

GUEST EDITORIAL

What's New in Musculoskeletal Tumor Surgery

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Orthopaedic surgeons continued to be faced by novel challenges related to the COVID-19 pandemic over the past year. Nevertheless, inquiry into the treatment of tumors of the musculoskeletal system continued to result in a proliferation of available information to help to guide clinical practice. As in the past, the vast majority of published studies were retrospective in nature, likely due to the rarity and expansive range of the diseases treated by orthopaedic oncologists. Therefore, the new information described in this Guest Editorial, albeit robust, should be considered in the context of the limitations of the evidence. We conclude this article with studies by musculoskeletal oncologists that are unique in that they are prospective collaborative endeavors.

Primary Bone Tumors

Table I shows a number of recent studies on bone tumors¹⁻⁴⁵.

Pelvis and Spine

The reconstruction of the pelvis following internal hemipelvectomy has been an area of intense clinical review. Reconstruction options that have been reported to have reasonable surgical outcomes, albeit with high complication rates, include double-barreled free vascularized fibular grafting, structural allograft, individualized hemipelvic prosthesis, an ice-cream cone prosthesis, and personalized 3-dimensional (3D) printing-based limb salvage and reconstruction implants^{2,4,5,10,12,14}. A few studies have identified risk factors for poorer oncologic and surgical outcomes in pelvic tumors. These include a venous tumor thrombus, a margin of <2 mm, complete acetabular resection compared with transacetabular resection, and sarcopenia^{1,3,7,8}.

The National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) database, the American College of Surgeons (ACS) National Cancer Database, and the California Cancer Registry were queried by several authors who concluded that radiation therapy is the most common local modality used in the United States for Ewing sarcoma of the sacrum or pelvis and has similar efficacy to surgical resection

with or without radiation therapy; that 5-year disease-specific survival in patients with mobile vertebral column sarcomas was 56%, with worse survival for osteosarcoma; and that patients with malignancies of the mobile spine with public insurance are vulnerable to worse outcomes, even if they receive standard treatment^{6,9,11}.

Lower Extremity

Reconstruction of the femur and tibia is another area of interest in the field, particularly with respect to review of the long-term outcomes of endoprosthetic reconstruction. These include the Finn/Orthopaedic Salvage System distal femoral rotating-hinge prosthesis; stemmed, cementless, non-extendable endoprostheses; cryoablation; and compliant compressive osseointegration^{15,16,18,22,25,26}. The size of the patient cohorts in these retrospective series ranged from 12 to 328 patients, all with intermediate-term to very long-term follow-up (in some cases, decades). Long-term cumulative revision rates were generally around 30%. Notably, the failures in compliant compressive osseointegration, which allow for shorter residual bone segments, were generally early, with intermediate-term durability. However, these prostheses are newer and, therefore, long-term durability is unknown. Hindiskere et al. described the outcomes of telescopic allograft augmentation to augment residual femoral length, with implant survivorship of 80% at 7 years²¹.

Long-term outcomes of amputations for oncologic reasons have also been an area of investigation. Geiger et al.¹⁷ and Döring et al.²⁰ published functional and quality-of-life outcomes 20 to 40 years after the initial treatment for a limb sarcoma. The authors found that the cumulative incidence of amputation at 25 years after limb salvage was 18%, with periprosthetic joint infection as a risk factor for failure of limb salvage. Phantom limb pain and functional impairment are very common, even decades after amputation. It is clear that, despite the high incidence of complications with limb-salvage surgery, all attempts should be made, when feasible, to avoid limb amputation, particularly in young patients.

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TABLE I Studies on Bone Tumors

| Study | Article Title | Key Findings |
|--------------------------------|---|---|
| Bone: pelvis and spine | | |
| Liang ¹ (2021) | Venous Tumor Thrombus in Primary Bone Sarcomas in the Pelvis. A Clinical and Radiographic Study of 451 Cases | A venous tumor thrombus is most common in patients with pelvic osteosarcoma (23%) compared with patients with other primary bone sarcomas and is a negative prognostic factor. |
| Erol ² (2021) | Pelvic Ring Reconstruction After Iliac or Iliosacral Resection of Pediatric Pelvic Ewing Sarcoma. Use of a Double-Barreled Free Vascularized Fibular Graft and Minimal Spinal Instrumentation | Double-barreled free vascularized fibular graft after iliosacral resection for Ewing sarcoma in children resulted in the need for reoperation in 3 of 16 patients. Union rates were high in this cohort, with good functional outcomes. |
| Kurisunkal ³ (2021) | Is 2 mm a Wide Margin in High-Grade Conventional Chondrosarcomas of the Pelvis? | In a series of 105 patients with pelvic chondrosarcoma, a margin of >2 mm was a significant predictor of increased local recurrence-free survival. |
| Jamshidi ⁴ (2021) | Type III Internal Hemipelvectomy for Primary Bone Tumors with and without Allograft Reconstruction: A Comparison of Outcomes | In a retrospective cohort of 32 patients who underwent a Type-III pelvic resection, those who underwent allograft reconstruction fared better than those who did not undergo reconstruction with regard to functional outcomes, pain, and limp. |
| Xie ⁵ (2022) | A Novel Limb-Salvage Reconstruction Strategy with a Custom Hemipelvic Endoprosthesis and Preserved Femoral Head Following the Resection of Periacetabular Tumors: A Preliminary Study | In 14 patients who underwent acetabular resection, reconstruction with an individualized hemipelvic prosthesis and preservation of the femoral head showed acceptable early functional and oncological outcomes and a 35.7% complication rate. |
| Jawad ⁶ (2022) | Impact of Local Treatment Modality on Overall- and Disease-Specific Survival for Nonmetastatic Pelvic and Sacral Ewing Sarcoma | Data from the ACS National Cancer Database and the SEER database on patients treated in the United States for Ewing sarcoma of the sacrum or pelvis indicate that radiation therapy is the most common local modality and has similar efficacy as surgery and surgery with radiation therapy. |
| Kapoor ⁷ (2022) | Leaving Half the Acetabulum in Pelvic Resections Improves Hip Function. Is There a Need to Revisit Conventional Pelvic Resections? | Transacetabular resections, where feasible, result in better functional outcomes than full acetabular resections. |
| Brinkmann ⁸ (2022) | Impact of Preoperative Sarcopenia in Patients Undergoing Sacral Tumor Resection | In a series of 48 patients undergoing sacrectomy, central sarcopenia was not predictive of wound complications or infection but was an independent risk factor for local tumor recurrence. |
| Jawad ⁹ (2021) | Primary Mobile Vertebral Column Sarcomas: Prognostic Factors Vary by Histologic Subtypes | The SEER database was used to identify 712 patients with mobile vertebral column sarcomas. The 5-year, disease-specific survival was 56%, with worse survival for osteosarcoma. |
| Wu ¹⁰ (2021) | Three-Dimensional Printing-Based Personalized Limb Salvage and Reconstruction Treatment of Pelvic Tumors | In a series of 28 patients who underwent personalized 3D printing-based limb salvage and reconstruction for pelvic tumors, at a median follow-up of 32 months, 9 patients had died and 9 patients had complications (infection, dislocation). Functional outcomes were good. |
| Stroud ¹¹ (2022) | Survival of Patients with Primary Osseous Malignancies of the Mobile Spine Is Associated with Access to "Standard Treatment" Protocols | The California Cancer Registry identified 484 patients with malignancies of the mobile spine. Medicaid and public insurance and Medicare were associated with higher mortality compared with private insurance. The authors concluded that patients with public insurance are vulnerable to worse outcomes, even if they receive standard treatment. |
| Fujiwara ¹² (2021) | Limb-Salvage Reconstruction Following Resection of Pelvic Bone Sarcomas Involving the Acetabulum | The authors reviewed a series of 122 patients with a periacetabular bone sarcoma who underwent internal hemipelvectomy and various forms of reconstruction or no reconstruction. Functional outcomes scores were worse in those who had a major complication. If the ilium can be maintained, an ice-cream cone prosthesis with antibiotic-laden cement is a reasonable option. |
| Court ¹³ (2021) | Video-Assisted Thoracoscopic En Bloc Vertebrectomy for Spine Tumors. Technique and Outcomes in a Series of 33 Patients | There were 33 patients who underwent video-assisted thoracoscopic surgery for resection of a vertebral tumor. There were 18 complications (55%), mostly pulmonary. The authors recommended the technique for smaller tumors without substantial chest wall and/or mediastinal invasion. |
| Wellings ¹⁴ (2021) | Comparison of Free Vascularized Fibular Flaps and Allograft Fibular Strut Grafts to Supplement Spinopelvic Reconstruction for Sacral Malignancies | The authors reviewed 44 cases of en bloc resection of the pelvis for a malignant tumor and concluded that supplementation of spinopelvic reconstruction with a free vascularized fibula was associated with a shorter time to union compared with reconstruction with an allograft fibular strut graft. |

