Limb-Salvage Strategies to Optimize Quality of Life: The M.D. Anderson Cancer Center Experience

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Introduction

Sarcomas of bone and soft tissue are rare neoplasms with diverse histology and biologic behavior. Approximately 6,600 new cases of soft-tissue sarcoma and 2,500 new cases of bone sarcoma present each year. Most of these tumors develop in the extremities.

An increased understanding of sarcoma biology, advances in diagnostic imaging modalities, the development of effective adjuvant therapy regimens, and the application of new technologies and techniques for surgical resection and reconstruction have changed the nature and scope of treatment for these tumors. These advances have helped shape current surgical strategies and have prompted an increase in technically demanding limb-sparing surgical procedures.

Successful limb conservation preserves, repairs, or reconstructs critical structures necessary for limb function without compromising the oncologic objective of complete tumor extirpation. Because of several factors, the number of patients who are candidates for limb conservation is increasing without a significant increase in the risk of local tumor recurrence or an adverse effect on overall patient survival. The factors causing this result include refinements in diagnostic and extirpative approaches, improvements in bone and joint reconstruction, and better techniques for coverage of soft-tissue defects.

These developments have prompted a critical evaluation of the variables affecting limb preservation, functional outcome, and quality of life for the sarcoma survivor. This report discusses the strategies used at The University of Texas M.D. Anderson Cancer Center to improve the quality of life for patients diagnosed with these complex extremity tumors. Four case examples illustrate the range of clinical challenges confronting the sarcoma oncology team as members try to attain a better patient outcome using multimodality therapy and limb-sparing surgery.

Multidisciplinary Approach

Because of the rarity of the disease and the unique issues related to its management, we have established a Sarcoma Center at The University of Texas M.D.
The Anderson Cancer Center. The Center’s purpose is to optimize evaluation and treatment of sarcoma patients. A multidisciplinary team consisting of surgical oncologists (general and orthopaedic surgeons), plastic surgeons, medical oncologists, radiotherapists, pathologists, cytologists, interventional and diagnostic radiologists, psychiatrists, physiatrists, physical and occupational therapists, and nurses staffs the Center. Team members discuss therapy options and their sequencing, duration, and coordination.

Before treatment is initiated, the sarcoma patient undergoes a comprehensive assessment that addresses both oncologic and quality-of-life issues. The success of this management strategy is based on the coordinated efforts of the sarcoma team throughout the preoperative, intraoperative, and postoperative periods.

**Preoperative Strategies**

Preoperative planning—including imaging studies, biopsy, preoperative therapy, and rehabilitation considerations—is critical to optimal oncologic and functional outcomes.

Appropriate diagnostic imaging studies are obtained so that the local tumor can be visualized and the patient’s disease staged. For patients with soft-tissue sarcomas, magnetic resonance (MR) imaging most precisely delineates the extent of the primary tumor and its relationship to adjacent bone, blood vessels, and nerves. Computed tomography (CT); ultrasound; and, to a lesser degree, plain radiography, angiography, and scintigraphy provide complementary information when appropriate for selected patients. For patients with bone sarcomas, plain radiographs of the affected extremity provide critical information about characteristics of the tumor such as the site of involvement within the bone, pattern and extent of bone destruction, type of periosteal changes, presence of matrix mineralization within the tumor, and presence of soft-tissue extension.

CT provides cross-sectional images and greater contrast resolution to delineate bony details. MR imaging can clearly define additional determinants of salvageability, including involvement of major neurovascular structures, extent of intramedullary bone involvement, soft-tissue extension, and contamination of an adjacent joint. Staging for all sarcomas includes a chest radiograph and a CT scan to evaluate for pulmonary metastases. A technetium bone scan is the procedure of choice to screen the skeleton for bony metastases, when appropriate.

