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Operative Techniques in
Orthopaedics

Surgical Management of Soft Tissue Sarcomas of the Extremities

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The operative treatment of soft tissue sarcomas (STSs) requires extensive planning involving a multidisciplinary approach. The diagnosis is established through imaging and subsequent biopsy, which must be performed without contaminating surrounding tissues in ways that might complicate the definitive resection. Many factors related to both the patient and the sarcoma must be carefully evaluated to determine the most appropriate form of adjuvant treatment and the feasibility of limb salvage. Finally, patients should be counseled preoperatively regarding functional expectations. This article discusses the techniques and considerations that are essential to optimizing both oncologic outcome and patient satisfaction in the management of soft tissue sarcomas.
Oper Tech Orthop 24:79-84 © 2014 Published by Elsevier Inc.

KEYWORDS sarcoma, soft tissue, biopsy, surgery, technique, outcomes

Imaging

Magnetic resonance imaging (MRI) is the tool of choice for the evaluation of soft tissue sarcomas (STSs) and is a crucial part of surgical management. Studies should be performed before biopsy so as to determine the optimal biopsy technique and again in the weeks before definitive surgery, especially if the patient underwent adjuvant chemotherapy or radiotherapy in the interim. Size, depth relative to the fascia, signal characteristics, and heterogeneity of the lesion should be assessed, as should any proximity to or involvement of major nerves, blood vessels, and other critical structures. Osseous invasion by STSs is unusual, but if present, it can also be accurately diagnosed by MRI.[1] Finally, the presence and extent of surrounding oedema should be noted, as these areas have been shown to contain tumor cells.[2] These factors should then be taken into account when making decisions regarding adjuvant treatment and limb salvage. At this stage of surgical planning, it is also important to anticipate the need for other surgical specialists or teams; for example, a vascular surgeon may need to reconstruct a major artery or a plastic surgeon may be required to provide soft tissue coverage. If the patient receives neoadjuvant treatment, repeat MRI should be performed preoperatively to assess any changes before operative intervention.

Biopsy

Biopsy should be regarded as the first of many steps in the surgical management of STSs. Because of the highly transplantable nature of these tumors, appropriate planning and technique are critical. Following an incisional biopsy or after a needle biopsy when no adjuvant therapy would be used, the biopsy tract is considered contaminated by malignant cells and requires en bloc excision with the tumor. For this reason, the biopsy should be performed by, or in close consultation with, the treating orthopaedic oncologist.

Percutaneous biopsy can take the form of fine-needle aspiration, which yields a suspension of cells for analysis, or core biopsy, which displays these cells in the context of their matrix and has been shown to be highly accurate.[3-5] Open incisional biopsy, which remains the most definitive method, should be undertaken if previous attempts at core needle biopsy were nondiagnostic. Excisional biopsy, in which the

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http://dx.doi.org/10.1053/j.oto.2014.02.010
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entire lesion is removed as part of the diagnostic process, should be reserved for soft tissue masses that are less then 5 cm in diameter and superficial to the fascia. Conversely, lesions that are greater than 5 cm, deep to fascia, or in close proximity to neurovascular structures should always be evaluated by imaging and, if the diagnosis is still unclear, then biopsy.

Open incisional biopsy should be performed through a longitudinal incision in an area that can be ellipsed out and removed en bloc with the STS at the time of definitive resection. Developing skin flaps and other unnecessary planes should be avoided. Instead, dissection should be carried straight down through the superficial and deep tissues, including through a single muscle, thereby preventing contamination of multiple muscles, as well as neurovascular structures. Once the lesion is encountered, a sample should be sent to pathology for frozen-section analysis so as to ensure that adequate lesional tissue has been obtained for diagnosis before completing the procedure. Hemostasis should be confirmed and, if necessary, a drain should be placed exiting distal to and in line with the incision; this allows the drain tract to be easily excised with the biopsy site and avoids contamination of the more proximal tissues in the event that an amputation is required.