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TABLE 1 (continued)

| Study | Article Title | Key Findings |
|----------------------------------|---|---|
| Bone: lower extremity | | |
| Ogura ¹⁵ (2021) | Finn/Orthopaedic Salvage System Distal Femoral Rotating-Hinge Megaprotheses in Oncologic Patients. Long-Term Complications, Reoperations, and Amputations | The authors reviewed 214 patients treated with a Finn/Orthopaedic Salvage System (OSS) knee prosthesis (Zimmer Biomet) after distal femoral resection over a 26-year period. There were 312 reoperations, and the cumulative incidence of implant removal or revision for any reason at 10 years was 30.1%, with a continued risk of 1.24% per year. |
| El Ghoneimy ¹⁶ (2022) | What Is the Cumulative Incidence of Revision Surgery and What Are the Complications Associated with Stemmed Cementless Nonextendable Endoprostheses in Patients 18 Years or Younger with Primary Bone Sarcomas About the Knee | The authors reviewed 328 patients who were <18 years of age and were treated for a bone sarcoma around the knee with resection and endoprosthetic reconstruction. The 8-year cumulative incidence of revision surgery for any cause was 32%. The mean leg-length discrepancy for those who were skeletally immature at the time of surgery was 3.5 cm. Functional scores were excellent in those who retained the prosthesis. |
| Geiger ¹⁷ (2022) | What Are Risk Factors for and Outcomes of Late Amputation After Treatment for Lower Extremity Sarcoma: A Childhood Cancer Survivor Study Report | Data from the Childhood Cancer Survivor Study were used to determine the risk of late amputation following limb-salvage surgery in children. The cumulative incidence of amputation at 25 years after limb salvage was 18%. Risk factors for amputation were male gender and history of periprosthetic joint infection. |
| Groundland ¹⁸ (2022) | What Are the Long-Term Surgical Outcomes of Compressive Endoprosthetic Osseointegration of the Femur with a Minimum 10-Year Follow-up Period? | This was a retrospective series of 110 patients with primary bone sarcoma of the proximal or distal femur. Of the 110 patients, 25 were treated with a compressive osseointegration implant and 85 were treated with conventional stemmed implants or amputation. Of the 25 patients, 20 were alive at 10 years. The rate of mechanical failure related to the compression device was 12%, and all failures occurred in the first 29 months. |
| Fernandes ¹⁹ (2021) | Clinically Important Reductions in Physical Function and Quality of Life in Adults with Tumor Prostheses in the Hip and Knee: A Cross-Sectional Study | The authors assessed 30 patients who underwent endoprosthetic reconstruction of the hip or knee and compared them with 30 age-matched controls with regard to physical function and quality of life. Pain and objective functional limitations were common in the surgical group, even in the contralateral limb. |
| Döring ²⁰ (2021) | How Common Are Chronic Residual Limb Pain, Phantom Pain, and Back Pain More Than 20 Years After Lower Limb Amputation for Malignant Tumors? | There were 21 patients with a median follow-up of 41 years who completed a standardized questionnaire to assess pain and daily prosthesis use; 17 of the 21 patients reported phantom limb pain and back pain. However, the 21 patients represented a small number of those who had undergone amputation (124), due to death, loss to follow-up, and declining to participate. Nevertheless, residual functional impairment appears to be common. |
| Hindiskere ²¹ (2021) | What Is the Survival of the Telescope Allograft Technique to Augment a Short Proximal Femur Segment in Children After Resection and Distal Femur Endoprosthesis Reconstruction for a Bone Sarcoma? | The authors reviewed 14 patients who underwent telescopic allograft augmentation of the femur due to a short residual bone segment. There were 3 delayed unions (14%), but no nonunions. The survivorship of the implant at 7 years was 80%. The authors concluded that telescopic allograft is a helpful method to provide adequate bone length to preserve the hip joint. |
| Christ ²² (2021) | Compliant Compression Reconstruction of the Proximal Femur Is Durable Despite Minimal Bone Formation in the Compression Segment | This was a retrospective case series of 12 patients who underwent proximal femoral reconstruction with compliant compression fixation. In contrast to distal femoral compliant compression implants, there was minimal bone formation at the compression segment. However, there was only 1 implant failure during a median follow-up of 6 years. |
| Jamshidi ²³ (2021) | How Can We Differentiate Local Recurrence from Heterotopic Ossification After Resection and Implantation of an Oncologic Knee Prosthesis in Patients with a Bone Sarcoma? | Heterotopic ossification after the use of oncologic knee prostheses for reconstruction after tumor resection occurred in 8% of patients. Local recurrence occurred in 10%. Heterotopic ossification occurred earlier than local recurrence and was associated with well-defined borders. |
| Jamshidi ²⁴ (2022) | Fibular Strut Allograft or Bone Cement for Reconstruction After Curettage of a Giant Cell Tumour of the Proximal Femur: A Retrospective Cohort Study | The authors reviewed 26 patients with a giant cell tumor of the proximal femur. Recurrence was similar between the allograft-strut reconstruction group (25%) and the cement reconstruction group (21%). Osteoarthritis was more common in the cement group. |

