Malignant Proximal Fibular Tumors

Surgical Management of 112 Cases

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Background: Malignant tumors of the proximal part of the fibula are rare. We sought to analyze the presenting characteristics, postoperative complications, and local recurrences of malignant tumors in the proximal part of the fibula in a large series of patients.

Methods: We identified 112 histologically confirmed malignant tumors of the proximal part of the fibula from the time period between 1910 and 2007. The sex ratio was nearly equal (fifty-four male, fifty-eight female). The average age of the patients was 27.6 years, and the average follow-up period was 5.7 years.

Results: Osteosarcoma (44%) was the most common diagnosis. Pain (86%), palpable mass (51%), and peroneal nerve symptoms (12%) were the most common presenting symptoms. One hundred and three (92%) of 112 underwent curative surgical treatment. The two most common procedures were amputation in fifty (45%) of 112 patients and Malawer type-II resection in twenty-four (21%) of 112 patients. Deliberative sacrifice of the peroneal nerve was performed in seventy-four patients (66%). Postoperative complications occurred in fourteen (12.5%) of 112 patients, including wound issues (ten of 112), peroneal nerve palsy despite nerve preservation (two of twenty-nine), and posterior tibial artery thrombosis (two of 112). No long-term knee instability was seen in the fifty-three patients who underwent resection with lateral collateral ligament reconstruction. Fifty-six patients (50%) developed distant metastases and twelve (11%) had local recurrences.

Conclusions: Osteosarcomas are the most common malignant tumor of the proximal fibula. Complication rates are modest and long-term knee instability was not seen in patients undergoing reconstruction of the lateral collateral ligament. Local recurrence following resection is not uncommon and metastatic dissemination is the main cause of death. This series represents the largest collection of such tumors for which there is extended follow-up and data on surgical complications.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

O nly 2.5% of primary bone tumors are located in the fibula. Approximately half of these tumors are malignant and most mandate surgical management. Many malignant tumors of the proximal aspect of the fibula require radical or wide excision. Wide en bloc resection of the tumor, described by Malawer as a type-II resection of the proximal part of the fibula, is a wide intracompartmental resection that passes through normal tissue beyond the reactive zone. When en bloc resection passes through the reactive zone surrounding the tumor, it is considered a type-I resection.

The main concerns associated with proximal fibular resections are potential postoperative knee instability, peroneal nerve palsy, arterial insufficiency, and local recurrence of the tumor. A Malawer type-II wide intracompartmental resection includes removing the proximal part of the fibula with 6 to 7 cm of normal diaphysis, the anterolateral muscle compartments, the peroneal nerve, and the anterior tibial artery (Fig. 1). Resections result in detachment of the lateral collateral ligament and biceps femoris tendon, which can lead to knee instability. In our recent report on surgically treated benign proximal fibular tumors in which the lateral collateral ligament and biceps femoris tendon were sacrificed and reconstructed, we found no long-term knee instability.

Another concern in this anatomic location is the proximity of the common peroneal nerve. In some instances, the

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nerve may be intimately associated with the tumor and thus sacrifice of the nerve may be required to obtain appropriate oncologic margins (Fig. 2). Similar to postoperative knee instability, the rate of peroneal nerve palsy in those who do not have intentional sacrifice is not well defined, although estimates in the current literature range from 20% to 57%.

Likewise, the anterior tibial artery may either be involved or need to be intentionally ligated to obtain appropriate surgical margins (Fig. 1). Finally, as with all malignancies, particularly those near critical anatomic structures, local recurrence is a concern. The purpose of this study was to determine the rate of postoperative (1) knee instability, (2) permanent peroneal nerve palsies, (3) complications, and (4) local recurrences related to surgical resection of malignant proximal fibular tumors. To our knowledge, this represents the largest series in the reported literature.

Materials and Methods

We performed a retrospective review of our institution’s pathologic and surgical databases from 1910 to 2007 to identify all patients with malignant proximal fibular tumors. A type-II wide intracompartmental resection includes removing the proximal part of the fibula along with 6 to 7 cm of normal diaphysis, the anterolateral muscle compartments, the peroneal nerve, and the anterior tibial artery. Ext dig. longus m. = extensor digitorum longus muscle.

