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Indication and surgical approach for reconstruction with endoprosthesis in bone associated soft tissue sarcomas: Appropriate case management is vital

Öztürk R. Endoprosthesis in bone associated STS

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Abstract

It is important for surgeons performing sarcoma surgery to have the knowledge that bone resection, and tumor prosthesis applications in soft tissue sarcomas (STS) have unique features in terms of indication, surgical approach and follow-up, in terms of the management of these cases. Some STS are associated with bone and major neurovascular structures. Bone-associated STS are generally relatively large in size and relatively deep-seated. Additionally, the tendency for metastasis is high. In some cases, the decision about which structures to resect is difficult. These cases are often accompanied by poor oncological and surgical outcomes. Management of cases should be done by a multidisciplinary team in advanced centers specialized in this field. The surgical team must have sufficient knowledge and experience in the field of limb-sparing surgery. Preoperative evaluation and especially good planning of bone and soft tissue reconstruction are vital.

Key Words: Soft tissue sarcoma; Bone invasion; Bone resection; Endoprosthesis replacement; Prosthesis; Limb salvage; Indication; Approach

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Core Tip: In soft tissue sarcomas with bone invasion, resection of the tumor with wide margins including the relevant bone segment and endoprosthesis applications continue to be the recommended treatment method with satisfactory results. Preoperative evaluation and planning before surgery is crucial. In cases where there is a dilemma in surgical procedures, the decision of whether to perform bone resection affects the fate of the case. Bone and soft tissue reconstruction, especially after resection, should be planned meticulously to ensure adequate soft tissue coverage.

INTRODUCTION

In the management of soft tissue sarcomas (STS), wide excision is essential to achieve tumor-free surgical margins to preserve the limb. Radical resection of huge extracompartmental soft tissue sarcoma often requires simultaneous bone resection and reconstruction[1]. In these cases, endoprosthetic reconstruction may provide satisfactory results as a limb salvage strategy.

It is well known that the treatment and follow-up of bone, and STS should be managed with a multidisciplinary approach in advanced centers specialized in this field. This strong recommendation is especially valid in a special field such as bone resection, and tumor prosthesis applications in STS. Not adhering to diagnostic and treatment algorithms in the treatment management of sarcomas, or making interventions without having the knowledge and experience to interpret the patient's history, clinical examination, and radiological data, may lead to irreversible limb loss or fatal complications[2-4].

It is known that approximately 5% of all STS have bone invasion[5]. Bone resection, and tumor prosthesis applications in bone-related STS have their own unique nature/characteristics, different from classical prosthesis applications due to bone sarcomas. It has its own indications, differences in surgical practices and its own complications. Before making an indication for surgery in a case of soft tissue sarcoma that is relatively large in size and close to bone and major neurovascular structures, it is very important to review some important points.

Compared to prosthetic applications related to bone sarcomas, applications related to STS have their own difficulties[6]. One of these is the increased patient age[2,7]. Another is the frequent need for neoadjuvant or adjuvant radiotherapy. Especially the presence of bone invasion increases the patient's likelihood of receiving radiotherapy. Some other challenges are the presence of decreased chemosensitivity of the lesions and the potentially larger defects resulting from muscle compartment resections. Especially patients with bone invasion are likely to be metastatic, and therefore chemotherapy is usually administered to these patients. Despite additional chemotherapy, these cases still

have worse survival than cases without bone invasion[5]. Another difficulty is the existence of sarcoma cases that have undergone unplanned R1 resection. These accidental surgeries are generally performed without preoperative imaging, staging and biopsy, and are generally performed in centers that do not specialize in musculoskeletal system tumors. Although extensive resection is performed along with bone resection and adjuvant treatments are given, these interventions can make management difficult and worsen the results[8,9]. In conclusion, current data show that the probability of a case of soft tissue sarcoma with bone invasion resulting in amputation is higher than the possibility of continuing with preservation of the limb[5].

In the preoperative evaluation of STS, relatively less attention is paid to the presence or absence of bone invasion[10]. In fact, magnetic resonance imaging (MRI) is the gold standard in the preoperative evaluation of these sarcomas[2-4]. It provides vital information about the location of the tumor, its size, extensions, and its relationship with important structures such as bones, vessels and nerves. Plain radiographs and computed tomography are valuable in evaluating the presence of bone erosion[2,3]. The tumor may abutting to the bone, and this can involve less than one-third of the bone, or two-thirds of the bone. Sometimes, it not only abutt, but also erodes the adjacent bone, in which case medullary signal changes may also be observed. In tumors that abutting is less than one-third of the bone, subperiosteal resection is sufficient and there is no need for bone resection and reconstruction. Conversely, abutting to the bone is usually present in tumors that involve at least two-thirds or more of the bone. And in the presence of evidence of bone invasion, resection of the involved segment is essential for adequate surgical margins[1]. The decision on whether to perform resection for tumors that abutt to approximately two-thirds of the bone should be made carefully. In case of dilemma, an another method that can help in making a decision is whether the sarcoma is mobile or not on the adjacent bone[3,5]. This evaluation should be made preoperatively and intraoperatively. In intraoperative evaluation, it should be evaluated whether the tumor is mobile or not, especially after opening the fascia around the tumor. If the tumor is mobile, subperiosteal resection is usually sufficient. Because the periosteum, which is a