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TABLE 1 (continued)

| Study | Article Title | Key Findings |
|--------------------------------------|---|--|
| Lex ²⁵ (2021) | Acetabular Complications Are the Most Common Cause for Revision Surgery Following Proximal Femoral Endoprosthetic Replacement: What Is the Best Bearing Option in the Primary and Revision Setting? | The authors reviewed 233 patients who underwent proximal femoral endoprosthetic replacement for oncologic reconstruction. The revision rate was 15% at a mean follow-up of 74 months. Acetabular revisions were the most common reoperation in both the hemiarthroplasty and arthroplasty groups. Re-revision rates were lower with dual-mobility bearings, constrained bearings, or large-diameter heads (>32 mm). |
| Ogura ²⁶ (2021) | Long-Term Competing Risks for Overall and Cause-Specific Failure of Rotating-Hinge Distal Femoral Arthroplasty for Tumour Reconstruction | A review of 209 patients who underwent resection of the distal femur for tumor and reconstruction using a rotating-hinge knee prosthesis between 1991 and 2016 was performed. Risk factors for implant failure were the percentage of femoral resection and extent of quadriceps resection. The type of joint resection was associated with the risk for infection, and a bone-stem ratio of >2.5 was predictive of aseptic loosening. |
| Jawad ²⁷ (2021) | Malignant Neoplasms Originating from the Bones of the Foot: Predilection of Hematological Malignancies and Sex-Related and Ethnic Disparities in Amputation | The authors queried the National Cancer Institute's SEER database and identified 514 patients diagnosed with a malignancy of the small bones of the lower limb. Disease-specific survival was 73% at 5 years, and male gender and Hispanic race were associated with amputation. |
| Labott ²⁸ (2021) | Utility of the ACS-NSQIP Surgical Risk Calculator in Predicting Postoperative Complications in Patients Undergoing Oncologic Proximal Femoral Replacement | The authors used the online ACS-NSQIP surgical risk calculator to predict complications for 103 proximal femoral replacements. They found that the calculator significantly underestimated the actual risk of 54%. |
| Groundland ²⁹ (2021) | Is Osseous Reattachment of the Greater Trochanter Necessary Compared to Soft-Tissue-Only Abductor Repair in Proximal Femoral Megaprosthesis Reconstruction? | The authors reviewed 53 patients who underwent proximal femoral endoprosthetic reconstruction and found that salvage of the greater trochanter for reattachment to the endoprosthesis did not lead to improved function compared with soft-tissue-only abductor repair. |
| Errani ³⁰ (2021) | Does the Addition of a Vascularized Fibula Improve the Results of a Massive Bone Allograft Alone for Intercalary Femur Reconstruction of Malignant Bone Tumors in Children? | The authors reviewed 60 pediatric patients with diaphyseal tumors undergoing intercalary resection and reconstruction with massive allograft with or without vascularized free fibula. No differences in union rates, complications, or functional outcomes were found. |
| Bone: upper extremity | | |
| Schneider ³¹ (2021) | What Is the Implant Survivorship and Functional Outcome After Total Humeral Replacement in Patients with Primary Bone Tumors? | The authors reviewed 31 patients who underwent total humeral endoprosthetic reconstruction for a primary bone malignancy. The revision-free implant survivorship was 77% at 1 year and 74% at 5 years. At a mean follow-up of 75 months, only 13 patients were still alive, and these patients had good functional outcomes. |
| Liang ³² (2022) | Elbow Hemiarthroplasty with a 3D-Printed Megaprosthesis for Defects of the Distal Humerus or Proximal Ulna After Tumour Resection: A Preliminary Report | There were 13 patients with aggressive or malignant tumors of the distal humerus or proximal ulna who underwent en bloc resection and reconstruction with a 3D-printed megaprosthesis with hemiarthroplasty. The preparation of the prosthesis took a mean of 8.0 days. Apart from 1 dislocation, there were no failures related to the implant at a mean follow-up of 25.7 months. Functional outcomes were excellent. |
| Houdek ³³ (2022) | Allograft Prosthetic Composite Reconstruction Using a Reverse Total Shoulder Arthroplasty for Failed Oncologic Proximal Humerus Reconstruction | There were 11 patients with failure of a previous proximal humeral reconstruction treated with a reverse shoulder arthroplasty with an allograft-prosthetic composite. Re-revisions were required for 2 patients with allograft complications. Overall function improved significantly. |
| Kruckeberg ³⁴ (2021) | Total Elbow Arthroplasty for Tumors of the Distal Humerus and Elbow | The authors reported on 33 patients who underwent elbow arthroplasty for oncologic reconstruction. Postoperative complications were common (45%), with the most common being periprosthetic fracture. The 5-year implant survival was 88%. |
| Jawad ³⁵ (2021) | Prognostic Factors, Disparity, and Equity Variables Impacting Prognosis in Bone Sarcomas of the Hand: SEER Database Review | The authors queried the National Cancer Institute's SEER database for patients diagnosed with primary sarcomas originating from the bones of the hand and the wrist. Disease-specific survival was 90% at 5 years and 84% at 10 years. |
| Imaging and perioperative management | | |
| Cranmer ³⁶ (2022) | Is Chemotherapy Associated with Improved Overall Survival in Patients with Dedifferentiated Chondrosarcoma? A SEER Database Analysis | The authors queried the SEER database for patients diagnosed with non-metastatic dedifferentiated chondrosarcoma and found that, in 185 patients, chemotherapy did not improve survival. |