Sarcomas must undergo biopsy for identification of histologic type and grade before therapy starts. Since the late 1970s, percutaneous biopsy techniques have been used at M.D. Anderson for the diagnosis of bone and soft-tissue lesions. In our experience, needle biopsy is a safe and accurate (90%) method of obtaining tissue for diagnosis if performed by an expert in percutaneous biopsy techniques of the musculoskeletal system. The primary concern with this technique is the limited amount of tissue it yields. However, tissue obtained by this technique can be processed for standard histologic and cyto logic preparations, immunohistochemical studies, electron microscopy, flow cytometry, and molecular studies. Percutaneous needle biopsy is an expedient, cost-saving, minimally invasive procedure with negligible risk of complications that makes surgical biopsy unnecessary.

Surgical biopsies are more frequently performed than are needle biopsies at many centers. Regardless of the technique used, the biopsy procedure should be performed by personnel expert in managing extremity sarcomas. Poorly performed surgical biopsies cause problems (such as a misoriented biopsy incision or postoperative hematoma or infection) that may result in a more radical resection or prompt amputation rather than salvage of the limb; these problems may also increase local tumor recu-
rences. Therefore, open biopsies should be carefully planned and performed at the center where the definitive surgery is to be undertaken.

Even when a surgical biopsy is well executed, the surgically created biopsy site must be excised in continuity with the resected tumor specimen to reduce the incidence of local recurrence. Resection of overlying skin, fat, fascia, and muscle to incorporate the biopsy site may result in a more complex wound closure with possible soft-tissue reconstruction if the initial biopsy is created without consideration of the ultimate tumor resection.

Preoperative tumor cytoreductive therapies include irradiation for soft-tissue sarcomas and chemotherapy for both bone and soft-tissue sarcomas. These therapies may profoundly affect the feasibility of limb-sparing surgery by providing a tumor-free margin adjacent to critical structures. No consensus has been reached on the role of systemic chemotherapy for soft-tissue sarcomas or the preferred sequence of radiation therapy and surgery; however, these therapies are particularly useful preoperatively for sarcomas at sites that previously were believed to be unsalvageable and historically were treated by amputation.

Rehabilitation of the patient with cancer of the extremity also begins with the preoperative assessment. An understanding of the planned surgical procedure and adjuvant therapies can help the physiatrist create a postoperative rehabilitation program to meet the specific needs of the patient. Formulation of a structured rehabilitation program begins during the preoperative physical and occupational therapy assessment. Orthoses and assistive devices can be fitted preoperatively to reduce the time, cost, inconvenience, and pain associated with measurement and fitting immediately after the operation. Review of the rehabilitation plan allows the physiatrist and patient to reach congruent expectations and reduces patient anxiety. Individual and family counseling may be initiated immediately after the diagnosis has been established so that emotional support is provided before, during, and after active treatment has begun.

Surgical Strategies

Local tumor can be ablated by either amputation or a limb-sparing procedure. Tumor extirpation with wide surgical margins best controls local tumor. A wide excision removes the primary tumor en bloc along with its reactive zone and a cuff of normal tissue in all planes. Strategies to overcome resection of involved skin, muscle, nerve, blood vessel, and bone tissue are focused on reconstruction of the tissue deficits. This reduces short- and long-term patient morbidity, restores function, and should have a positive impact on the patient’s quality of life.

The surgical oncologist must determine whether performing a limb-sparing procedure is feasible, based on clinical presentation, stage of disease, local extent of tumor, involvement of vital structures, and tumor response to preoperative chemotherapy or irradiation (or both). The principal goal of limb conservation is to maintain a sensate and functional extremity. The extent of the resection for extremity sarcomas determines the functional deficit and influences the type of reconstruction used if reconstruction is necessary.

Limb Salvage

Soft-Tissue Sarcomas

Soft-tissue sarcomas are frequently large, deep-seated lesions that are often adjacent to or involve major blood vessels, nerves, and bone. If sacrifice of these structures is necessary to achieve satisfactory surgical margins, a complex reconstruction of the deficient tissue (soft tissue, bone, major blood vessels, and nerves) is done when the tumor is resected.