Fig. 1
A type-II wide intracompartmental resection includes removing the proximal part of the fibula along with 6 to 7 cm of normal diaphysis, the anterolateral muscle compartments, the peroneal nerve, and the anterior tibial artery. Ext dig. longus m. = extensor digitorum longus muscle.

Fig. 2
proximal fibular tumors that had been histologically confirmed and treated surgically. The study group was subanalyzed from 1910 to 1993 and 1994 to 2007. The cutoff was chosen because in the past two decades at our institution, axial imaging, adjuvant therapy, and surgical indications and treatment were more predictable for analysis. While patients were not specifically recalled for the study, the medical records, radiographs, and histologic specimens of each patient was analyzed. This study was approved by our institutional review board.

One hundred and twelve malignant proximal fibular tumors were identified (Table I). Tumors were classified according to the Musculoskeletal Tumor Society. There were fifty-four male patients and fifty-eight female patients with a mean age of 27.6 years (range, five to eighty-six years). The tumors involved the right side in sixty-two patients (55%). The mean follow-up was 5.7 years (range, six months to forty years), with a minimum follow-up of two years or until death. No patients were lost to follow-up.

The most common symptoms at presentation were pain in ninety-six patients (86%), palpable mass in fifty-seven patients (51%), and pathologic fracture in six patients (5%). In thirteen patients (12%), there were neurological symptoms associated with compression of the peroneal nerve. The presenting symptoms were considered to be those specifically told to the surgeon by the patient, as documented in the medical record.

Surgical Technique in Recent Decades
Malawer type-II wide resection included excision of the proximal part of the fibula, 6 to 7 cm of normal diaphysis, the anterior and lateral muscle compartments, the peroneal nerve, the anterior tibial artery, and the proximal tibiofibular joint extra-articularly (Fig. 3). A single incision was made to expose the three muscle compartments and the popliteal space. The biceps femoris tendon was identified as was the common peroneal nerve just inferior to the tendon. The biceps femoris was incised just proximal to its fibular insertion, as was the lateral collateral ligament. The lateral head of the gastrocnemius was incised just distal to its insertion on the lateral aspect of the femur. Access was then gained to the popliteal fossa. The posterior tibial artery and vein were

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### TABLE I Histologic Diagnoses and Treatment of 112 Malignant Tumors of the Proximal Part of the Fibula

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total Tumors by Diagnosis</th>
<th>No Surgical Treatment</th>
<th>Type-I En Bloc Resection</th>
<th>Type-II En Bloc Resection</th>
<th>Amputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteosarcoma</td>
<td>49 (44%)</td>
<td>—</td>
<td>4</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td>Chondrosarcoma</td>
<td>26 (23%)</td>
<td>—</td>
<td>19</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Ewing sarcoma</td>
<td>21 (19%)</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Fibrosarcoma</td>
<td>5 (5%)</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Parosteal osteosarcoma</td>
<td>3 (3%)</td>
<td>—</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hemangiosarcoma</td>
<td>3 (3%)</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Malignant bone lymphoma</td>
<td>2 (2%)</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Metastatic bone disease</td>
<td>2 (2%)</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Liposarcoma</td>
<td>1 (1%)</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Total no. of tumors by type of intervention</td>
<td>112 (100%)</td>
<td>9 (8%)</td>
<td>29 (26%)</td>
<td>24 (21%)</td>
<td>50 (45%)</td>
</tr>
</tbody>
</table>

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Fig. 3
After a type-II resection, the resulting defect typically results in the lateral aspect of the tibia being exposed. Lat. ligament = lateral collateral ligament, Lat. Tibial condyle = lateral aspect of the tibial condyle.
traced distally. Sacrifice of the anterior tibial artery and the common peroneal nerve were generally required for wide type-II resections of the proximal part of the fibula. The anterior tibial artery and vein were ligated from the posterior aspect. The common peroneal nerve was ligated and incised just proximal to the fibula.

