Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

AAOS Clinical Practice Guideline Summary

The Musculoskeletal Tumor Society Clinical Practice Guideline on the Management of Metastatic Humeral Disease

Nicholas S. Tedesco, DO, FAAOS

NathanW. Mesko, MD, FAAOS

Felasfa Wodajo, MD, FAAOS

Management of Metastatic Humeral Disease Work Group

Staff of the American Academy of Orthopaedic Surgeons and the Musculoskeletal Tumor Society

From the Department of Orthopaedic Surgery, Western University College of Osteopathic Medicine of the Pacific Northwest, Good Samaritan Regional Medical Center, Corvallis, OR (Tedesco), the Department of Orthopaedic Surgery, Case Western Reserve University Cleveland Clinic, Cleveland, OH (Mesko), and the University of Virginia School of Medicine - Inova Campus, Virginia Cancer Specialists, Fairfax, VA (Wodajo).

Correspondence to Dr. Tedesco: nicholas.tedesco@gmail.com

Dr. Tedesco or an immediate family member has stock or stock options held in Doctorpedia and RomTech; has received nonincome support (such as equipment or services), commercially derived honoraria, or other non–research-related funding (such as paid travel) from Medscape; serves as a board member, owner, officer, or committee member of Musculoskeletal Tumor Society; Editorial board: Journal of the American Osteopathic Academy of Orthopaedics. Dr. Mesko or an immediate family member serves as a paid consultant to Bone Support, ONKOS Surgical, and Stryker; is a member of a speakers' bureau or has made paid presentations on behalf of Stryker and ONKOS Surgical; serves as a board member, owner, officer, or committee member of Musculoskeletal Tumor Society. Dr. Wodajo or an immediate family member serves as a paid consultant to ONKOS Surgical.

J Am Acad Orthop Surg 2024;00:1-7

DOI: 10.5435/JAAOS-D-24-00053

Copyright 2024 by the American Academy of Orthopaedic Surgeons.

ABSTRACT

Management *of Metastatic Humeral Disease* is based on a systematic review of published studies surrounding the management of metastatic disease, multiple myeloma, and lymphoma limited to the humerus. This guideline contains seven action statements to assist orthopaedic surgeons, orthopaedic oncologists, physicians, and any other qualified healthcare professionals involved in the surgical management of metastatic disease of the humerus. It is also intended to serve as an information resource for decision makers, researchers, and developers of clinical practice guidelines. In addition to providing pragmatic practice recommendations, this guideline also highlights gaps in the literature and informs areas for future research and quality measure development. This guideline has been endorsed by the American Academy of Orthopaedic Surgeons.

Overview and Rationale

This Clinical Practice Guideline (CPG) for the management of metastatic humeral disease was developed by the Musculoskeletal Tumor Society (MSTS) with assistance of the Academy of Orthopaedic Surgeons (AAOS) Clinical Quality and Value Department's methodologists.[1] This CPG was approved by the MSTS Executive Committee in April 2023 and endorsed by the AAOS Board of Directors in September 2023.

The incidence and burden of metastatic bone disease (MBD) and subsequent skeletal-related events (SREs)—defined as a bone/spine subjected to a pathological fracture or spinal cord compression, severe bone pain from malignancy, hypercalcemia, the need for surgery on a bony site, or the need for radiation therapy on a bony site—continue to climb as the global population rises. In addition, SREs continue to climb as treatments for metastatic cancer continue to evolve and improve, extending prognosis.

Today, it is estimated that more than 50% of patients diagnosed with metastatic disease will live beyond 10 years from their index diagnosis, making reconstruction considerations critical in matching the longevity of the

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.

Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

patient.[2] The economics, alone, show that a staggering amount of money is spent treating SREs globally (and dealing with their subsequent downstream effects). In the United States, SREs account for nearly one-fifth of all cancer care-related expenditure,[3] with the estimated total cancer care expenditure by 2030 reaching $246 billion.[4] In addition, length of stay, consuming hospital resources, is notably prolonged in those patients undergoing surgical events directly related to their skeletal metastatic burden,[5] especially taking into consideration that one SRE is a harbinger for a higher likelihood of additional SREs in the future. In the United States, it is estimated that the healthcare burden of SREs is approaching 800,000 events annually,[1] highlighting the large burden of resources needed to meet this growing trend. Such costs to consider when treating this rising epidemic includes direct medical costs of both the current event and the long-term medical and end of life cost, quality-of-life measures, and the indirect costs affecting patient and family time away from the home and away from work that affect their ability to be contributing members to society.

Concerning pathologic fractures, the most common sites of metastatic skeletal disease occur in the spine, pelvis, and ribs, with the humerus being the second most affected long bone (behind the femur). Around 20% of all MBD occurs in the upper extremity,[6] with around 16 to 39% of all impending or completed pathologic fractures in long bones occurring in the humerus.[7] This leads to a detrimental effect on the ability to perform activities of daily living and necessary feeding or personal hygiene activity.