The most common clinical need af-
ter tumor extirpation is adequate soft-tissue reconstruction to provide reliable wound coverage. This is particularly important when preoperative radiation is a component of the multimodality treatment. Radiation creates a less than optimal tissue bed that is susceptible to wound breakdown, seroma and hematoma formation, and infection.

Adequate soft-tissue reconstruction is critical to the success of limb preservation in surgery for sarcoma of an extremity. Local or free transfers of unirradiated autologous tissues can obliterate dead space after tumor extirpation and can provide reliable and expedient wound closure. Moreover, healthy, well-vascularized, unirradiated soft tissue can protect underlying blood vessels, nerves, and bones and can withstand the mechanical forces of tension, compression, and shear, which occur across joints and in the hands and feet. An immediate one-stage extirpation-reconstruction procedure results in predictable wound coverage and has a low associated failure rate. It can also reduce perioperative morbidity and the duration of hospitalization and facilitate the restoration of function.

Interstitial radiotherapy (brachytherapy) may help preserve the integrity of immediately adjacent but uninvolved major nerves and blood vessels. Brachytherapy is an effective adjuvant for local control of high-grade soft-tissue sarcomas; it is particularly useful in the limb-sparing management of soft-tissue sarcomas in anatomic locations with at-risk neurovascular structures. Implantation of the interstitial catheters at the time of surgery permits a high dose of radiation to be delivered to the tumor bed with maximal sparing of surrounding normal tissue. Direct application of radiation to a smaller volume of tissue favors an optimal functional outcome. Moreover, local therapy (surgery and brachytherapy) can be completed in 10 to 12 days compared with the 9 to 13 weeks required for external-beam radiation (5 to 7 weeks of therapy) and surgery (4 to 6 weeks before or after radiation). The benefits of a shorter overall duration of local therapy are lower cost, greater patient convenience, earlier resumption of systemic therapies, and earlier return to normal activities.

The involvement of major neurovascular structures is not always an absolute contraindication for limb salvage. Limb-sparing surgery can be performed in select patients who must have major peripheral nerves and vital vascular structures removed to achieve satisfactory tumor excision. Major arterial and venous reconstructions have successfully maintained limb viability without compromising oncologic margins. Multiple cable nerve grafts and vascularized nerve grafts in compromised tissue beds have been used to maximize motor function and restore protective sensation in areas of the extremity important for long-term preservation of the limb.

Case 1
A 70-year-old man presented with a progressively enlarging soft-tissue mass along the subcutaneous region of the elbow of his dominant arm. Physical examination showed a firm mass densely adherent to the proximal ulna. Imaging studies delineated the extent of the mass (6 cm x 3 cm x 3 cm) and confirmed the involvement of the underlying bone and joint. Needle biopsy established the diagnosis of leiomyosarcoma. Preoperative radiation was delivered to 50 Gy.

A composite resection was performed of the irradiated skin, the tumor-bearing soft tissue, and the elbow joint. A custom prosthetic elbow joint was implanted to restore elbow function, and a free ipsilateral latissimus dorsi muscle flap was used to provide stable soft-tissue coverage over the metallic prosthesis in the previously irradiated tumor bed.
After a period of immobilization, an aggressive supervised rehabilitation program was initiated to optimize elbow, wrist, and shoulder function. During 3 years of follow-up, the patient has remained free of disease and has maintained a functional, painless range of motion of the elbow and wrist as well as full, unrestricted hand and shoulder function.