In all STS cases, the anticipated margins of resection should be planned based on the initial presenting MRI scan. According to the definitions established by Enneking, an intralesional excision passes through the tumor, and a marginal excision passes through the surrounding reactive zone. A wide resection excises the lesion with a cuff of normal tissue on all sides, and a radical excision removes the entire compartment. It is important to note that a radical excision does not necessarily require amputation, and, conversely, that amputation may be intralesional, marginal, wide, or radical.[6]

Intralesional excisions lead to local recurrence rates of nearly 100%, and radical excision causes significant morbidity and is not necessary for disease control. For these reasons, intralesional and radical resections are generally not practiced. Wide resection is the preferred treatment for STSs.[7] If on the initial MRI, the surgeon feels that an adequate amount of normal tissue can be kept on the tumor while not sacrificing critical structures, then surgery alone is all that is necessary. This is, however, generally reserved for small, superficial sarcomas.

For most patients with large sarcomas that are deep to fascia or adjacent to critical neurovascular structures, a wide margin would not be possible without drastically affecting the function of the limb. For this reason, a marginal resection in combination with radiotherapy is generally used. This practice maintains vital structures, which improves functional outcomes of the limb, without increasing the rate of local recurrence when compared with wide resection.[8-13]

The actual volume of resection necessary to achieve a wide margin is highly dependent on the type of surrounding tissues. For example, muscle, fat, and skin act as poor barriers to sarcoma cell growth, so 2-3 cm of these tissues is ideally resected to achieve a wide margin, whereas the fascia generally resists the penetration of tumor cells and, therefore, provides an adequate margin itself. It is important to recognize that the pseudocapsule surrounding the STSs is not a true barrier to the adjacent tissues, and therefore should not be considered equivalent to a fascial layer. Because of the efficacy of adjuvant therapy, critical vessels and nerves can often be spared when in direct contact with the surface of the lesion by dissecting along the adventitia or epineurium, respectively.[14] If only a limited area of vessel wall is adherent or infiltrated by the tumor, a partial resection can be performed, leaving the uninvolved portion of the vessel in continuity followed by a "patch"-type repair. However, if these critical structures are fully encased by the tumor, they must be sacrificed to avoid incising the tumor and thereby contaminating the surgical field.

Reconstruction of major vessels can be performed with the assistance of a vascular surgeon using the contralateral superficial femoral vein, reversed saphenous vein, or a synthetic graft. When necessary, this should be performed just before the last stages of the tumor resection to minimize ischemic time to the limb. The resulting function is potentially very high but remains unpredictable, with a significant risk of complications related to wound healing and lymphedema, as well as subsequent amputation.[15-17]

Like vessels, nerves can be removed from the surface of the tumor or, if adherent, freed from within the epineural sheath, which can remain with the specimen as part of the margin, in the context of multidisciplinary care, generally following preoperative radiation.[14] If nerve resection is necessary, the resulting deficits can be addressed through tendon transfer or splinting, although these techniques rarely result in a normally functioning extremity. Nerve transfer or grafting is usually unsuccessful, especially in adults and cases in which when radiation is used. However, resection of some major nerves due to sarcoma involvement, particularly in the lower extremity, can be expected to result in quite reasonable functional outcomes.[18-20] Therefore, limb salvage with nerve reconstruction is often not advisable in the context of other major neurovascular or soft tissue or bone involvement.[16,21]

If the tumor abuts bone, the periosteum can be stripped and removed with the specimen to provide a satisfactory margin if adjuvant radiation is used.[14] However, in this situation, the surgeon should recognize the increased risk of fracture and consider prophylactic fixation, especially in weight-bearing bones receiving radiotherapy.[22] In the rare case of STS invading the bone itself, the affected region should be resected and reconstructed. Cemented modular oncologic prostheses for lesions that are adjacent to joints are the most predictable option in the lower extremity and allow for immediate weight bearing. Allograft reconstructions can be considered with metadiaphyseal defects. Although these may potentially achieve osseous integration and thereby preserve bone stock, they also carry the risk of failure due to nonunion, fracture, and other complications, especially if radiotherapy is used.[23-25] Arthrodesis may be beneficial for some joints such as the wrist and ankle.[26,27] Prostheses can be used for the shoulder and elbow in the upper extremity,[27] and motion-sparing reconstructions using bulk autograft or allograft have been described for periarticular lesions in the forearm.[28-30] Nonessential bones, such as the fibula or the distal ulna, can often be resected and stability restored with soft tissue reconstruction alone.