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TABLE 1 (continued)

| Study | Article Title | Key Findings |
|---------------------------------|--|--|
| Kiatisevi ³⁷ (2022) | Does Local Zoledronate Applied to Pasteurized Bone Autografts Improve the Likelihood of Union of Graft-Host Junctions After Limb-Sparing Surgery? | The authors reviewed 73 patients who underwent oncologic reconstruction with pasteurized bone autograft with follow-up of at least 2 years. There were 8 metaphyseal fractures and 7 nonunions. Local zoledronate application did not improve union rates. |
| Holzer ³⁸ (2021) | Is There an Association Between Bone Microarchitecture and Fracture in Patients Who Were Treated for High-Grade Osteosarcoma? A Controlled Study at Long-Term Follow-up Using High-Resolution Peripheral Quantitative CT | Nineteen patients treated for osteosarcoma at least 20 years previously were assessed with dual x-ray absorptiometry and high-resolution peripheral quantitative CT; they were also queried with regard to fracture history. The authors found that a high proportion had osteopenia or osteoporosis and experienced fractures. However, the authors did not find differences in microarchitectural bone parameters. |
| Aryal ³⁹ (2021) | What Is the Comparative Ability of 18F-FDG PET/CT, 99mTc-MDP Skeletal Scintigraphy, and Whole-Body MRI as a Staging Investigation to Detect Skeletal Metastases in Patients with Osteosarcoma and Ewing Sarcoma? | The authors prospectively recruited 54 patients who were diagnosed with osteosarcoma or Ewing sarcoma. The presence of skeletal metastases was assessed with ¹⁸ F-FDG PET/CT, whole-body MRI, and ^{99m} Tc-MDP skeletal scintigraphy. There was no difference found in the sensitivity, specificity, negative predictive value, or positive predictive value among the 3 staging modalities. |
| Laitinen ⁴⁰ (2021) | Clinical Differences Between Central and Peripheral Chondrosarcomas | There were 714 patients treated surgically at 2 centers for chondrosarcoma of the extremities or pelvis. Oncologic outcomes were similar between the central and peripheral locations. In patients with hereditary multiple exostosis, the most common locations were the pelvis and scapula. |
| Tsagkozis ⁴¹ (2022) | Intralesional Margin After Excision of a High-Grade Osteosarcoma: Is It a Catastrophe? | In this small series, oncologic outcomes were improved in intralesional resections of osteosarcoma in cases in which there was a good response to chemotherapy. |
| Lazarides ⁴² (2022) | Investigating Readmission Rates for Patients Undergoing Oncologic Resection and Endoprosthetic Reconstruction for Primary Sarcomas and Tumors Involving Bone | In a retrospective review of 149 patients who underwent surgery for a primary bone tumor or a soft-tissue tumor invading bone, the readmission rate within 90 days was 28.3% and was associated with female sex, higher tumor grade, and longer procedure duration. |
| Haase ⁴³ (2022) | Tranexamic Acid Improves Early Postoperative Mobilization in Cancer Patients Undergoing Endoprosthetic Reconstruction | In this comparative retrospective cohort study, the authors found that patients who underwent oncologic endoprosthetic reconstruction were more likely to walk and had longer endurance if tranexamic acid was administered perioperatively. |
| Schumacher ⁴⁴ (2022) | Evaluation of Triage Tool for Low-Grade Cartilage Tumors: Four-Quadrant Approach | A retrospective cohort with 56 lesions was used to determine that a 4-quadrant approach that uses patient symptoms and radiographic features is a useful tool in distinguishing benign enchondromas from low-grade chondrosarcomas. |
| Lee ⁴⁵ (2021) | Surface Osteosarcoma: Predictors of Outcomes | The authors reviewed 51 patients treated at a single center for a surface osteosarcoma. With a median follow-up of 6 years, 3 patients developed a local recurrence and 5 patients developed metastases. |

The reconstruction of the proximal femur has been a notable area of investigation. Jamshidi et al. reported that patients with a giant cell tumor of the proximal femur are more likely to develop osteoarthritis if they undergo reconstruction with cement rather than strut allograft²⁴. In a large retrospective study from the United Kingdom, Lex et al. found that, in patients with proximal femoral endoprosthetic reconstruction, acetabular revisions were the most common reoperation following both hemiarthroplasty and arthroplasty, and re-revision rates were lower with dual-mobility bearings, constrained bearings, or large-diameter heads (>32 mm)²⁵. Christ et al. reported on a small series of 12 patients who underwent proximal femoral reconstruction with compliant compression fixation and found that hypertrophic bone at the bone-implant interface was not common, as it is in distal femoral reconstructions²². Finally, Groundland et al. reported that, in patients

who underwent proximal femoral endoprosthetic reconstruction, salvage of the greater trochanter for reattachment to the endoprosthesis did not lead to improved function compared with soft-tissue-only abductor repair²⁹.

Upper Extremity

The upper extremity is less commonly affected by bone sarcomas and metastatic bone disease. However, there have recently been several studies showing the oncologic and surgical outcomes of reconstruction of the shoulder and elbow. Schneider et al. reviewed 31 patients who underwent total humeral endoprosthetic reconstruction³¹. The revision-free implant survivorship was 77% at 1 year and 74% at 5 years. However, only 13 patients were still alive for the functional outcome assessment. Liang et al.³² and Kruckeberg et al.³⁴ reviewed the outcomes of patients who underwent elbow

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arthroplasty with custom-made or standard prostheses and reported that, despite a high risk of complications, implant survival at 2 and 5 years was 88% to 100%, with excellent functional outcomes. With regard to the proximal humerus, Houdek et al. reviewed 11 patients with a failed previous proximal humeral reconstruction who were treated with reverse shoulder arthroplasty with an allograft-prosthetic composite. Re-revisions were required for 2 patients with allograft-related complications. The overall function improved significantly³³. Finally, Jawad et al. queried the SEER database for patients diagnosed with primary sarcomas originating from the bones of the hand and the wrist and reported that disease-specific survival was 90% at 5 years and 84% at 10 years³⁵.

Imaging and Perioperative Management

In further studies in the recent literature, authors reported on perioperative management and imaging for bone tumors. In a SEER database study, Cranmer et al. reported that chemotherapy did not improve survival for dedifferentiated chondrosarcoma³⁶. In a comparative retrospective cohort study, Haase et al. found that patients who underwent oncologic endoprosthetic reconstruction were more likely to walk and had longer endurance if tranexamic acid was administered perioperatively⁴³. In a retrospective review by Lazarides et al., 149 patients were identified who underwent a surgical procedure for a primary bone tumor or a bone-involving soft-tissue tumor; the readmission rate within 90 days was 28.3% and was associated with female sex, higher tumor grade, and longer procedure duration⁴². Finally, in an important prospective observational study, Aryal et al. assessed 54 patients with osteosarcoma or Ewing sarcoma for the presence of skeletal metastases with ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT), whole-body magnetic resonance imaging (MRI), and ^{99m}Tc-methylene diphosphonate (MDP) skeletal scintigraphy. The authors found no difference in the sensitivity, specificity, negative predictive value, or positive predictive value among the 3 staging modalities³⁹.