Case 2
A 44-year-old man presented with a soft-tissue mass in the anteromedial thigh associated with progressive lower extremity edema. The patient was referred to our institution for evaluation and treatment of a soft-tissue mass measuring more than 15 cm. The mass was diagnosed as a low-grade fibromyxoid sarcoma by needle biopsy. MR imaging revealed that the mass encompassed the superficial femoral artery and vein. To achieve satisfactory surgical margins, these major vascular structures were resected with the tumor and reconstructed with saphenous vein grafts by a vascular surgeon. A plastic surgeon performed a free myocutaneous rectus abdominus flap to obliterate the resultant dead space and to protect the underlying vascular reconstruction. Postoperatively, the patient began an intensive physical therapy program to control lower extremity edema, maximize lower extremity range of motion and muscle strength, and optimize gait. After 4 years of follow-up, the patient remains free of disease, with minimal residual edema and full function of the affected limb.

Bone Sarcomas
Primary malignant tumors of bone most frequently involve the osseous regions near the joint. Satisfactory oncologic resection frequently involves sacrifice of the tumor-bearing segment of bone in continuity with the adjacent joint. Advances in biomechanical engineering, allograft biology, and microvascular surgical techniques have expanded the alternatives for skeletal and joint reconstruction. The extremity can be reconstructed with a biologic, mechanical, or composite biologic-mechanical implant. Current methods of reconstructing skeletal and joint defects after sarcoma excision include prosthetic arthroplasty, osteoarticular allografts, allograft/prosthesis composites, and vascularized and nonvascularized large segment autogenous bone grafts and large-segment allografts. Local muscle flaps and free tissue transfers can adequately cover the wound over the reconstruction and reduce wound complications for patients with deficient or compromised soft tissues.

The reconstruction method chosen should have the lowest associated rate of early postoperative complications so that a delay in the resumption of adjuvant systemic therapy can be avoided. Our experience has shown that prosthetic arthroplasty, when appropriate, results in early return to function with low perioperative morbidity (less than 2%); therefore, it is our method of choice for most skeletal reconstructions. Such reconstructions usually yield satisfactory short-term results if applied appropriately.

The reconstructive approach selected must account for the patient’s work-related demands and lifestyle expectations, consonant with the ultimate goal of long-term survival. Although late functional outcome and complications depend on site and reconstruction method, no reconstruction performed to preserve mobile joint function will last the lifetime of the long-term cancer survivor.

The durability of the various methods of reconstruction has been a major concern of the orthopaedic oncologist. Analyses of prosthetic reconstructions...
after segmental bone resections report survivorship to be approximately 70% to 80% at 5 years and 60% to 70% at 10 years.26 Loss of fixation, mechanical failures, wear debris from polyethylene components, and late infection have compromised the long-term durability of prosthetic reconstructions. Bone graft rejection, resorption, fracture, infection, joint instability, and degenerative arthritis have limited the usefulness of currently available biologic reconstruction alternatives.

Many reconstruction techniques that have proved successful in adults cannot be applied to children. As a result, amputation has been, until recently, the recommended treatment for the surgical management of pediatric osseous malignancies of the extremities. The functional and psychological outcome achieved by ablative surgery remains the standard against which any form of limb-sparing surgery must be measured. As a result of advances in technology and development of surgical techniques to preserve limb length and function in skeletally immature patients, the number of patients considered for limb salvage is increasing. These approaches primarily involve the use of expandable prostheses32-35 and allografts.27,36

As with adults, the principal method of bone and joint reconstruction for skeletally immature patients is prosthetic arthroplasty. When an adjacent growth plate in the tumor-bearing bone is sacrificed but skeletal growth is undisturbed in the contralateral unaffected extremity, limb-length inequality results. Contemporary prosthetic devices can accommodate this dynamic state through an expansion mechanism engineered into the prosthesis.

The success of longitudinally extensible prosthetic bone and joint replacements has varied.32-35 The great functional demands children and adolescents frequently place on prostheses have caused mechanical failures, resulting in prosthetic fracture, inability to lengthen the prosthesis, or loss of achieved lengthening. As the proportion of long-term survivors increases because of increasingly effective chemotherapy, the life expectancy of the reconstructed limb may not keep pace with the life expectancy of the patient.