strong barrier, protected the bone from tumor. Cases with "planned positive" surgical margins performed in cases close to structures with natural barrier properties such as bones, vessels or nerves, have similar recurrence rates to series with negative surgical margins, especially when they supported by adjuvant treatments[3,5,10]. In cases like this, each cases necessary to be evaluated by a multidisciplinary team in a specialized center in the field of tumors. This team should include at least a medical oncologist, radiation oncologist, orthopedist, radiologist and pathologist. The patient should be evaluated in terms of neoadjuvant treatments, surgery and adjuvant treatments, taking into account the tumor subtype, location, size, age, and general condition of the patient. It is vital that the surgery is performed by a surgical team with knowledge, and experience in this field[2,4].

Another difficulty in the treatment management of STS is experienced in some cases in interpreting bone changes in preoperative examinations. It should be carefully examined whether there is a signal change in the bone marrow space adjacent to soft tissue sarcoma and whether the signal change is bone edema, invasion or metastasis. Ferguson *et al*[5] reported that in cases where there was a signal change in the bone marrow space, they performed resection, taking into account the risk of tumor presence. In the study of Lin *et al*[11], there was suspicion of bone invasion in 9 patients in preoperative images. They performed bone resection in all cases, and histological evaluation revealed no bone invasion in 8 cases.

In some cases, especially Juxta-articular STS, the tumor is near critical structures such as vessels, nerves and bone, and removal of the tumor alone is very difficult or not possible with wide margins. In such cases, resection of the tumor-related bone segment may be planned. Additionally, if there is evidence of invasion of the vessels and nerves, their resection is required[1]. One of the nightmare complications after endoprosthesis reconstruction is infection[2,12,13]. Bone-associated STS are usually larger than 10 cm and sometimes larger than 15 cm. Just as a bone defect may occur after resection, a serious soft tissue coverage defect may also occur. Providing adequate soft tissue coverage after reconstruction of the bone defect with a prosthesis is a very critical factor in reducing

infections. Therefore, before surgery, planning regarding soft tissue coverage should be planned meticulously and the operation should be completed after the necessary preparations[2,7,13].

The presence of a mass abutting to the bone, involving approximately two-thirds of the bone on MRI, poses a dilemma for treatment. Especially when the mass is located in an area close to the joint, such as the distal femur, it becomes more difficult to decide because the shape of the bone is relatively more irregular and the beginnings and endings of the muscles are more common here. The thin cortex of the metaphysis may make it difficult to determine whether a cortical erosion is present. Other areas noted to be difficult to interpret include tendinous insertions in bone and the linea aspera of the femur[14].

When evaluated in terms of subgroups of STS, subperiosteal resection can usually be sufficient in well-differentiated liposarcoma, while high-grade tumors such as synovial sarcoma, malignant fibrous histiocytoma, and malignant peripheral nerve steath tumor generally tend to erode the bone and may require resection of the affected segment[1,2,4]. It is clear that these tumors require more careful evaluation and a more cautious surgical approach in terms of bone erosion.

To summarize the indications for bone resection and potential endoprosthesis in STS. The presence of bone invasion clearly detected in preoperative radiological examinations is an indication for resection. Even if there is no bone invasion in radiological examinations, in the presence of a mass that covers almost the entire bone or surrounds it 360 degrees, bone resection should be performed since wide surgical margins will not be possible without resection of the relevant bone segment. When it is determined that there is no bone invasion and no signal change in the bone marrow space in preoperative radiological examinations, tumor mobility should be examined manually preoperatively and intraoperatively. Bone resection is indicated for tumors that are not mobile on the bone. In mobile tumors, resection with periosteum seems sufficient[1,5,6,11,13].