Etiology, Risk Factors, and Treatment Considerations

Metastatic disease is primarily of carcinoma origin and is the direct result of a malignancy arising from a primary organ site (breast, colon, prostate, lung, skin, etc.) which then spreads to a distant site (eg, skeleton). Metastatic skeletal sites oftentimes present incidentally during routine cancer staging/surveillance but also commonly can be brought to light with worsening pain or symptoms. Multiple myeloma is a primary malignancy of the bone marrow and affects the entire skeletal system, making diffuse lytic lesions in the appendicular and axial skeleton. Lymphoma, while less often primarily arising in the bone, more commonly originates in the lymphatic system (spleen, lymph nodes, etc.) and concurrently involves the bone as a secondary site. Skeletal sites can be present at the index diagnosis or appear later in the disease course, with various histologies having a higher (breast, lymphoma) or lower (bladder, colon) affinity for bone. Nearly two-thirds of skeletal sites of disease can ultimately have pain symptoms attributed, with 10 to 20% of these sites ultimately going on to pathologic fracture.[2]

When thinking about pathologic fractures of the humerus in metastatic disease, lymphoma, or myeloma, known risk factors for developing fractures exist. These are advanced stages of disease, poor disease control with systemic therapy (hormonal, immunotherapy, targeted therapy chemotherapy) agents, tumor size, faster tumor growth rate, lytic morphology, specific tumor location in a higher stress anatomic location (ie, tensile portion of the involved bone), continued pain after localized radiation therapy, the lack of incorporating bone-modifying drugs into treatment plans (eg, RANK-L inhibitors, bisphosphonates), female sex, advanced age, underlying osteoporosis, patient noncompliance with medications or weight-bearing restrictions, impaired balance, localized trauma, and inadequate home safety or supervision.[1]

Treatment for lesions is dependent on many factors, including tumor sensitivity to systemic or radiation measures, hand dominance, biologic potential for healing with nonsurgical treatment (breast, myeloma, lymphoma), size, location, joint involvement or preexisting arthritis, patient prognosis, patient comorbidities, functional capacity loss directly attributed to the skeletal lesion, patient compliance, and the local and family support system in place to aid with follow-up appointments, activities of daily living, and rehabilitation compliance. Each treatment consideration has associated known risks. The ultimate overarching goal is to balance the restoration of function and improvement in pain offered by a particular intervention with the requirements for recovery and the patient's overall prognosis and performance status. Importantly, open, informed discussions on the available treatment options need to drive the treatment decision, tailoring the prioritization of treatment options based on the individual

This clinical practice guideline was approved by the Musculoskeletal Tumor Society Executive Committee on April 12, 2023, and endorsed by the American Academy of Orthopaedic Surgeons on September 17, 2023.

The complete document, *Management of Metastatic Humeral Disease*, includes all tables, and figures, and is available at: https://www.orthoguidelines.org/topic?id=1045&tab=all_guidelines

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.

characteristics of the situation as well as the values and preferences of the patient.

State of the Literature and Consensus

Despite numerous studies in the literature attempting to look at various methods for treating pathologic humerus fractures in the setting of metastatic disease, lymphoma, or myeloma (nonsurgically, surgical stabilization techniques, oncologic excision and reconstruction with allograft or endoprosthesis, minimally invasive techniques, etc), there remains a lack of consensus in the orthopaedic and cancer community regarding the treatment of fractures and around the understanding of which patients may most benefit from different treatment modalities. Described surgical techniques include intralesional curettage with fixation using a plate or nail construct with or without use of bone cement augmentation, placement of a plate or nail without curettage, en bloc excision with arthroplasty versus endoprosthetic reconstruction, or minimally invasive techniques (cryoablation, cementoplasty, radiofrequency ablation, or photodynamic balloon placement).[6-10]

The MSTS developed their current CPG to aid physicians and other practitioners who incorporate the management of patients with metastatic disease, multiple myeloma, and lymphoma of the humerus into their practice. Furthermore, the findings from this CPG represent a resource highlighting areas that need additional investigation to provide improved evidence-based guidelines for the management of bony metastatic humeral burden.

This CPG on the treatment of metastatic humeral disease involved reviewing 3,914 abstracts and more than 307 full-text articles to develop seven action statements supported by 17 research articles meeting stringent inclusion criteria.[1] Each action statement is based on a systematic review of the research related to the surgical treatment of MBD of the humerus. The review resulted in four statements classified as limited action statements. The strength of recommendation considers the research quality, quantity of patients treated in the included research studies, and trade-offs between the benefits and harms of a treatment, the magnitude of a treatment's effect, and whether there are data on critical outcomes. Strength of recommendation is assigned based on the quality of the supporting evidence (Tables 1 and 2). These action statements also included three consensus statements: the first for comparing survivorship and other oncologic outcomes between en bloc resection, curettage, internal fixation, or intramedullary nailing. The second consensus option recommends that both nonsurgical and surgical treatment can be considered in patients with metastatic humeral disease. Also included was a consensus action statement referring clinicians to the American Society of Clinical Oncology (ASCO), American Society of Hematology (ASH), and International Consensus Meeting on Venous Thromboembolism (ICM-VTE) guidelines when considering pharmacologic prophylaxis in patients with cancer undergoing a major surgery.