The small size of the affected pediatric bones and the dynamic changes such bones undergo present an ongoing challenge for engineers. Prosthetic designs have been modified to address these problems; however, the expandable prostheses currently in use require many operative procedures during the period of active skeletal growth. Newer designs that provide for lengthening without an invasive procedure have been described.37,38 These implants are still in the investigational stage of development.

Osteoarticular allografts, large-segment allografts, and autogenous fibular grafts offer biologic reconstructive alternatives. However, these techniques have severe limitations because of the size and geometry restrictions of available host and donor bones. The published experience is scant; however, in selected patients, favorable outcomes have been reported.36

In selected pediatric patients, novel approaches focus on preserving native joint and skeletal growth of the affected bone when the growth plate and epiphysis are not involved by tumor. Safe techniques for transepiphyseal resections to preserve the growth plate and the integrity of the adjacent joint are being investigated, although they are rarely applicable. When feasible, this approach may have substantial long-term advantages over the alternatives discussed earlier. The application of the limb-lengthening approaches to musculoskeletal oncologic problems raises the possibility that poor results secondary to limb-length discrepancy might be salvageable when active cancer treatment is completed.39

One of the most challenging dilemmas facing orthopaedic oncologists today
Mechanical devices fail over time as an expected consequence of prolonged survival in a predominately young, active patient population. Current biologic reconstruction alternatives are too limited for widespread application. Continuous improvements in prosthesis design and fixation methods and greater understanding of the mechanisms of prosthetic failure will prolong the longevity of future prosthetic reconstructions. Advances in biologic methods in the more distant future, including osseous and soft-tissue regeneration and prefabrication through tissue engineering techniques, hold the promise of durable reconstruction for the high demands of a lifetime of activity.

Case 3
A 22-year-old man, right-hand dominant, presented with a history of a mass in the distal forearm and recently progressive pain. Radiographs showed an osteoblastic lesion of the distal third diaphysis of the ulna. Needle biopsy showed a high-grade intramedullary osteosarcoma. No distant disease was detected. Preoperative chemotherapy (intraarterial cisplatin and intravenous doxorubicin and ifosfamide) resulted in radiographic, angiographic, and clinical evidence of favorable response. A wide local excision of the osteosarcoma was done with preservation of the distal radioulnar joint. Bone transplantation was performed using an autogenous vascularized segmental fibula graft to facilitate rapid healing in anticipation of postoperative chemotherapy and because of the subcutaneous location of the bone to be reconstructed. Healing was uneventful after casting. Aggressive supervised rehabilitation resulted in restoration of a normal range of motion and strength at the elbow with only a 5-degree limitation in wrist extension and supination. The patient returned to full activities as an automotive mechanic. At 5 years after surgery he remains free of disease.

Case 4
A 14-year-old boy presented with a 2-month history of pain about the right knee. Radiographs showed an osteoblastic lesion involving the proximal tibia. The lesion was diagnosed by open biopsy as a high-grade intramedullary osteosarcoma. No distant disease was found during staging studies. The patient was randomized to receive preoperative chemotherapy according to the Children’s Cancer Group protocol 7921 (intravenous infusion of cisplatin, doxorubicin, and methotrexate with or without muramyl tripeptide-phosphatidy ethanolamine, MTP-PE). Radiographic and clinical evidence indicated that the response to chemotherapy was favorable.

A wide local excision of the osteosarcoma was performed. An expandable prosthetic knee replacement was implanted because of the anticipated skeletal growth in this patient, whose bone age was that of a 12-year-old. A gastrocnemius rotation flap provided soft-tissue coverage for the reconstruction. After a period of immobilization and vigorous supervised rehabilitation, the patient could fully extend and flex the knee and walk unassisted. Staged operative expansion of the prosthesis on three occasions maintained satisfactory function and limb-length equality (total lengthening was 5 cm) at 3 years after surgery.