If there was no appreciable anterior soft-tissue component of the neoplasm, the interosseous membrane was incised lateral to the origin of the tibialis anterior. In this fashion, the extensor digitorum longus muscle was removed with the specimen. If the lesion extended distally, then the extensor hallucis longus was resected in part. Laterally, the peroneus longus was resected with the specimen. If the lesion extended distally, part of the peroneus brevis was also resected. If indicated, the posterior tibial artery was followed to its bifurcation and a decision was made about the peroneal artery. If this artery could be preserved, then the branches to the soleus and flexor hallucis longus were ligated when these muscles were excised. If the peroneal artery compromised the surgical margins, it was then ligated, leaving just the posterior tibial artery and vein to supply the lower leg.

The fibula was then osteotomized distally at the predetermined level and gently retracted anteriorly. The resection included the soleus muscle. With a more distal resection of the fibula, part of the flexor hallucis longus muscle could be resected. Part of the posterior tibialis muscle was sacrificed for surgical margins because it originates on the interosseous membrane. Proximally, the tibiofibular joint was excised extra-articularly, including a part of the lateral cortex of the tibia. For this, resection of the tibialis anterior was performed anteriorly from its origin on the tibia, as well as resection of the tibialis posterior at the posterior aspect of the tibia.

Reconstruction consisted of repairing the lateral collateral ligament and covering the soft-tissue defect and exposed tibial shaft (Fig. 4). The lateral collateral ligament and biceps tendon were reattached with nonabsorbable sutures to soft tissue and the anterolateral capsule with the knee positioned in 30° of flexion. This reattachment was supplemented with use of a staple to the tibia. The resultant soft-tissue defect with the exposed popliteal and posterior tibial arteries and bare lateral surface was covered by rotating the lateral gastrocnemius muscle into the defect. All en bloc resections had tumor-free margins histologically. An ankle-foot orthosis was necessary in patients who had anterior and peroneal nerve loss following a type-II resection.

Patients were followed through the tumor registry at our institution. Our follow-up routine included seeing patients at two weeks, three months, six months, nine months, and one year postoperatively. Thereafter, follow-up was dependent on the particular patient and the results of pathology. Radiographs were obtained at each follow-up visit, while subsequent magnetic resonance imaging (MRI) was obtained at three, six, and nine months postoperatively, and then at semiannual or annual follow-ups. Early follow-up (prior to 1980) was similar except that MRI was not yet available.

For the most recent patients, clinical knee stability was assessed with use of the varus stress test at 30° of knee flexion. Surgeons subjectively graded the amount of lateral opening, which was graded in millimeters as described previously. Briefly, the affected limb was placed over the side of the examining table, with the clinician placing his or her fingers directly over the joint. A varus stress at 30° of flexion was then placed on the knee, and the amount of lateral opening was quantified. Earlier patients were assessed on the basis of subjective complaints of knee instability and surgeon assessment of varus instability.

Given the long study period, rehabilitation was not identical for all patients after en bloc resection. However, the protocol has been similar for patients in recent decades. In general, patients were allowed to walk with partial weight-bearing for six weeks. A knee immobilizer was used full-time for the first four weeks. For the subsequent two weeks, patients were allowed to perform gentle knee-motion exercises. After six weeks, the immobilizer was discontinued and patients progressed to full weight-bearing with the use of a gait aid for the next four weeks. Formal physical therapy was initiated after six weeks.

**Statistical Analysis**

Differences in rates between groups were determined with use of the Fisher exact test. Microsoft Excel 2003 (Microsoft Corporation, Redmond, Washington) was used for statistical calculations.

**Source of Funding**

No source of external funding was used for any aspect of this study.

