Popliteal Sarcomas
Presentation, Prognosis and Limb Salvage

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Soft tissue sarcomas of the popliteal fossa are rare diseases. Resection is challenging because of their extracompartmen-tal location and proximity to neurovascular structures. Their prognosis is inferior to intracompartmental extremity soft tissue sarcomas. We ascertainment the mode of initial presentation, the rates of local recurrence and distant metastasis, and the morbidity and complications of limb salvage procedures. We retrospectively analyzed the data of 29 consecutive patients operated on between 1989 and 2003. The median followup was 79 months. Sixteen, five, and eight patients were diagnosed with high-, intermediate-, and low-grade tumors, respectively. High-grade tumors were smaller than low- and intermediate-grade tumors. Thirty-one percent of patients presented with localized pain. Of the 26 patients who had primary limb salvage resections, 14 had negative surgical margins, six had close margins, and six had positive margins. Seventeen patients were treated with radiotherapy and 10 patients received chemotherapy. The local recurrence rate was 10.3%, four patients with high-grade tumors had distant metastasis, and the limb-salvage rate was 86.2%. Postoperatively, six patients experienced wound dehiscence and four had mild flexion contractures. Soft tissue sarcomas of the popliteal fossa have an atypical presentation. Limb salvage can be accomplished in most patients with low morbidity and good systemic and local control.

Level of Evidence: Level IV, Therapeutic study. See the guidelines for Authors for a complete description of level of evidence.

Soft tissue sarcomas of the popliteal fossa are rare, accounting for less than 5% of all soft tissue sarcomas of the extremities.8 Surgery in this anatomic area is challenging. Performing a good resection with wide surgical margins is often difficult because of the periartricular location and the proximity to neurovascular structures.8,22,28 Enneking et al suggested patients with soft tissue sarcomas in the flexor fossae (axilla, epitrochlear fossa, antecubital fossa, inguinal space, and popliteal fossa) usually had a poorer prognosis and were more likely to have recurrence than patients with intracompartmen-tal or extracompartmen-tal lesions of similar histologic grade and size.12 They usually recommended primary amputation for tumors in these locations.12 Based on three conceptual changes during the past two decades, the senior author (MMM) has performed limb-sparing resections on most patients with soft tissue sarcomas of the popliteal fossa. These changes include the realizations that microscopic disease often can be controlled by radiation therapy, that tumors once termed unresectable can become resectable after a course of neoadjuvant chemotherapy (assuming a good reaction), and that resection of the sciatic nerve or its main branches is not a contra-indication for a limb-salvage procedure.1,9–11,20,26,31,33,36

In a literature search using the PubMed database we identified only three case series of patients with popliteal soft tissue sarcomas.8,23,37 The studies suggested an equal prognosis as soft tissue sarcomas in other locations and a high limb-salvage rate. However, the numbers of patients in these series were small (11–16 patients) and only high-grade tumors were investigated. In addition, none of the studies analyzed the clinical aspects of soft tissue sarcomas of the popliteal fossa, namely their clinical presentation, surgical techniques, and postoperative morbidity and complications.
We wondered what the local recurrence rate, the metastatic rate, the survival rate, and the limb salvage rate were in 29 consecutive patients with popliteal sarcomas treated at our institution. We also questioned how these tumors first presented, and what were the associated morbidity and complications of limb-sparing resection.

**MATERIALS AND METHODS**

From a prospective musculoskeletal tumor database we identified patients with soft tissue sarcomas of the popliteal fossa who had surgery from 1980 to 2003. There were 615 patients who were surgically treated for soft tissue sarcomas. Of these, we identified 29 consecutive patients (4.7%) who presented with soft tissue sarcomas of the popliteal fossa and who underwent surgery by the senior author (MMM) from 1989 to 2003. We retrospectively reviewed and analyzed patients’ medical records to determine the occurrence of local recurrence and distant metastasis, limb salvage rate, and survival. We also reviewed patients’ records for details regarding the clinical presentation of popliteal sarcomas and for the morbidity and complications of limb-salvage resections.

