dysplasia of the fibular diaphysis. B. Operative photograph showing exposure of a benign-aggressive tumor. The soleus (So) is detached from its fibular origin and, along with the lateral gastrocnemius muscle (G), is retracted medially and proximally to reveal the posterior crest of the fibula (arrow). The flexor hallucis longus can be spared or resected, depending on the grade and local extent of the tumor. The peronei muscles (Pe) are mobilized anteriorly, retractors are positioned underneath the fibula, and the resection is performed at the level determined before surgery. C. Postoperative radiograph. D. Plain radiographs showing Ewing sarcoma of the fibular diaphysis. (B: Courtesy of Martin M. Malawer.) (continued)
**Reconstruction and Wound Closure**

- Intercalary resections usually do not require osseous reconstruction. Low intercalary resections that leave only a short segment may require reinforcement of the lateral malleolus to preserve lateral ankle stability (TECH FIG 6).
- Distal resections of the fibula, which are rarely done, require reconstruction because of the loss of a component of the ankle joint. Reconstruction with a microvascularized fibula is recommended. Alternatively, the ipsilateral fibula can be used for reconstruction. A type I resection of the proximal fibula is performed, and the fibular head and neck are attached to the tibial plafond with a screw and to the fibular shaft with a plate (TECH FIG 6C).

**TECH FIG 5** • (continued) E. The tumor is exposed using the upper two thirds of the utilitarian fibular incision. F. Because of the extraosseous tumor extension, the soleus is split to expose and mobilize the neurovascular bundle; the muscle remains attached to the fibula.

**TECH FIG 6** • A, B. Plain radiographs showing reinforcement of the lateral malleolus by means of a screw after low intercalary resection of the fibula. C. A distal fibular defect can be reconstructed with a microvascularized fibula from the contralateral leg or transposition of the ipsilateral proximal fibula.
PEARLS AND PITFALLS

Proximal Fibula Resection

- **Intraoperative**
  - Semisupine position with flexed knee using the utilitarian fibular incision
  - Mobilization and protection of the peroneal nerve
  - Exploration of the popliteal vessels, when required
  - Selection of surgery (curettage/type I or II resection) according to tumor type and anatomic extent
  - Reconstruction of the LCL attachment site after resection of the proximal fibula

- **Postoperative**
  - Specific rehabilitation according to the tumor type, including ankle–foot orthosis for patients who underwent type II resection

Fibular Diaphysis Resection

- A utilitarian incision of adequate length for wide exposure of the resected fibular segment
- En bloc resection of the surrounding cuff of muscles in high-grade sarcomas
- Mandatory reinforcement of the lateral malleolus in low intercalary resections

POSTOPERATIVE CARE AND REHABILITATION

Proximal Fibula Resection

- Continuous suction is required for 3 to 5 days, and perioperative intravenous antibiotics are continued until the drainage tubes are removed.

Curettage

- Early ambulation is encouraged with partial weight bearing for 3 weeks as well as passive and active range of motion of the knee joint. Unrestricted weight bearing is allowed upon wound healing.

Type I and II Resections

- Postoperatively, the extremity is immobilized in a cast for 3 weeks in 20 degrees of knee flexion to allow soft tissue healing. After cast removal, full weight bearing is allowed as well as full active range of motion around the knee.
- An ankle–foot orthosis is required for patients who underwent type II resection and had foot drop because of peroneal nerve dysfunction.
- Patients who have high-grade sarcoma are treated with postoperative chemotherapy.
- Patients with Ewing sarcoma are further treated with radiation therapy consisting of external beam radiation of 6,000 to 7,000 Gy.

Fibular Diaphysis Resection

- Continuous suction is required for 3 to 5 days, and perioperative intravenous antibiotics are continued until the drainage tubes are removed.
- This is followed by early ambulation with partial weight bearing for 3 weeks, together with passive and active range of motion of the knee joint. Unrestricted weight bearing is allowed after wound healing.

OUTCOMES

- Resections of the fibula, even those that require en bloc resection of the muscle cuff, are usually associated with minimal impact on lower extremity function.
- The weight-bearing capacity of the leg is not impaired and its major muscle groups usually remain intact. The only exception is the occurrence of foot drop and the need to use an ankle–foot orthosis after intentional resection of the peroneal nerve in a type II proximal fibular resection.
- Knee stability is similarly preserved when care is taken to adequately reconstruct the LCL attachment site and allow its healing and gradual loading.

COMPLICATIONS

- Peroneal nerve injury in curettage or type I resection of the proximal fibula
- Lateral knee instability due to inadequate LCL reconstruction or inadequate postoperative rehabilitation
- Lateral ankle instability because of inadequate fixation of the lateral malleolus in low intercalary resections of the fibular diaphysis
- Chronic swelling of the leg after extensive type II resection, requiring lymphatic drainage
- Deep infections

REFERENCES