**Results**

In all 112 patients, the diagnosis was established by histologic analysis (Table I). Forty-nine patients (44%) had an osteosarcoma, twenty-six (23%) had a chondrosarcoma, twenty-one (19%) had an Ewing sarcoma, five (5%) had a fibrosarcoma, three (3%) had a parosteal osteosarcoma, three (3%) had a hemangiosarcoma, two (2%) had a malignant bone lymphoma, two (2%) had metastatic bone disease, and one (1%) had a liposarcoma involving the bone. Of note, the diagnosis of Ewing sarcoma was not utilized until after 1930. Based on the Musculoskeletal Tumor Society (MSTS) staging system, there were twenty-nine (26%) stage-I, twenty-four (21%) stage-II, and fifty-six (50%) stage-III malignant tumors. Three tumors that were surgically treated
prior to 1950 were not able to be classified given the lack of details in the medical records.

One hundred and three of 112 patients (92%) had surgical treatment (Table I). Of the 112 patients, forty-nine (44%) also had adjuvant therapy consisting of radiation therapy and/or chemotherapy. Nine patients (8%) had an incisional biopsy only, followed by radiation therapy and/or chemotherapy.

Amputation was performed in fifty (45%) of 112 patients. From 1910 to 1993, an amputation was performed in forty-three patients (86%); an above-the-knee amputation was performed in forty-two patients and a hip disarticulation was performed in one patient. From 1994 to 2007, seven patients (14%) required an amputation. The rate of amputation between earlier and most recent times was not significantly different (p = 0.6). The diagnoses leading to amputation were classic osteosarcoma in thirty-three patients, Ewing sarcoma in eight patients, fibrosarcoma in four patients, hemangiosarcoma in two patients, parosteal osteosarcoma in one patient, chondrosarcoma in one patient, and metastatic disease in one patient.

En bloc resection and reconstruction were performed in fifty-three patients (47%). From 1990 to 1993, this occurred in forty-three patients (81%), whereas it occurred in ten patients (19%) from 1994 to 2007. Two types of en bloc resection were performed. Type-I resection was performed in twenty-nine patients (26%). The majority (twenty-seven [93%] of twenty-nine patients) occurred from 1910 to 1993, whereas only two (7%) occurred from 1994 to 2007. Type-II resection was performed in twenty-four patients (21%). There was a significant increase in the number of type-II resections from the earlier to later time period (17% [sixteen of ninety-four total patients] versus 44% [eight of eighteen total patients], respectively, p = 0.02).

Of the forty-nine patients with an osteosarcoma, amputation was performed in thirty-three patients (67%), type-II wide intracompartamental resection in twelve patients (25%), and type-I resection in only four patients (8%). Of the three patients with a parosteal osteosarcoma, an above-the-knee amputation was performed in one, a type-II resection in one, and a type-I resection in one. Of the twenty-six patients with a chondrosarcoma, a type-I resection was performed in twenty patients (77%), a type-II resection was carried out in five patients (19%), and an amputation was required in one patient (4%) with a chondrosarcoma secondary to Ollier’s disease. Of the twenty-one patients with a Ewing sarcoma, seven patients (33%) only had an incisional biopsy followed by radiation therapy and/or chemotherapy; the other fourteen patients had surgical treatment that included an amputation in eight patients (38%), a type-I resection in three patients (14%), and a type-II resection in three patients (14%).

At the time of the last follow-up, all living patients were ambulatory. Twenty-four patients who had a wide resection sacrificing the peroneal nerve (type-II resection) and two patients who developed an iatrogenic peroneal nerve palsy postoperatively required an ankle-foot orthosis. The postoperative rate of peroneal nerve palsy was approximately 7% (two of twenty-nine patients) when nerve preservation surgery had been used. Overall, sixty-two patients had a limb-salvage procedure. Of these sixty-two patients, three patients required an above-the-knee amputation as the result of postoperative complications. None of the remaining fifty-nine patients had subjective complaints of knee pain or varus instability during the latest analysis.

There were two intraoperative complications. In one patient, the tibial nerve was lacerated, requiring a posterior tibial nerve to peroneal nerve reconstruction. In another patient, the popliteal artery was lacerated. A reverse saphenous vein graft was utilized for the reconstruction. No other intraoperative complications were noted.

