Limb Preservation in Patients With Bone and Soft Tissue Tumors

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In years past, amputation was the only treatment option for patients with bone and soft tissue tumors. How did limb preservation become a better option?

Advancements in imaging modalities have contributed dramatically to our ability to resect tumors while preserving essential neurovascular structures. Magnetic resonance imaging and angiography have provided precise detail of the anatomic boundaries of the tumor, as well as an accurate tool for surveillance of the resected tumor bed. Modern oncologic prosthetic devices have improved dramatically over the past decade. Modularity and more user friendly instrumentation have attracted many surgeons to incorporate these implants into complex adult reconstruction procedures. Adjuvant treatment, including radiation and chemotherapy, may be used effectively for local control. Presurgical treatment of both bone and soft tissue sarcomas often reduce tumor volume and allow for a wider surgical margin while preserving vital structures. Preoperative chemotherapy for Ewing sarcoma and osteosarcoma is particularly helpful because it provides information after resection regarding the tumor’s response to treatment. Greater than 95% tumor necrosis indicates a good response and has a more favorable prognosis. The success of chemotherapy in these 2 bone sarcomas has made a significant impact on our ability to perform limb salvage. Appropriate biopsy techniques have continued to be emphasized in the orthopedic literature. Longitudinal incisions, staying within a solitary compartment, and avoiding exposure of major neurovascular structures is crucial. Large studies have evaluated local recurrence; disease-free survival and survival outcome have not shown a significant difference between limb salvage and amputation.

When is limb preservation not the best treatment option?

Amputation may be a better option than limb salvage if, following tumor resection, the function of the limb would be severely limited. This may occur following resections of large...
tumors involving the brachial plexus or a combination of the sciatic and femoral nerves. A painful, functionless limb is considered much worse than an amputated limb. Patients with extensive comorbidities that would not tolerate a large resection and reconstruction would be better served with an amputation. The length of surgery, blood loss, the incidence of infection, and in many cases, the postoperative recovery time, decreases with amputation.

Amputation is often necessary to obtain a clear margin with sarcomas involving the hands and feet. Extremity prostheses continue to improve and are a viable option for a patient who will benefit little functionally from limb salvage or who has comorbidities placing the patient in jeopardy from a prolonged procedure and rehabilitation.

What are the reconstruction options?

Surgeon preference and experience plays a large role in the selection of which reconstruction will be performed. There is a wide range of reconstructive options for soft tissue and bone sarcomas. Bone sarcomas often require replacement of the adjacent joint. Modular oncologic replacement systems are commonly used. Proximal and distal femur replacements are the most common regions for modular oncologic prosthetic reconstruction. The allograft prosthetic composite is a popular reconstruction for proximal tibia reconstructions. It has the advantage of patella tendon attachment to the allograft with the enhanced stability afforded by a rotating hinge knee. Additionally, cadaver allograft alone or in combination with a joint replacement may also be considered. Intercalary allografts may be used for resections involving the diaphysis without joint involvement. Cadaver grafts may be used in combination with vascularized grafts. The vascularized fibula has been used successfully in many parts of the body to supplement other cadaver grafts, or alone.

What barriers exist for limb preservation?

Soft tissue, nerves, and vessels are the limiting factors for adequate limb preservation. The bone can be reconstructed with cadaver bone and/or an oncologic prosthesis. The soft tissues need to be mobilized either from a local uninvolved region or through vascularized transfer. Potential complications should be anticipated and appropriate steps taken at the discretion of the surgical team. The barriers for limb preservation often are avoided by the establishment of a highly trained and skilled surgical team. This would consist of an orthopedic oncologist, vascular surgeon, plastic surgeon, and general surgical oncologist.

What complications are associated with limb preservation?

Potential causes of morbidity include infection, pain and extensive rehabilitation. Blood loss and operative time is often significantly increased in general in comparison to amputation; and this may be a cause for concern depending on the age and comorbidities of the patient. Wound complications, allograft nonunion and/or fracture, and prosthetic loosening are all potential complications. Deep venous thromboses and pulmonary emboli are concerns, however little is known regarding which patients should receive prophylaxis, the length of prophylactic therapy, and the age at which there is a concern for potential thrombosis.

What challenges will patients face after limb preservation surgery?

The rehabilitation is often extensive after limb preservation. Patients need to be prepared for functional limitations for both the short and long term. Some of these limitations are not always predictable preoperatively and there tends to be some outcome variability, which is patient dependent. An experienced physical therapist is helpful and patients may benefit from a preoperative visit with them to establish a postoperative plan. An absence from school or work is often needed during the treatment and recovery period. Reentry back to activities of daily living can be challenging. A modified school or work schedule is usually needed until the patient can transition back to their previous routine.

What is the future of limb preservation?

Limb preservation has a bright future. Image-guided navigation surgery appears to have great promise. It is currently used in pelvic and lower extremity resections at our institution and other large cancer centers (Figures 1, 2). This will hopefully increase the precision of resections and allow us to preserve as much normal tissue as possible, which may translate to better healing and function. With ad-
Advancements in medical therapy, improved targeted drugs that have fewer immunosuppressive side effects and show a greater reduction in tumor volume will facilitate resection. With government health care cost regulation, surgical reconstructive options may be limited in the future to what is most affordable in the short term but not the most functionally effective and durable.

Figure 1: MRI of the pelvis of an 18-year-old man with osteosarcoma involving the right hemipelvis. A CT-guided navigation was used to make bone cuts to preserve the hip joint. Figure 2: One-year postoperative radiograph following wide resection and hip reconstruction. A new hip joint was reconstructed using bone graft and synthetic mesh. The patient was able to ambulate without assistive devices and has equal leg lengths.