There were 15 males and 14 females with a mean age of 45 years (range, 16–86.5 years). Sixteen lesions were classified as high-grade, five were classified as intermediate-grade, and eight were classified as low-grade soft tissue sarcomas (Table 1). Sixteen patients (55%) presented with a nonpainful mass and nine patients (31%) with a locally painful mass (Table 2). Two patients presented with local recurrence after initially being treated at another institution, and two patients were diagnosed with distant metastasis during preoperative staging. Four patients with high-grade tumors had previous excisions by surgeons who did not suspect malignancy. According to magnetic resonance imaging (MRI) measurements the median lesion size was 371 cm\(^2\) (range, 12–5613 cm\(^2\)). Twenty-six patients (89.6%) had limb-salvage resections and three patients (10.3%) had primary amputations. Two patients who had primary amputations originally were treated at other institutions and presented to our outpatient clinic with local recurrences and heavy radiation damage to the skin and soft tissues overlying the popliteal fossa and distal thigh. The third patient presented with radiation-induced sarcoma of the popliteal fossa and preferred to have an amputation rather than a limb-salvage procedure.

Of the 26 patients who had primary tumor resections, neurovascular structures were intimately close to the tumor in nine patients (34.6%) and embedded in the tumor in three patients (11.5%). In one patient both popliteal vessels were surrounded by the tumor and in two patients the peroneal nerve was embedded in the tumor. One patient had segmental resection of the peroneal nerve and one patient had resection of both popliteal vessels and reconstruction of the popliteal artery with a saphenous vein graft. One patient with extensive metastatic disease had the peroneal nerve preserved despite its embedment in the tumor for palliation. Fourteen patients (53.8%) had negative surgical margins (greater than 1 cm), six (23.07%) had close surgical margins (less than 1 cm), and six (23%) had positive surgical margins.\(^{20,25,30,35,36}\) Five of the six positive margins involved either the adventitia or the nerve sheath. One patient with positive surgical margins who presented with metastatic disease had palliative surgery; her popliteal nerve, which was embedded in the tumor, was preserved (Table 3).

Eight of the 29 patients were treated with neoadjuvant and adjuvant therapy, two patients were treated with only adjuvant chemotherapy, and one patient received one cycle of neoadjuvant chemotherapy before it was stopped because of life-threatening side effects. Seventeen patients received postoperative radiation therapy. We did not treat any of our patients with preoperative radiation therapy. Patients were followed for a minimum of 2 years or until death (range, 4–192 months; median, 79 months).

Preoperative evaluation of all patients included a complete history and physical examination with an emphasis on the neurologic examination of the ipsilateral lower extremity and assessment of arterial pulses. Imaging studies included plain radiography, MRI angiography of the involved limb (Fig 1), and occasionally computed tomography (CT) (Fig 1). Patients had chest CT to rule out distant metastasis. Before institution of definitive treatment, tissue diagnosis was obtained using core needle biopsy to minimize local contamination. The biopsy site was determined by the surgeon (MMM) and the interventional radiologist (JJ) who performed the biopsy.

For popliteal tumor resection, we placed the patient in the prone position and both lower limbs were draped. The contralateral leg was prepared for saphenous vein harvesting for arterial reconstruction if the popliteal artery was resected. An S-
shaped incision was made, crossing from proximal-medial to distal-lateral at the level of the knee. The medial proximal arm of the incision facilitated identification of the popliteal vessels as they exit the adductor hiatus, and the lateral distal arm enabled easy exposure of the peroneal nerve, posterior to the fibular head. In addition, by making the distal arm of the incision lateral we avoided damaging the greater saphenous vein, which runs on the medial aspect of the leg (Fig 2).

The two main vessels responsible for venous drainage of the leg are the popliteal vein and the greater saphenous vein. During tumor resection, excision of the popliteal vein may be unavoidable. Therefore, care should be taken not to damage the greater saphenous vein. Ligation of the popliteal vein and ipsilateral greater saphenous veins may lead to severe venous insufficiency.