In the entire series, there were fourteen (12.5%) major postoperative complications (Table II). However, there was a significant increase in the risk of postoperative complications in the most recent era as compared with the risk during the earlier time period (44% versus 6%; p = 0.0002). In all, two patients had thrombosis of the posterior tibial artery, six patients had wound infections, four patients had wound-healing issues, and two patients developed peroneal nerve palsies. Both patients with thrombosis of the posterior tibial artery had undergone a type-II resection. One patient subsequently underwent an arterial graft and sympathectomy, while another patient had an above-the-knee amputation. Skin necrosis and wound-healing failure was present in one patient each, also after a type-II resection. The first complication required a latissimus dorsi free flap and the second, an above-the-knee amputation. One patient required an above-the-knee amputation for recurrent infection. Peroneal nerve palsy occurred in two (7%) of twenty-nine patients in whom the nerve was preserved during the initial operation.

With a mean follow-up time of 5.7 years (range, six months to forty years), a local recurrence occurred in twelve patients (11%) (Table III). The recurrence occurred after a median time of thirteen months (range, four to seventy-five months). Local recurrence rates were similar in the earlier and later time periods (11% versus 11%; p = 0.4). Eight patients (9%) from the earlier time period developed regional lymph node metastases. Distant metastases occurred in fifty-six patients (50%). The most common metastatic sites were the lungs (thirty-four patients, or 30%) and the skeleton (eleven patients, or 10%). The overall median survival for patients in the earlier time period was thirty-one months (range, six months to forty years). At the most recent follow-up, no patient in the later era had succumbed to disease.

Of the forty-nine patients with osteosarcoma, amputation was performed in thirty-three patients (67%), type-II intracompartamental resection was performed in twelve patients (25%); and type-I resection was performed in only four patients (8%). The amputation rate decreased from 65% in the earlier time period (1910 to 1993) to 55% in the later time period (1994 to 2007) (p = 0.6), whereas type-II en bloc resections increased from 20% to 45%, respectively, during those same time periods (p = 0.02). Local recurrence occurred in three (6%) of forty-nine patients. Local recurrence occurred in two (2%) of the 112 total patients after a type-I en bloc resection and in one (1%) of the
112 total patients after a type-II en bloc resection. All required an above-the-knee amputation. The local recurrence rate was similar in the earlier and later eras (11% and 11%, respectively). Metastases to the ipsilateral groin occurred in three (3%) of 112 patients. Metastatic dissemination occurred in thirty-two (29%) of the 112 patients, and those thirty-two died from uncontrolled disease despite the use of multi-agent chemotherapy.

Of the twenty-six patients with chondrosarcoma, a type-I resection was performed in nineteen patients (73%), a type-II resection was performed in six patients (23%), and an amputation was performed in one patient (4%) who had a chondrosarcoma secondary to Ollier’s disease. There was a nonsignificant increase in type-II en bloc resections from the earlier (1910 to 1993) to later (1994 to 2007) era (from 15% to 50%, respectively; p = 0.4). Local recurrence occurred in two patients after a type-I excision. Both occurred in the earlier time period and both patients required an above-the-knee amputation; however, both patients developed metastases in the groin and subsequently died of metastatic dissemination of disease.

Of twenty-one patients with Ewing sarcoma, seven patients (33%) had only an incisional biopsy followed by radiation therapy and/or chemotherapy. Fourteen patients (67%) also had surgical treatment. An above-the-knee amputation was performed in eight patients (38%); type-I resection, in three (14%); and type-II resection, in three (14%). There was a significant increase in type-II en bloc resections (from 5% to

![TABLE II Complications After Index Surgical Treatment of 112 Malignant Proximal Fibular Tumors*](image1)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Type-I En Bloc Resection</th>
<th>Type-II En Bloc Resection</th>
<th>Amputation</th>
<th>Total No. of Complications by Complication Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infection</td>
<td>2/6</td>
<td>2/6</td>
<td>2/6</td>
<td>6/14</td>
</tr>
<tr>
<td>Wound-healing issue</td>
<td>1/4</td>
<td>2/4</td>
<td>1/4</td>
<td>4/14</td>
</tr>
<tr>
<td>Posterior tibial artery thrombosis</td>
<td>—</td>
<td>2/2</td>
<td>—</td>
<td>2/14</td>
</tr>
<tr>
<td>Peroneal nerve palsy</td>
<td>—</td>
<td>2/2</td>
<td>—</td>
<td>2/14</td>
</tr>
<tr>
<td>Total no. of complications by index surgical treatment</td>
<td>3/14 (21.5%)</td>
<td>8/14 (57%)</td>
<td>3/14 (21.5%)</td>
<td>14/14 (100%)</td>
</tr>
</tbody>
</table>

*The data are expressed as the number of complications according to complication type or index surgical treatment subgroup, followed by the total number of complications in each particular subgroup.