Soft-Tissue Tumors

Table II shows a number of recent studies on soft-tissue tumors⁴⁶⁻⁶⁵.

Predictive Modeling

There is ongoing interest in identifying patient, tumor, and perioperative factors that impact both surgical and oncologic outcomes in patients with soft-tissue tumors^{46-49,57,61,65}. Analyses of the impact of patient age on surgical management and oncologic outcomes have demonstrated similar rates of limb-salvage surgery with significant differences in the choice of systemic therapies⁶⁵. Hartley et al. reported on the outcomes of nonagenarians undergoing a surgical procedure for soft-tissue sarcomas and advocated for curative management for nonagenarian patients on a case-by-case basis⁴⁷.

Preoperative risk stratification scores are an evolving clinical tool to guide patient and physician decision-making. Lee et al. developed a prognostic risk score in patients undergoing curative-intent resection of lung sarcoma metastases⁵⁷. They identified that older age, multiple lung metastases, retroperitoneal sarcoma, and R1 resections of the primary tumor were negative prognostic factors for overall survival. Spence et al. applied the modified Glasgow Prognostic Score (including preoperative C-reactive protein and albumin) to patients with soft-tissue sarcoma and demonstrated that it strongly correlated with overall survival⁴⁸.

Health System Effects

There has been a recent interest in the impact of health-care delivery on outcomes in patients with soft-tissue sarcoma^{50,51}. In 2021, Fujiwara et al.⁵⁰ published a retrospective review of regional variations in soft-tissue sarcoma care in the United Kingdom before and after the 2006 issuance of the National Institute for Health and Care Excellence (NICE) guidelines in the United Kingdom. They found that regional variation in survival was significantly reduced after the NICE guidelines and that the overall size of tumors and incidence of metastasis at presentation decreased significantly following the implementation of the national guidelines. Ogura et al. assessed the impact of access to care in patients with soft-tissue sarcoma utilizing the National Cancer Database in the United States⁵¹. Patients with a prolonged time to initiation of treatment following diagnosis had worse overall survival.

Soft-Tissue Tumor Subtypes

Given the variation in presentation, treatment, and outcomes of the different histologic sarcoma subtypes, specific subtypes merit consideration^{54,55,58,61}. Fice et al. evaluated patients treated for synovial sarcoma and proposed that tumors with minimal mitoses and necrosis could be considered low-grade as they showed improved overall survival and recurrence-free survival compared with higher-grade tumors⁵⁵. Maduekwe et al. evaluated sarcoma subtypes with a known propensity to metastasize to lymph nodes to evaluate the likelihood of nodal surgery and nodal positivity⁶¹. They demonstrated that clear cell sarcoma and angiosarcoma had the highest rates of nodal positivity and advocated for patients presenting with these subtypes to undergo pathologic nodal evaluation. Finally, Tseng et al. examined the impact of the presence of dedifferentiation within well-differentiated liposarcomas and demonstrated worse overall survival in patients with a dedifferentiated component⁵⁸.

Systemic and Radiation Therapy

The role of adjuvant therapies in soft-tissue sarcomas continues to be of interest^{56,60,64}. Although biologic therapies have shown tremendous potential in other malignancies, the favorable impact on soft-tissue sarcoma treatment has been limited. Jones et al. led an international, Phase-3, randomized

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controlled trial comparing the impact of pazopanib plus carotuximab with that of pazopanib alone in patients with advanced angiosarcoma⁶⁴. No significant difference in progression-free survival was found between the groups. The role of radiation therapy continues to evolve in the management of soft-tissue sarcoma. Konieczkowski et al. evaluated a perioperative protocol consisting of low-dose preoperative radiation and reduced-field postoperative radiation for soft-tissue sarcomas⁶⁰. They reported similar overall survival, disease-free survival, and local recurrence-free survival when compared with standard postoperative radiation. The utility of neoadjuvant radiation in patients with cutaneous and soft-tissue angiosarcoma was evaluated by Sharon et al.⁵⁶, who demonstrated that neoadjuvant radiation therapy was associated with negative margins and may be of benefit in this population.

Hand and Foot Sarcomas

Soft-tissue sarcomas arising from the hands and feet are a challenging entity given their anatomic considerations and continue to be an area of study^{59,62}. Mallett et al. reviewed 44 patients with foot and ankle soft-tissue sarcomas undergoing flap reconstructions⁵⁹. They found a 10-year limb-salvage rate of 84%, with no differences in complications or functional outcomes between pedicled and free flaps. Lans et al. presented a single-center review of patients presenting with soft-tissue sarcomas of the hand⁶². Epithelioid and synovial sarcomas were the most common histologic subtypes. Based on their findings, the authors concluded that hand sarcomas are aggressive, have a high metastatic potential, and warrant long-term surveillance.

Metastatic Bone Tumors

Table III shows some recent studies evaluating patients with metastatic bone disease⁶⁶⁻⁷⁶.

Long Bone Metastases

The treatment of impending or completed pathologic fractures of the long bones, particularly the femur, continues to be an area of ongoing interest^{69,71}. Groot et al. retrospectively compared patients undergoing operative management for either impending or completed pathologic long bone fractures⁶⁹. The matched-cohort regression model demonstrated that 1-year survival was significantly worse for patients undergoing a surgical procedure for completed pathologic fractures. The completed pathologic fracture group also had higher intraoperative blood loss, higher perioperative transfusion rates, longer anesthesia time, and higher reoperation rates when compared with the impending fracture group. Arpornsuksant et al. investigated the rate and predictors of local disease progression following intramedullary nailing in pathologic long bone fractures⁷¹. They demonstrated that there was a low overall risk of progression and that younger age and a primary diagnosis of renal cell carcinoma were predictive of local tumor progression.

Periacetabular Metastases

Surgical techniques for the management of periacetabular metastatic bone disease continue to evolve^{68,72}. English et al. reported on a cohort of patients with acetabular metastases treated with minimally invasive stabilization with percutaneous screw placement and cementoplasty and compared the outcomes between those who underwent adjunct ablation treatments and those who did not⁶⁸. They reported improved functional outcomes and minimal complications. In patients with disease progression requiring arthroplasty, conversion was uncomplicated. For larger osseous defects, Kennedy et al. reported on the survival of an antiprotrusio acetabular cage in patients with periacetabular bone metastases⁷². They demonstrated 100% acetabular component survival at the final follow-up and concluded that antiprotrusio cages are a viable option in patients with periacetabular metastatic bone disease.