The thin and friable popliteal fascia lies in close proximity to the neurovascular bundle (especially the peroneal nerve, which lies just deep to the popliteal fascia at the level of the fibular head), making it a critical landmark. Subcutaneous flaps were made to identify the popliteal fascia. The landmarks and various structures of the popliteal fossa often can be palpated through the fascia, which then was incised accordingly. Failure to realize the dissection is underneath the fascia and only a few millimeters separate the blade from the vessels and nerves of the popliteal fossa can easily result in injury to those structures.

The initial step of a popliteal fossa resection was exposure and identification of the neurovascular bundle. This allowed mobilization of the vulnerable structures before resection. In the popliteal space the nerves usually are found posterior to the tumor mass and the vessels usually are anterior to it. Mobilization usually was accomplished by exposing the structures in the distal thigh and proximal leg and following them to the popliteal fossa. The inferior genicular vessels pull the popliteal artery down the popliteal space.

After surgery, the patient’s extremity was placed in a long posterior splint in 15° to 30° knee flexion to relieve tension on the neurovascular bundle and skin incision. Physiotherapy for muscle strengthening and range of motion was not started until the skin incision was completely healed, typically after 10 to 14 days.

Use of radiation therapy, chemotherapy, or both was based on the characteristics of the tumor, the patient, and the type of surgical margins. Treatment was at the discretion of the attending oncologist and was not standardized to a specific protocol. Treatment for patients with low-grade soft tissue sarcomas depended on the surgical margins. If wide negative surgical margins were achieved, patients were simply followed closely. If tumor cells were close to or involved the surgical margins patients were treated with adjuvant external beam radiation. Regardless of the resected margins, all patients with intermediate-grade tumors received postoperative radiation therapy. Patients presenting with high-grade soft tissue tumors usually were treated with neoadjuvant and adjuvant chemotherapy. Contraindications for chemotherapy included advanced age, severe comorbidities, and a maximum tumor diameter less than 5 cm. Chemotherapy was not administered when the oncologist believed the potential risks of treatment outweighed its possible benefits. Patients with high-grade soft tissue sarcomas generally were treated with adjuvant radiation therapy. Exceptions included patients whose tumor necrosis rate exceeded 90% after being treated with neoadjuvant chemotherapy and whose surgical margins were negative, and patients who had primary amputation with negative margins.

For the first 2 years, patients were evaluated every 3 months by physical examination, MRI of the operated limb, and chest
Patients were evaluated semiannually for an additional 3 years and annually thereafter. Two orthopaedic oncologists (TP, JB) reviewed and analyzed the clinical records, imaging studies, and operative reports for details regarding the clinical presentation of popliteal sarcomas, tumor size, surgical margins, the occurrence of local recurrence and distant metastasis, the limb salvage rate, and postoperative morbidity and complications following limb-sparing resections.

We used the Mann-Whitney nonparametric statistical test to compare the sizes of the lesions between the high-grade tumors and the low- and intermediate-grade tumors. A p value < 0.05 was considered significant.

RESULTS

The rate of local recurrence was surprisingly low (Table 4). Three patients had local recurrences (10.3%) develop; all had high-grade soft tissue sarcomas. One of these patients first presented to our outpatient clinic with local recurrence after initially being treated at another institution. He had a second recurrence after his tumor was resected at our institution. In two patients, the local recurrence developed within 1 year of surgery. The third patient presented with local recurrence 5 years after her primary amputation (Table 3). All patients with local recurrences were treated with additional resection and adjuvant radiation therapy. Two patients who had local recurrences were tumor-free 4 and 6 years after their second resection, respectively. The third patient had two resections and an above-knee amputation after multiple recurrences, and eventually died from metastatic disease.