![TABLE III Local Recurrence Among 112 Malignant Proximal Fibular Tumors*](image2)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No Surgical Treatment</th>
<th>Type-I En Bloc Resection</th>
<th>Type-II En Bloc Resection</th>
<th>Amputation</th>
<th>Total No. of Recurrences by Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteosarcoma</td>
<td>—</td>
<td>2/4</td>
<td>1/12</td>
<td>0/33</td>
<td>3/49</td>
</tr>
<tr>
<td>Chondrosarcoma</td>
<td>—</td>
<td>2/19</td>
<td>0/6</td>
<td>0/1</td>
<td>2/26</td>
</tr>
<tr>
<td>Ewing sarcoma</td>
<td>0/7</td>
<td>1/3</td>
<td>1/3</td>
<td>2/8</td>
<td>4/21</td>
</tr>
<tr>
<td>Fibrosarcoma</td>
<td>—</td>
<td>—</td>
<td>0/1</td>
<td>0/4</td>
<td>0/5</td>
</tr>
<tr>
<td>Parosteal osteosarcoma</td>
<td>—</td>
<td>1/1</td>
<td>1/1</td>
<td>0/1</td>
<td>2/3</td>
</tr>
<tr>
<td>Hemangiosarcoma</td>
<td>—</td>
<td>0/1</td>
<td>—</td>
<td>1/2</td>
<td>1/3</td>
</tr>
<tr>
<td>Malignant bone lymphoma</td>
<td>0/1</td>
<td>0/1</td>
<td>—</td>
<td>—</td>
<td>0/2</td>
</tr>
<tr>
<td>Metastatic disease</td>
<td>0/1</td>
<td>—</td>
<td>—</td>
<td>0/1</td>
<td>0/2</td>
</tr>
<tr>
<td>Liposarcoma</td>
<td>—</td>
<td>—</td>
<td>0/1</td>
<td>—</td>
<td>0/1</td>
</tr>
<tr>
<td>Total no. of recurrences by index treatment type</td>
<td>0/9 (0%)</td>
<td>6/29 (21%)</td>
<td>3/24 (13%)</td>
<td>3/50 (6%)</td>
<td>12/112 (11%)</td>
</tr>
</tbody>
</table>

*The data are expressed as the number of recurrences according to diagnosis or index treatment subgroup, followed by the total number of tumors in each particular subgroup.
100%, respectively; \( p = 0.04 \) and a nonsignificant decrease in amputations (from 42% to 0%, respectively; \( p = 0.5 \)) between the earlier and later time periods.

**Discussion**

Malignant tumors of the proximal part of the fibula are rare, yet life-threatening. These tumors require aggressive surgical management with radical or wide resection. Recent advances in neoadjuvant treatment have allowed for more use of limb-salvage procedures; however, the close proximity of the lateral collateral ligament, biceps femoris tendon, peroneal nerve, and surrounding vasculature make the surgical management intricate. The goals of this study were to assess postoperative knee instability, peroneal nerve palsies, complications, and local recurrences in the largest series to date (see Appendix).

The current investigation is limited first by its prolonged study period. Nevertheless, the long time frame allows for the accrual of a large number of patients with relatively rare tumors with similar histologic characteristics and extended follow-up. Second, treatments were not standardized, given the unpredictable nature of malignant lesions and the numerous surgeons who were involved. Third, postoperative knee stability was not reliably assessed in a similar fashion by all clinicians throughout the study period. However, a consistent method was utilized beginning in 1994.