Amputation
Unfortunately, a role for amputation still exists despite the excellent results reported by most centers for extremity sarcomas. Amputation may be the most prudent surgical option for selected patients who are at the highest risk of complications that could place their limbs, if not their lives, in jeopardy. For some patients, preservation of the limb at any cost can result in a painful or marginally useful flail extremity. Imprudent attempts to salvage an extremity can lead...
to increased short-term and long-term morbidity, delayed resumption of systemic therapies, and increased hospitalization and recuperative time, all of which have an undesired impact on quality of life.

Factors involved in the decision to amputate include the inability to achieve satisfactory oncologic surgical margins, tumor involvement of critical structures necessary for function, inability to reconstruct the resultant defect after tumor extirpation, patient age, and progression of local disease while the patient receives chemotherapy. Limb amputation is a predictable effective method of achieving local tumor control. Amputation has low associated morbidity before, during, and after surgery. Problems that arise with amputations usually involve stump–prosthesis interface problems, stump pain, phantom sensations and pain, and bone overgrowth of the amputation stump in skeletally immature patients.

Surgical strategies to improve the outcome of amputation focus on creating adequate stump length and adequate soft-tissue coverage while preventing stump and phantom pain. Functional outcome is affected by the level of amputation necessary to extirpate the tumor. Inadequate residual bone and soft tissue can adversely affect outcome. Energy consumption and cardiopulmonary stress are inversely related to length of the residual limb and directly related to gait velocity and cadence. A longer limb allows more even distribution of weight-bearing forces over a broader limb–prosthesis socket interface so that joint contractures are less likely to develop.

Selected patients can undergo a free composite osteomyocutaneous tissue transfer using tissue from areas of the amputation specimen unaffected by tumor. This procedure provides a better limb stump for prosthetic fitting. Bone-lengthening techniques applied after completion of chemotherapy can provide a longer stump to facilitate fitting of the prosthesis. Free soft-tissue transfers also provide stable coverage of the stump wound in patients with compromised local tissues. Several surgical procedures may be necessary to address bone overgrowth in children until skeletal maturity is reached.

Phantom pain can be disabling for the amputee. The incidence of phantom pain and related phenomena varies widely and has not been investigated extensively in cancer patients undergoing amputation. Many treatment approaches to control pain have been attempted, including surgical ablative procedures of the peripheral and central nervous system, neurostimulation, medications, physical therapy, and psychological and behavioral therapies. Aggressive pain management with patient-controlled analgesia or epidural analgesia has effectively reduced postoperative pain. Considerable interest has been shown in preemptive analgesic strategies that provide pharmacologic neural block with opioids and local anesthetic drugs before surgical injury. A prospective randomized clinical trial is now underway at our institution under the auspices of the Pain and Symptom Management Service to study the effects of administering epidural opioid and local anesthetic drugs before surgical injury.

Rotationplasty is an alternative to amputation when limb salvage is not feasible for lower extremity bone sarcomas. Although it is done more commonly outside the United States, it has become increasingly less frequently used world-
Rotationplasty is now considered only rarely for selected patients in this country. This procedure substitutes the ankle joint for the absent knee joint by rotating the lower leg 180 degrees on its neurovascular pedicle, thereby converting an above-the-knee amputation into the functional equivalent of a below-the-knee amputation. The patient wears an external custom-fitted prosthesis. Gait training is necessary and critically important to optimize function.

Gait analysis and oxygen consumption studies of rotationplasty patients have shown that their level of function is comparable to that of below-the-knee amputees. The major objection to this procedure is cosmetic; many patients and their parents have difficulty adjusting to the appearance of a shortened extremity with the “foot on backwards.” Preoperative counseling for the patient and family members and contact with former patients who have had this procedure have helped rotationplasty candidates and their families address this issue. Videotapes showing the appearance of the operated limb with and without the prosthesis are also useful to patients considering this procedure.