Spinal Metastases

There has been an interest in quantifying the impact and value of surgical interventions for patients with spinal metastases^{66,70}. Schoenfeld et al. used a Markov state-transition model to evaluate the cost-effectiveness of operative management in patients with spinal metastases⁷⁰. The authors concluded that surgical intervention is cost-effective when patients present as nonambulatory due to acute neurologic compromise. Malik et al. evaluated the impact of dedicated cancer centers (DCCs) on postoperative complication rates and reimbursements in patients undergoing surgical treatment for spinal metastases⁶⁶. They found that patients undergoing a surgical procedure at a DCC had a lower risk of postoperative sepsis, urinary tract infections, renal complications, emergency department visits, and 90-day mortality when compared with patients undergoing a surgical procedure at other centers.

Predictive Models

Predictive models and clinical risk assessment tools continue to be an area of active research in metastatic bone disease^{67,73-76}. The Skeletal Oncology Research Group (SORG) machine-learning (ML) algorithms have been widely studied as tools to estimate survival in patients with extremity metastases. The SORG ML algorithms have now been validated in different external cohorts and have demonstrated good discriminatory validity in different patient populations^{67,75}. Raad et al. utilized the National Surgical Quality Improvement Program (NSQIP) database to create a clinical tool to predict 30-day mortality in patients undergoing surgical fixation of metastatic extremity fractures. Their model utilized preoperative patient demographic variables and laboratory findings and was able to better predict 30-day mortality compared with existing models⁷⁶.

COVID-19 Pandemic

The global academic literature has been flooded with new information on COVID-19 throughout the pandemic. Bunzli et al. published an international qualitative study conducted

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TABLE II Studies on Soft-Tissue Tumors

| Study | Article Title | Key Findings |
|----------------------------------|--|--|
| Hutchinson ⁴⁶ (2022) | Is Metformin Use Associated with Prolonged Overall Survival in Patients with Soft Tissue Sarcoma? A SEER-Medicare Study | The SEER-Medicare database was queried and the authors found that that, even after controlling for a number of confounding variables, there was an association between metformin use and increased survival in patients with soft-tissue sarcoma. However, the authors did not suggest definitive causation. |
| Hartley ⁴⁷ (2022) | Outcomes of Soft-Tissue Sarcoma in Nonagenarians | In a retrospective review of patients treated at a single center, 48 patients who were >90 years of age and were diagnosed with a soft-tissue sarcoma over 23 years had a median overall survival of 20 months. The authors recommended curative management for nonagenarian patients on a case-by-case basis. |
| Spence ⁴⁸ (2022) | Does the Modified Glasgow Prognostic Score Aid in the Management of Patients Undergoing Surgery for a Soft-Tissue Sarcoma? An International Multicentre Study | The authors of this retrospective review of 493 patients with soft-tissue sarcoma treated at 6 hospitals in 3 countries found that the modified Glasgow Prognostic Score (including preoperative C-reactive protein and albumin), among other factors such as tumor size and grade, was predictive of poorer survival. |
| Nakamura ⁴⁹ (2021) | A Comparison of Clinical Outcomes Between Additional Excision After Unplanned and Planned Excisions in Patients with Soft-Tissue Sarcoma of the Limb: A Propensity Matching Cohort Study | In this large database study, the authors used propensity score matching to compare outcomes between patients with a soft-tissue sarcoma of the extremity who had an unplanned excision followed by a re-excision and patients who only had a primary planned excision, and found that there was no difference in mortality or local failure. |
| Fujiwara ⁵⁰ (2021) | Regional Variation in the Survival of Patients with a Soft-Tissue Sarcoma of the Extremity and Trunk Wall Under a Centralized Care System: What Has Been the Impact of National Policies in the UK? | The authors reviewed the outcomes of 1,775 patients with sarcoma referred to a large national referral center before and after the issuance of the NICE guidelines in the United Kingdom in 2006. They found that regional variation in disease-specific survival significantly decreased after the NICE guidelines, particularly in patients with soft-tissue sarcoma, who presented with smaller tumors and earlier stages of disease. |
| Ogura ⁵¹ (2021) | Patients with an Increased Time to Treatment Initiation Have a Poorer Overall Survival After Definitive Surgery for Localized High-Grade Soft-Tissue Sarcoma in the Extremity or Trunk: Report from the National Cancer Database | The authors identified 23,786 patients from the National Cancer Database who had undergone definitive surgery between 2004 and 2015 for a localized, high-grade, soft-tissue sarcoma of the limbs or trunk, and used a regression model to identify time to treatment initiation as an independent risk factor for poorer overall survival. Times to treatment initiation of 0 to 30 days had the best outcomes. |
| Spierenburg ⁵² (2021) | Management of Tenosynovial Giant Cell Tumour of the Foot and Ankle | The author reviewed 84 patients with tenosynovial giant cell tumor of the foot or ankle treated at 2 centers. Recurrence rates were highest in the diffuse type (61%). Systemic treatment was used for recalcitrant cases, with good responses offset by toxicities and relapse after treatment cessation. |
| Spierenburg ⁵³ (2022) | Surgical Management of 144 Diffuse-Type TGCT Patients in a Single Institution: A 20-Year Cohort Study | A retrospective review of 144 patients with diffuse-type tenosynovial giant cell tumor treated surgically over 20 years at a single center found that incomplete excision and presence of a tumor on postoperative MRI correlated with radiographic progression and worse clinical outcomes. |
| Andreani ⁵⁴ (2022) | Synovial Sarcomas: A Single Surgeon Experience of 130 Cases | The authors reviewed 130 patients treated at their center over a 20-year period for synovial sarcoma. The metastasis rate was 28%, and the overall survival in the study period was 82%. Larger tumor size was associated with metastasis. |

continued

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TABLE II (continued)