The rate of distant metastasis was unexpectedly low and most patients were alive at the time this study was conducted. Of the 16 patients with high-grade tumors four (25%) had distant metastasis develop. Two patients were diagnosed with metastatic disease during preoperative staging and the other two were diagnosed with metastatic disease after resection of their primary lesions. None of the patients with low-grade and intermediate-grade soft tissue sarcomas had metastatic disease. Overall, 26 of the 29 patients were still alive. Two patients died from pulmonary metastases and one patient, who had resection of low-grade soft tissue sarcoma, died 3 years postoperatively from unrelated reasons. Of the 16 patients who presented with high-grade soft tissue sarcomas, 14 (87.5%) were still alive at the time this study was conducted. Two of these patients had distant metastasis without any sign of local recurrence and 12 (85.7%) had no signs of local or metastatic disease.

The overall limb salvage rate was 86.2% (Table 4). Of the 29 study patients, three had primary above-knee amputations, and one patient first treated with two local resections after multiple recurrences had an above-knee amputation. The limb-salvage rate for patients with high-grade soft tissue sarcomas was 75%. The limb-salvage rate for patients with high-grade soft tissue sarcomas who were alive at the time this study was conducted and who had no sign of local or systemic disease also was 75%.
Patients with popliteal sarcomas often presented with atypical symptoms (Table 2), high-grade lesions were smaller ($p = 0.023$) than low- and intermediate-grade lesions, and the time to diagnosis was relatively short. Of the nine patients (31%) who presented with painful masses, five had high-grade soft tissue sarcomas, one had an intermediate-grade soft tissue sarcoma, and three had low-grade soft tissue sarcomas. The larger tumors usually protruded to the posterior aspect of the thigh, but none expanded distally into the posterior leg. Six patients reported having an asymptomatic mass in the popliteal fossa for more than 2 years (range, 2.5–10 years) that enlarged, became painful, or both, shortly before they first presented to our outpatient clinic. Of these six patients, three were diagnosed with low-grade lesions, two with intermediate-grade lesions, and one with high-grade soft tissue sarcoma. The larger tumors usually protruded to the posterior aspect of the thigh, but none expanded distally into the posterior leg. Six patients reported having an asymptomatic mass in the popliteal fossa for more than 2 years (range, 2.5–10 years) that enlarged, became painful, or both, shortly before they first presented to our outpatient clinic. Of these six patients, three were diagnosed with low-grade lesions, two with intermediate-grade lesions, and one with high-grade soft tissue sarcoma. The median time to diagnosis from the onset of patients’ symptoms was 2.5 months (range, 0.5–12 months).

The postoperative complications and morbidity rates were low. Of the 26 patients who had primary resections six had superficial surgical wound dehiscence, four of whom had wound breakdown during the course of adjuvant radiation therapy. All six patients were treated with systemic antibiotics and two patients had surgical débridement. All surgical wounds healed. Five patients had common peroneal nerve palsy postoperatively, one of whom had additional paresthesias in the distribution of the tibial nerve. In four of these patients, the neurologic deficiencies were secondary to neuropraxia and eventually resolved. The remaining patient sustained permanent peroneal palsy from segmental nerve resection. Other postoperative complications, each affecting one patient, were deep vein thrombosis of the superficial femoral vein and radiation neuritis.

The patients’ knee range of motion (ROM) often was preserved or only mildly compromised. Fourteen of the 26 patients (53.8%) who had primary resections had full ROM of the knee, 12 patients (46.1%) had mild to moderate limitations in knee flexion ($120°–90°$), and four patients (15.3%) had mild flexion contractures ($5°–15°$). No patient in our series required knee manipulation or contracture release.