Rehabilitation

Critical to the successful outcome of surgery for cancer of the extremity is a comprehensive rehabilitation program. The methods for restoring and maintaining the integrity of the involved extremity are introduced preoperatively and implemented soon after surgery. This reduces perioperative morbidity and facilitates early return to function.

A comprehensive rehabilitation program addresses the rehabilitation needs of each patient immediately after surgery and in the long term. Each program is specific for the needs of an individual patient. The primary focus of inpatient therapy is to facilitate mobilization to prevent complications associated with prolonged bed rest. Transfers, gait training, stair-climbing, and muscle-strengthening and range-of-motion exercises are initiated in the immediate postoperative period. Instruction and practice for safe performance of activities of daily living are also provided because postoperative range-of-motion restrictions or bracing may complicate self-care.

Before hospital discharge, equipment needs for home and workplace are evaluated, and supervised or self-guided outpatient therapy programs are implemented to reduce the incidence and severity of chronic conditions (such as lymphedema, soft-tissue and joint contractures, and myofascial pain syndromes). Because pain control is a critical component in successful acute rehabilitation, the adequacy of analgesia is evaluated and adjustments are made if needed. For patients with difficult pain management problems, the Pain and Symptom Management Service provides expert consultation.

The therapy program established for the individual patient is reinforced upon discharge, and the patient’s progress is followed closely. The rehabilitation regimen is dynamic, and adjustments are matched to the patient’s progress in achieving optimal functional level. Physiatric management strategies include the use of orthoses to support the involved extremity, modifiable ambulation devices, and adaptive equipment (such as bathtub benches and elevated commode seats). Environmental adaptations such as access ramps, bathroom grab bars, and widened doorways can increase safety and accessibility while reducing fatigue. Occupational therapy can provide ongoing instruction about fatigue management and the safe use of adaptive equipment.

After the immediate postoperative period, physiatric interventions may include flexibility or endurance exercises, scar massage instruction, and ongoing assessment of patient protection of in-
sensate skin. Sexuality may be affected through pain, restricted mobility, or role changes. Discussion of such issues with the patient and partner can resolve problems. Vocational assessment may be required, including recommendations about work site modifications and disability services or referral to vocational rehabilitation or retraining programs. Psychological counseling is initiated preoperatively, and family support networks are established during treatment. Both remain ongoing priorities.

Quality-of-Life Evaluation

The validation of instruments to measure life satisfaction is an evolving focus of clinical research. Most health indices concentrate on physical function; however, increasingly investigators are developing comprehensive quality-of-life measures using relevant objective and subjective parameters. The most widely studied quality-of-life assessments have included measures of physical, psychosocial, economic, and global well-being. A growing number of studies designed to evaluate rigorously treatment outcomes have emerged.

Sugarbaker et al examined quality of life in extremity soft-tissue sarcoma patients treated either by amputation and chemotherapy or by limb-salvage surgery, radiotherapy, and chemotherapy. The quality-of-life assessment used several different instruments, including the psychosocial adjustment to illness scale, the sickness impact profile, the Barthel function scale, and the Katz activities of daily living scale. In addition, the patient’s economic status, mobility, pain, status of sexual relationships, and treatment trauma were assessed. Based on the data obtained, they were unable to prove that quality of life was higher in patients who underwent limb salvage than in patients who underwent amputation.

Lampert et al retrospectively identified patients with soft-tissue sarcomas at high risk of developing a poor functional outcome. Their study showed that patients with lower extremity soft-tissue sarcoma were more at risk of becoming disabled than were patients with soft-tissue sarcoma in other areas of the body. Patients with lower extremity lesions had more frequent edema and difficulty with mobility, more problems with performing activities of daily living, and more frequent vocational changes than did patients with lesions involving the head, neck, trunk, and upper extremity.