| Study | Article Title | Key Findings |
|------------------------------------|---|--|
| Fice ⁵⁵ (2022) | Does Synovial Sarcoma Grade Predict Oncologic Outcomes, and Does a Low-Grade Variant Exist? | The authors reviewed 35 patients treated at their center over a 19-year period for synovial sarcoma. The metastasis rate was 22% and was significantly correlated with tumor grade. The authors recommended considering some low-risk cases as grade 1, as the metastasis rate was low, with an 80% 10-year survival. |
| Sharon ⁵⁶ (2022) | Neoadjuvant Radiation for Cutaneous and Soft Tissue Angiosarcoma | The authors queried the National Cancer Database (2004-2016) and identified 597 patients diagnosed with localized angiosarcoma treated with surgical resection. Only 27 (4.5%) received neoadjuvant radiation therapy. Risk factors for local recurrence were positive surgical margins and head and/or neck location. Neoadjuvant radiation therapy was associated with clear surgical margins, but not improved survival. |
| Lee ⁵⁷ (2021) | A Novel Preoperative Risk Score to Guide Patient Selection for Resection of Soft Tissue Sarcoma Lung Metastases: An Analysis from the United States Sarcoma Collaborative | The authors reviewed 352 patients treated from 2000 to 2016 across a collaborative group of sarcoma centers in the United States with surgery for lung metastases of soft-tissue sarcoma with curative intent. The median overall survival was 49 months for this cohort of patients specifically selected for curative intent. Risk factors for poorer survival were >1 metastasis, retroperitoneal location, R1 resection, and age of ≥55 years. |
| Tseng ⁵⁸ (2021) | Dedifferentiation Within Well-Differentiated Liposarcoma of the Extremity or Trunk: Implications for Clinical Management | The authors reviewed 210 patients with Mouse double minute 2 homolog (MDM2)-verified trunk or extremity liposarcoma who underwent surgical management from 2009 to 2019. Oncologic outcomes were significantly worse for those tumors with a dedifferentiated component. |
| Mallett ⁵⁹ (2021) | Comparison of Flap Reconstruction for Soft Tissue Sarcomas of the Foot and Ankle | The authors reviewed 44 patients treated for a soft-tissue sarcoma arising from the ankle or foot that required coverage in the form of a free, pedicled, or rotational perforator flap with a median follow-up of 10 years. Complications, mostly wound infections, occurred in 43% of patients, but there were no amputations due to flap failure. The authors concluded that flap reconstruction is a vital part of limb-salvage surgery for sarcoma. |
| Konieczkowski ⁶⁰ (2021) | Low-Dose Preoperative Radiation, Resection, and Reduced-Field Postoperative Radiation for Soft Tissue Sarcomas | In this single-center retrospective cohort study, 78 patients with soft-tissue sarcoma treated with low-dose preoperative radiation therapy, surgery, and postoperative radiation therapy were compared with propensity-score-matched patients who underwent surgery and postoperative radiation therapy alone. The overall survival, disease-free survival, and local recurrence-free survival were similar between groups. |
| Madueke ⁶¹ (2021) | Pathologic Nodal Staging for Clinically Node Negative Soft Tissue Sarcoma of the Extremities | The authors reviewed the data of 4,158 patients identified in the National Cancer Database treated surgically for extremity SCARE (synovial, clear cell, angio, rhabdo, and epithelioid) sarcoma without clinical nodal involvement. A total of 669 patients (16%) underwent regional lymph node surgery. Lymph nodes were positive in 7% of all patients, more commonly in cases of clear cell sarcoma and angiosarcoma. Patients with positive lymph nodes had poorer overall 5-year survival. |
| Lans ⁶² (2021) | Soft-Tissue Sarcoma of the Hand: Patient Characteristics, Treatment, and Oncologic Outcomes | The authors reviewed 69 patients with a soft-tissue sarcoma of the hand. The most common histological subtypes were epithelioid sarcoma (23%) and synovial sarcoma (15%). The metastasis rate for epithelioid sarcoma was 15%, and for synovial sarcoma, it was 40%. The authors concluded that, despite the generally smaller size of the tumors, the patients remained at high risk for systemic relapse. |

continued

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TABLE II (continued)

| Study | Article Title | Key Findings |
|-----------------------------|--|---|
| Wilke ⁶³ (2021) | Intraoperative Indocyanine Green Fluorescence Angiography Is Sensitive for Predicting Postoperative Wound Complications in Soft-Tissue Sarcoma Surgery | This was a prospective cohort study of 23 patients who underwent wide resection of a soft-tissue sarcoma. Indocyanine green (ICG) angiography was used after wound closure to evaluate tissue perfusion at the wound edges. Eight patients developed a wound complication. The overall sensitivity of ICG to predict wound complications was 50%, with greater sensitivity in the lower extremity. |
| Jones ⁶⁴ (2022) | Efficacy and Safety of TRC105 Plus Pazopanib vs Pazopanib Alone for Treatment of Patients with Advanced Angiosarcoma: A Randomized Clinical Trial | This study was a multinational, multicenter, open-label, parallel-group, Phase-3, randomized clinical trial of 123 adult patients with advanced angiosarcoma who were randomized 1:1 to receive pazopanib alone or carotuximab (an immunoglobulin G1 antibody targeting angiogenesis) plus pazopanib. Progression-free survival did not differ between groups (hazard ratio, 0.98 [95% CI, 0.52 to 1.84]; $p = 0.95$). The median progression-free survival was 4.3 months for the pazopanib group and 4.2 months for the combination arm. |
| Seldon ⁶⁵ (2021) | Variation in Management of Extremity Soft-Tissue Sarcoma in Younger vs Older Adults | A total of 8,953 adult patients treated for soft-tissue sarcoma of the extremity from 2004 to 2014 were identified in the National Cancer Database. Young adults (18 to 39 years of age) were more likely to receive chemotherapy, but less likely to receive radiation therapy, than older adults. The rates of limb salvage compared with amputation were similar between groups. |

between April and May 2020⁷⁷. The authors interviewed sarcoma surgeons from diverse global settings in which they explored surgical decision-making during the first few months of the COVID-19 pandemic. Participants represented public and private hospitals in 14 countries: Australia, Argentina, Canada, India, Italy, Japan, Nigeria, Singapore, Spain, South Africa, Switzerland, Turkey, the United Kingdom, and the United States. Of the 18 participants, 17 described a decision that they had made about patient care since the start of the pandemic that was “a first” for them. Themes that arose included uncertainty, limited resources, and duty of care. The authors described a framework for “least-worst” decision-making in a rapidly changing environment.

The PARITY Trial and Other Collaborative Studies

The Prophylactic Antibiotic Regimens in Tumor Surgery (PARITY) trial was published online on January 6, 2022⁷⁸. The PARITY trial was a parallel, blinded, randomized controlled trial conducted across 55 clinical centers in 12 countries between January 2013 and October 2019. Patients who required surgical management by excision of the femur or tibia and endoprosthetic reconstruction for oncologic indications were randomized to a 1 or 5-day regimen of postoperative prophylactic intravenous cephalosporin. The primary outcome was a surgical site infection. Secondary outcomes included antibiotic-related complications, unplanned reoperations, oncologic and functional outcomes, and mortality.