DISCUSSION

Treatment outcome and clinical presentation of popliteal sarcomas were not extensively studied.8,23,37 Because of their extracompartmental location and proximity to neurovascular structures, their resection is considered challenging and their prognosis is regarded as inferior to intra-

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Fig 2A–B. (A) An intraoperative photo shows sciatic nerve exploration. The popliteal artery and vein were identified proximal and distal to the tumor mass (vessels loops). The gastrocnemius heads and the hamstring muscles have been detached and reflected permitting complete observation. The vessels and nerves were explored before resecting the tumor. (B) A schematic shows the technique used for popliteal exploration. The upper insert shows the skin incision and subcutaneous flaps necessary to permit exposure. Care should be taken not to open the popliteal fascia while developing the flaps to reduce the risk of neurovascular injury. The lower insert shows the release of the gastrocnemius heads which then are reflected distally for maximal exposure. The popliteal vessels are identified distally between the gastrocnemius heads. BF = long and short heads of biceps femoris, LG = lateral gastrocnemius, MG = medial gastrocnemius, PA = popliteal artery, PV = popliteal vein, PN = peroneal nerve, TN = tibial nerve, SN = sciatic nerve, SM = semimembranosus, ST = semitendinosus.
In our series of 29 consecutive patients with popliteal sarcomas, the local recurrence rate and metastatic rate were low and limb-salvage rate was high. In addition, the clinical presentations of the tumors often were unusual, and the morbidity and complication rates after limb salvage resections were low.

Our study has several limitations. It is a noncontrolled study of a relatively small heterogeneous population and not histopathologically uniform; the minimum followup was only 2 years. However, to our knowledge, this is the largest reported series of popliteal soft tissue sarcomas in the English literature. Because most local and systemic recurrences of soft tissue sarcomas occur during the first 2 postoperative years, and because our median followup was more than 6 years, we believe the rates of local recurrence and systemic disease would increase only slightly during a longer followup. An additional limitation of our study is that patients were not uniformly treated with neoadjuvant and adjuvant therapy. Conversely, patients’ treatment was based on a constructed approach which took into consideration the characteristics of the tumor, the patient, and the type of surgical margins. This limitation precludes making strong conclusions regarding the overall efficacy of neoadjuvant and adjuvant therapy; however, our therapeutic approach, and specifically the value of postoperative radiotherapy in limiting local recurrence, can be evaluated. Finally, we did not have functional scores available given the extended time frame of the study and its retrospective nature. Nonetheless, some generalizations may be made about other aspects of outcome.

The rates of local recurrence and distant metastasis were unexpectedly low. None of the patients who presented with low- and intermediate-grade tumors had local recurrence or metastatic disease, three patients (10.3%) with high-grade soft tissue sarcomas had local recurrences, and four patients had distant metastasis develop. Our results are comparable to the treatment results of patients with soft tissue sarcomas in other anatomic locations, and are similar to results of other studies of soft tissue sarcomas of the flexor fossae (axilla, epitrochlear fossa, antecubital fossa, inguinal space, and popliteal fossa), where patients also were treated with chemotherapy and radiotherapy.

Several studies have emphasized the importance of negative surgical margins in the excision of soft tissue sarcomas of the extremities. In an extracompartimental space such as the popliteal fossa, where major vessels and nerves traverse, performing radical resections is impossible and wide resections often are difficult to achieve. When the popliteal vessels or sciatic nerve are in close proximity to the tumor, we routinely remove the adventitia or the nerve sheath respectively to achieve close or only microscopically positive surgical margins. Accordingly, the surgical margins were positive in 23% of resections and close in 23%. Adjuvant radiation therapy, which has been reported to achieve acceptable local control in the presence of close or microscopically positive surgical margins, probably played an important role in limiting local recurrences in our series. Similarly, Eilber et al reported one local recurrence in 16 patients with high-grade soft tissue sarcomas of the popliteal fossa treated with neoadjuvant chemotherapy and radiotherapy.
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*H = high; I = intermediate; L = low; MFH = malignant fibrous histiocytoma; R = resection; AKA = above-knee amputation; N = neoadjuvant chemotherapy; A = adjuvant chemotherapy; NED = no evidence of disease; DOD = deceased
Philippe et al\textsuperscript{23} reported no local recurrences in eight children with popliteal sarcomas who were treated with tumor resections and adjuvant therapy.