The quality of life in patients undergoing multimodality treatment for extremity soft-tissue sarcoma was examined by Chang et al. Objective and subjective measures—including economic, sexual, functional, and global quality-of-life variables—were assessed by questionnaire preoperatively and at 6-month intervals postoperatively. After surgery, patients reported an increase in pain and decreases in employment, frequency of sexual intercourse, sexual interest and pleasure, and muscle strength of the affected limb. At 1 year, the changes were not as marked but were still evident. Overall results suggested that the quality of life decreased after surgery in all of the patients studied.

Arzouman et al studied soft-tissue sarcoma patients who had received chemotherapy as a component of their treatment. They used the Ferrans and Powers quality of life index, the functional living index: cancer (FLIC), and additional study-specific questionnaires via telephone interviews. The quality-of-life index showed that patients were most satisfied with their faith in God, family health, long life, and spouses. Patients were least satisfied with sex life, stress or worries, unemployment, financial independence, and government influence. Quality of life in the family domain was significantly higher than quality of life in the health, functioning, and socioeconomic domains. FLIC assessment showed that patients were confident in
their prescribed course of treatment, were optimistic about the future, generally felt well, and felt that their quality of life had improved since treatment. Aspects of therapy that most interfered with patients’ lives were the length of treatment and the attendant financial burden.

Thirty-five patients treated for extremity soft-tissue or bone sarcoma by either limb-sparing surgery or amputation were evaluated by Weddington et al.61 These investigators used several assessment instruments, including the cognitive capacity screening examination, the Hopkins symptom check list, the Beck depression inventory, the profile of mood states scale, the Karnofsky performance scale, global adjustment to illness scale, and the schedule for affective disorders and schizophrenia, lifetime version. Both the amputees and the limb-salvaged patients scored similarly regarding mood, cognition, body image, global physical functioning, global adjustment to illness and surgery, and lifetime prevalence of psychiatric disorders before and after surgery.

Postma et al.62 evaluated 33 long-term survivors of lower extremity bone sarcomas who were treated by either limb salvage or amputation. Self-report questionnaires, semistructured interviews, and visual analog scales were used to measure psychoneurotic and somatic distress, activities of daily living, self-esteem, and adjustment to illness. Physical complaints were more frequently noted in limb-salvage patients, whereas difficulties with self-esteem and socialization were more frequently reported in amputees.

It is evident from these and other studies that quality of life is difficult to define and even more difficult to assess using standardized methods. Many studies measure only functional outcome; however, quality of life is a multidimensional construct in which functional ability is only one component. Most studies that include other quality-of-life domains are flawed by including too few patients who have undergone comparable therapies for tumors arising in similar anatomic locations. The lack of standardized and validated measures raises questions about the biologic significance of the reported results. Improved methods are needed to document better the impact of multimodality therapy on the quality of life for patients with limb malignancy.

The measure of quality of life is a dynamic rather than a static process that requires periodic reassessment. Short-term results cannot necessarily be extrapolated to reflect long-term outcome. Repeat surgeries for local tumor recurrence, wound-related complications, or failure of mechanical and biologic reconstructions can have a significant impact on an individual’s quality of life over time. These late-developing conditions can result in repeated hospitalizations, time loss from work or school, loss of social interaction during recuperative periods, increased stress on familial and other interpersonal relationships, and financial burdens. Few data are available regarding the implications of late complications on limb function and quality of life. Future long-term follow-up studies may better elucidate the patient’s true experience.

**Conclusion**

The impact of therapy on the quality of life is predicated on an ability to preserve those structures necessary for function, to match patient expectations with oncologically appropriate treatments, and to design a rehabilitation program that can be followed in the long term to sustain function. For the present, our goal is a cured and intact patient who can resume as near normal function as possible for the duration of his or her lifetime. However, the future holds the promise of less debilitating therapies (including genetic therapies that selectively destroy tumors), less toxic conformational radiotherapy strategies, and cus-
tomized tissue-engineered biologic reconstructions. In the future, health care professionals should be better able to intervene to preserve the maximum quality of life for patients burdened by malignancies of the extremity. 

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