We recently reported on the surgical management of 121 benign proximal fibular tumors. In that series, osteochondromas were the most common lesion. Although no long-term knee instability was noted, 3% of patients did experience a permanent postoperative peroneal nerve palsy, similar to the 7% rate reported in this series. Furthermore, there was an 8% local recurrence rate for benign tumors, similar to the 11% local recurrence rate noted in the current study for malignant tumors. Osteosarcomas are the most common malignant lesion of the proximal part of the fibula. Neoadjuvant chemotherapy followed by radical resection (above-the-knee amputation) or wide (type-II) resection and postoperative chemotherapy is the current treatment approach. In this series, only sixteen patients with an osteosarcoma had a limb salvage procedure. Due to the anatomy of the proximal part of the fibula, muscle invasion by the osteosarcoma and tumor infiltration of the capsule of the tibiofibular joint are seen in most of the specimens and the need for extra-articular resections has been emphasized for these lesions. In this series, of four patients who had type-I en bloc resection of the tumor, two had a local recurrence. There was only one recurrence in twelve patients who had extra-articular wide resection.

Surgery is the mainstay of treatment for chondrosarcoma of the proximal part of the fibula. Type-I en bloc resection with a wide margin of uninvolved tissue is not usually adequate. Local recurrence occurred in two (11%) of the nineteen patients who had a type-I en bloc excision. As such, we recommend the use of a type-II en bloc resection for the treatment of chondrosarcoma. Chondrosarcomas of the proximal part of the fibula rarely require radical resection. Amputation may be necessary for bulky tumors that are not amenable to limb-sparing techniques. In this series, one patient who had chondrosarcoma in multiple limbs required such treatment for a chondrosarcoma of the proximal part of the fibula.

Multi-agent chemotherapy and radiation therapy is the treatment of choice for Ewing sarcoma. However, surgery is suspected to have improved the prognosis in patients with Ewing sarcoma of the proximal part of the fibula. Wide or radical resection of the proximal fibular tumor in combination with chemotherapy and—in selected cases—radiation is the current treatment regimen.

In all patients who had a resection of the proximal part of the fibula, the insertion of the lateral collateral ligament was detached during the operation. There is evidence in clinical and experimental studies that instability of the knee may lead to knee osteoarthritis. It is thus recommended that, after the proximal part of the fibula is resected because of the presence of a tumor, the insertions of the biceps femoris muscle and of the lateral collateral ligament should be meticulously repaired and the rehabilitation program should be the same as after an acute injury of the lateral knee ligaments. The lack of any symptomatic instability in the patients treated with this technique suggests that the method has merit, as other investigators have reported.

The proximal part of the fibula is recognized as a complex surgical site because of the proximity of the peroneal nerve. In the present series, despite protective measures, a peroneal nerve palsy occurred in two patients after a type-I en bloc tumor resection. Other authors have noted a 0% to 100% iatrogenic peroneal nerve palsy rate (see Appendix). It is possible that a slow process of nerve traction resulting from the gradual expansion of the soft-tissue mass at the neck of the fibula may have protected the nerve from operative dissection. In type-I en bloc resections, it is necessary to free the nerve completely from the fibro-osseous tunnel at the fibular neck, as well as the tunnel formed by the fascia between the lateral and anterior compartments. Once these sites have been freed, considerable displacement of the nerve can be achieved with minimal traction. In limbs in which the tumor had expanded anteriorly into the extensor digitorum longus, this soft-tissue extension may be excised en bloc with the tumor and any peroneal nerve branches to this muscle are sacrificed.

Another complication in this series was thrombosis of the posterior tibial artery, which occurred in two patients after a type-II en bloc resection. This complication was treated successfully using an arterial graft and sympathectomy in one patient, while the other patient required an above-the-knee amputation. Finally, skin necrosis and wound-healing failure can be major after a type-II en bloc resection, requiring muscle flaps or above-the-knee amputations.

**Appendix**

A table showing a comparison of surgical treatment results from the literature is available with the online version of this article as a data supplement at jbjs.org. The authors thank Diane E. Grill, MS, for her assistance with the statistical analysis.
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