The overall limb salvage rate was 86.2\%. The indications for amputations were multiple recurrences of an especially aggressive tumor, and heavily scarred and damaged skin and soft tissues overlying the popliteal fossa secondary to previous surgery and radiotherapy. Others have reported comparable results. Eilber et al\textsuperscript{8} reported on 16 patients with high-grade popliteal soft tissue sarcomas. Only two of their patients had amputations. Philippe et al\textsuperscript{23} reported on 11 children with soft tissue sarcomas of the popliteal fossa, and only three had amputations.

Close proximity of the tumor to neurovascular structures or even neurovascular involvement were not an indication for amputation. Although the sciatic nerve, its major branches, and the popliteal vessels were often in close proximity to the tumor mass, only in 11.5\% were they embedded or surrounded by the tumor. This is a typical growth pattern of sarcomatous tumors, which unlike carcinomas, displace anatomic structures instead of infiltrating them.\textsuperscript{3,2} Consequently, by dissecting the adventitia and nerve sheath we usually were able to preserve the vessels and nerves with close or microscopically positive surgical margins. When the popliteal vessels were embedded in the tumor and were resected, the popliteal artery was reconstructed with a contralateral greater saphenous vein. This is in agreement with previous studies where vascular involvement was treated by resection and reconstruction instead of primary amputation.\textsuperscript{15,18,29} Reconstruction of the popliteal vein is not necessary because the ipsilateral saphenous vein adequately compensates for its loss. When the peroneal, tibial, or sciatic nerves were embedded in the tumor they were resected en bloc with the tumor mass instead of performing primary amputation, similar to methods reported by others.\textsuperscript{1,2,13} Bickels et al\textsuperscript{1} reported on 15 patients who had resections of the sciatic nerve. Most of their patients achieved good functional results and none had pressure sores develop. Primary or graft repair of the nerve during the same operation is controversial because of the questionable negative effect of adjuvant radiotherapy on nerve healing.\textsuperscript{19,24,27}

On presentation, high-grade tumors were smaller than low- and intermediate-grade tumors. Although this is not contradictory to the accepted opinion that small size (< 5 cm) is a good prognostic sign for high-grade sarcomas, tumor size is not a recognized characteristic of a specific histologic grade.\textsuperscript{16,26,37} Patients’ presenting symptoms were atypical. Only 55\% of the patients presented with nonpainful asymptomatic masses and 31\% presented with locally painful masses. This clinical finding is in contrast to the classic presentation of soft tissue sarcomas as nonpainful, growing masses.\textsuperscript{3} Only one patient was diagnosed with synovial sarcoma, which is considered the typical pain-causing soft tissue tumor.\textsuperscript{3} We hypothesize the increased incidence of localized pain resulted partially from local compression of the tibial or peroneal nerves. The majority of painful masses were high-grade tumors, despite being smaller than low- and intermediate-grade tumors, presumably because their high growth rate did not allow adaptation of the nearby neural structures and surrounding tissues.

Considering tumors were often in close proximity to neurovascular structures and most patients were treated with postoperative radiation, the morbidity and complication rates after limb-sparing resections were unexpectedly low. We consider our routine wound closure technique of tenodesing the heads of the gastrocnemius to each other and to the hamstring muscles, important in preventing deep surgical wound breakdown because it creates a muscle barrier between the popliteal space and the skin and subcutaneous tissues. Another reason for the low complication rate might be that no preoperative radiotherapy was administered. O’Sullivan et al\textsuperscript{21} conducted a randomized trial comparing preoperative with postoperative radiation therapy and found more wound complications in the preoperative radiation group. Other have supported this finding.\textsuperscript{3,5} Unfortunately, we were not able to find any reports in the English literature on the morbidity and complications after resections of soft tissue sarcomas from the popliteal fossa.

We analyzed the treatment outcomes and clinical presentation of popliteal sarcomas. We found the presenting symptoms of popliteal sarcomas were often atypical, and high-grade lesions were more likely smaller than low- and intermediate-grade lesions. By using a wide anatomic approach coupled with careful surgical technique, and by individually tailoring perioperative treatment, limb-salvage procedures were accomplished in most patients, with low residual morbidity and good local and systemic control.

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References


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