When studies analyzing bone-related STS are examined. Yan *et al*[6] compared 29 cases of lower extremity STS with bone invasion on preoperative radiological

examination with cases without bone involvement. They found that survival was lower in cases with bone invasion. They reported 30 cases of juxtaarticular bone invasion located in the distal thigh. The complication rate was 17% and they reported that these results were acceptable. However, Nakamura *et al*[13], in their multicenter study, examined 27 high-grade cases located in the lower extremities with bone invasion. They observed a total of 22 surgical complications (infection, relapse, aseptic loosening) and noted the high complication rates. LeVay *et al*[15] reported that in STS, the direct spread pattern of the tumor to invade the neurovascular structures and bone reduces the survival rate. Ferguson *et al*[5] reported that survival was significantly worse in the presence of histologically confirmed bone invasion. However, they found that the presence of bone invasion did not increase local recurrence but significantly increased the amputation rate. In another study, Panicek *et al*[16] reported that the presence of bone invasion on preoperative MRI did not increase the risk of recurrence or metastasis, but negatively affected survival.

Follow-up functional scores of endoprostheses applied for STS can be consistent with the scores of endoprostheses after bone resection, although they are generally performed after soft tissue resections larger than 10 cm[1,2]. However, the majority of reports show that these cases are accompanied by high surgical complication rates and poor oncological outcomes. One of the most important reasons for poor functional outcomes is massive muscle resection with tumor. During follow-up, 5-year limb preservation rates are approximately 75%. The most common major complications are infection and recurrence[13].

STS with bone invasion is usually deep-seated, usually metastatic at diagnosis, and relatively larger. These features negatively affect the prognosis[5]. In addition, features such as their relatively large size and deep location have resulted in the metastasis-free survival of cases with bone invasion being worse than those without bone invasion. There are reports stating that the presence of bone invasion in STS alone is a risk factor in terms of metastasis development and surveillance, regardless of the treatments applied[1,2,10,13].

However, it should be clearly noted that despite numerous clinical studies investigating the role of preoperative radiotherapy and computed tomography in STS, there is still no consensus[1-4]. This further increases the importance of the surgical management. However, the results of limb-sparing surgery supported by radiotherapy are similar to amputation in terms of recurrence[5]. In the treatment management of soft tissue sarcoma, each case should be evaluated individually, taking into account all conditions, and the option of amputation should also be considered in selected cases. If poor limb function is anticipated after tumor resection and possible reconstruction, or if it is not possible to preserve or reconstruct motor nerves or main arteries and veins, or if reconstruction of the bone and/or soft tissue defect does not seem possible, the case should be evaluated for amputation[17].

Although there are some studies on the indications for bone resection and the results of endoprosthesis applications in STS, the available information is still limited. There are no standardized guidelines. One of the main reasons for this is the rarity of STS and the very rare indication for bone resection and endoprosthesis application in these tumors. The literature is mostly in the form of case series containing data from a single center, with no comparison. Another reason is that it is not possible to do some studies due to their nature. If bone resection is not performed in cases where the bone relationship cannot be understood in preoperative evaluation and relapse occurs, there is a possibility that the relapse may be caused by microscopic residual disease in the cortical bone. It is impossible to understand whether this recurrence is due to tumor cells remaining on the bone. And this does not justify routine bone resection in these cases[11]. More studies are needed on the interpretation of radiological changes detected in the bone adjacent to soft tissue and the treatment decision. The frequency of indications for bone resection may also be a subject of further research. Is the most common indication the presence of a tumor that has a close relationship with the bone and requires bone resection, even though there is no bone invasion in radiological evaluation? Or is it bone invasion? Additionally, in different studies, it is stated that surrounding the bone at least 180 degrees or two-thirds of it is an indication[1,2,5]. However, in clinical practice, there are

cases where the bone is surrounded at the specified rates, but on intraoperative examination, it is completely mobile and subperiosteal resection can be performed, and there are also cases where the bone is surrounded at less than 180 degrees, but the bone needs to be resected[6,10-17]. This seems to be another issue that needs to be focused on in the field of indications. The majority of available literature data report that recurrence does not increase in cases where bone invasion is proven by preoperative MRI or histologically. However, data show that limb and patient survival decreases in these cases. This stands out as another point that requires further examination. As a result, it is a fact that there is a need for multicenter comparative studies with a sufficient number of cases that examine in depth the different aspects of bone-associated STS in the future.

CONCLUSION

Wide resections of high-grade STS with involved bone and reconstruction with endoprostheses are often associated with high surgical complication rates and poor oncological outcomes. Despite everything, in cases with bone invasion, resection of the tumor with wide margins, including the relevant bone segment, and endoprosthesis applications continue to be the recommended treatment method with satisfactory results. Preoperative evaluation and planning before surgery is crucial. "Planned positive" surgical resection, when supported by adjuvant treatments, has similar recurrence rates to amputation. In cases where there is a dilemma in surgical procedures, the decision of whether to perform bone resection affects the fate of the case. Especially bone and soft tissue reconstruction, after resection, should be planned meticulously to ensure adequate soft tissue coverage. Careful periodic postoperative follow-up is required for surgical complications and oncological events.

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