Of the 604 patients included in the final analysis, 293 were randomized to a 5-day regimen and 311 were randomized to a 1-day regimen. A surgical site infection occurred in 44 patients (15.0%) allocated to the 5-day regimen and in 52 patients (16.7%) allocated to the 1-day regimen (hazard ratio, 0.93 [95% confidence interval (CI), 0.62 to 1.40]; $p = 0.73$). Antibiotic-related complications occurred in 15 patients (5.1%) allocated to the 5-day regimen and in 5 patients (1.6%) allocated to the 1-day regimen (hazard ratio, 3.24 [95% CI, 1.17 to 8.98]; $p = 0.02$). Although the results of the PARITY trial did not confirm a benefit of postoperative prophylactic antibiotics longer than 24 hours, the significantly higher risk of antibiotic-related complications in the 5-day regimen was a critical finding.

The secondary analysis of the PARITY database will allow investigators to investigate unanswered questions in the musculoskeletal oncology literature utilizing a high-quality, prospectively collected database. Gazendam et al. developed minimally important differences for both the Musculoskeletal Tumor Society Rating Scale-93 (MSTS-93) and the Toronto Extremity Salvage Score (TESS)⁷⁹. These values help to interpret the magnitude of treatment effects and inform patients and clinicians if the differences following interventions are clinically meaningful to patients.

Currently, there are 2 large collaborative prospective research initiatives led by orthopaedic oncologists. The Musculoskeletal Tumor Registry (MsTR) was launched as a pilot in 2018 by the American Academy of Orthopaedic Surgeons

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TABLE III Studies on Metastatic Bone Disease

| Study | Article Title | Key Findings |
|------------------------------------|---|--|
| Malik ⁶⁶ (2021) | What Is the Value of Undergoing Surgery for Spinal Metastases at Dedicated Cancer Centers? | The authors compared 90-day complication rates and reimbursements between patients undergoing surgical management of spinal metastases at DCCs compared with non-DCCs. Patients at DCCs had lower odds of mortality, sepsis, urinary tract infection, and emergency department visits. Reimbursement was lower at DCCs compared with non-DCCs. |
| Tseng ⁶⁷ (2022) | International Validation of the SORG Machine-Learning Algorithm for Predicting the Survival of Patients with Extremity Metastases Undergoing Surgical Treatment | This study evaluated the generalizability of the SORG ML algorithms in Taiwanese patients. The algorithms were good discriminators in this patient population but underestimated actual survival time. |
| English ⁶⁸ (2021) | Minimally Invasive Stabilization with or without Ablation for Metastatic Periacetabular Tumors | This retrospective cohort study evaluated patients with periacetabular metastases who underwent minimally invasive osteoplasty with screw fixation with or without ablation. All patients had improved functional outcomes with minimal complications. |
| Groot ⁶⁹ (2022) | Clinical Outcome Differences in the Treatment of Impending Versus Completed Pathological Long-Bone Fractures | A matched cohort study compared outcomes of patients undergoing surgery for either completed or impending pathologic fracture of long bones. Patients undergoing a surgical procedure for an impending fracture had higher 1-year survival, lower blood loss and transfusions, and lower reoperation rates. |
| Schoenfeld ⁷⁰ (2021) | The Cost-Effectiveness of Surgical Intervention for Spinal Metastases: A Model-Based Evaluation | A cost-effectiveness evaluation was performed comparing operative and nonoperative management of spinal metastases. For patients who were nonambulatory because of acute neurologic compromise, surgical intervention was found to be cost-effective. However, for patients who were ambulatory at presentation, surgical intervention was not found to be cost-effective. |
| Arpornsuksant ⁷¹ (2022) | What Factors Are Associated with Local Metastatic Lesion Progression After Intramedullary Nail Stabilization? | The authors reviewed risk factors for local disease progression in patients undergoing intramedullary nail fixation for metastatic bone disease. Younger patients and those with renal cell carcinoma were more likely to experience local disease progression. Overall, local disease progression was rare. |
| Kennedy ⁷² (2022) | Survival of the GAP II Cage in the Management of Metastatic Disease of the Acetabulum | A retrospective review of 56 patients who underwent acetabular reconstruction secondary to metastatic bone disease with an antiprotrusio acetabular cage was performed. Component survival was 100% at the final follow-up, with 5.4% patients undergoing reoperation within the study period. |
| Baumber ⁷³ (2021) | Development of a Scoring System for Survival Following Surgery for Metastatic Bone Disease | A retrospective review of 164 patients was performed to evaluate predictors of survival in patients undergoing surgery for metastatic bone disease. Higher American Society of Anesthesiologists (ASA) classification, hyponatremia, preoperative tachycardia, and the type of primary malignancy were all predictors of worse survival. |
| Groot ⁷⁴ (2022) | Body Composition Predictors of Mortality in Patients Undergoing Surgery for Long Bone Metastases | The authors evaluated the body composition of patients undergoing surgery for long-bone metastases with abdominal CT scans. Sarcopenia was found to be predictive of 90-day and 1-year mortality in this patient population. |
| Skalitzky ⁷⁵ (2022) | The Preoperative Machine Learning Algorithm for Extremity Metastatic Disease Can Predict 90-Day and 1-Year Survival: An External Validation Study | Authors utilized the SORG ML algorithm in an external cohort of patients to assess external validation. The SORG ML algorithms accurately predicted 90-day and 1-year survival in this external cohort, demonstrating good external validity. |
| Raad ⁷⁶ (2021) | The Pathologic Fracture Mortality Index: A Novel Externally Validated Tool for Predicting 30-Day Postoperative Mortality | A database study was performed to develop a clinical tool to predict 30-day mortality in patients undergoing surgical fixation for metastatic bone disease. The model was able to better predict 30-day mortality compared with currently available tools. |

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(AAOS) with guidance from the Musculoskeletal Tumor Society (MSTS)⁸⁰. The MsTR was broadened in 2019 to a full registry, becoming the third subspecialty registry to be incorporated into the AAOS family of registries. This registry allows surgeons to combine data on rare bone and soft-tissue tumors from institutions around the country and, therefore, track function, complications, and outcomes in patients treated for sarcomas. Finally, the Surveillance After Extremity Tumor Surgery (SAFETY) pilot randomized controlled trial has enrolled >150 patients with soft-tissue sarcoma across 25 clinical sites in 10 countries⁸¹. Patients in the SAFETY trial are randomized to more or less intense post-treatment surveillance and are followed for oncologic and quality-of-life outcomes.

The SAFETY investigators are preparing to transition to the definitive phase of the study in 2023.

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