Guideline Summary

The developed recommendations within this CPG are meant to aid any orthopaedic practitioners that encounter and treat MBD or multiple myeloma of the humerus presenting with an impending or realized pathologic fracture. This guideline is intended to assist healthcare professionals with shared clinical decision making with their patients and also in describing to patients why a selected intervention may represent the best available course of treatment when considering the management of impending or realized pathologic fractures isolated to the humerus.

The scope of this guideline does not include treatment of asymptomatic humeral disease or management of those patients who present with multiple simultaneous impending or realized pathologic fractures, where multiple other considerations affect treatment decisions. It is also not meant to supersede the clinical judgment of the treating surgeon, given the complexity of these patients in age, medical comorbidities, tumor prognosis, stage or line of treatments tried, patient values and preferences, and other factors that may influence the optimal or chosen treatment for each individualized patient. Finally, it does not incorporate medical treatment, bone-modifying agents, or radiation considerations that are often used in the multidisciplinary management of these patients.

Based on the reviewed evidence, the current CPG is able to provide limited recommendations on several PICO (patient, intervention, comparison, outcome) questions. First, a limited recommendation is made in favor of surgeon's choice for implant when fixation is required for impending or realized pathologic fractures of the humeral diaphysis. Roughly equivocal outcomes, complication rates, and revision surgery rates are noted in the literature regarding internal fixation with plating, intramedullary nailing, and photodynamic polymer.[7,11,12]

In addition, a limited recommendation is made in favor of use of cement augmentation during fixation

Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.

Table 1. Level of Evidence Descriptions

Combined Strength of Recommendation	Aggregate Strength of Evidence	Description of Evidence Quality
Strong	Strong or Moderate	Evidence from two or more "High"-quality studies with consistent findings for recommending for or against the intervention. Or Rec is upgrade from Moderate using the Evidence-to-Decision framework
Moderate	Strong, Moderate, or Limited	Evidence from two or more "Moderate"-quality studies with consistent findings, or evidence from a single "High"-quality study for recommending for or against the intervention. Or Recommendation is upgraded or downgraded from Limited or Strong using the Evidence-to-Decision framework
Limited	Limited or Moderate	Evidence from one or more "Low"-quality studies with consistent findings or evidence from a single "Moderate"-quality study recommending for or against the intervention. Or Recommendation is downgraded from Strong or Moderate using the Evidence-to-Decision Framework
No Recommendation	No reliable evidence	There is no supporting evidence, or higher quality evidence was downgraded due to major concerns addressed in the Evidence-to-Decision framework. In the absence of reliable evidence, the guideline work group is not making a recommendation

Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

when feasible. Two low-quality studies suggest that adding cement to the fixation construct can provide improvements in postoperative pain and mobility with no difference in complications when compared with no cement usage.[13,14]

Another limited recommendation is made in favor of reverse total shoulder arthroplasty over both conventional total shoulder replacement and hemiarthroplasty in cases where joint replacement is used in the setting of MBD to the proximal humerus. Reverse total shoulder arthroplasty has been shown in some comparative studies to improve range of motion and decrease instability compared with the other constructs.[15,16]

Table 2. Evidence to Decision Framework Score Thresholds

Upgrade/Downgrade Thresholds	EtDF Score
Increase recommendation strength +2	38-42
Increase recommendation strength +1	31-37
No change in recommendation strength	18-30
Decrease recommendation strength −1	13-17
Decrease recommendation strength −2	3-12

Finally, with low-quality levels of evidence, several studies support that a limited recommendation is made to consider age older than 60 years, Medicaid insurance, Black race, lower income, lower performance status, male sex, and rapidly growing tumor pathologies as being potentially negative prognostic factors for patients being surgically managed for MBD in the humerus.[17-27]

However, owing to the absence of literature meeting a priori inclusion criteria, no formal recommendation could be made for or against multiple PICO questions. Although no study specifically looked only at metastatic humeral disease, based on ASCO, ASH, and ICM-VTE guidelines in existence, oncology patients are at a higher risk for VTE, and therefore, adequate VTE prophylaxis should be considered during the perioperative period for

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.

Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

these patients. Unfortunately, there were no comparative studies and no data available for review to determine which patients would optimally benefit from nonsurgical versus surgical management. In addition, if surgical management is chosen, no studies compared en bloc resection, curettage, internal fixation, and intramedullary nailing. As a result, determining the optimal management approach for impending or realized pathologic fractures of the humerus will remain with the clinical judgment of the treating physician until comparative studies are available regarding oncological, functional, and patient-reported outcomes on these different management strategies.

Recommendations

This summary of recommendations by the MSTS on the *Management of Metastatic Humeral Disease* contains, above, a list of evidence-based surgical treatment recommendations. It was developed using the MSTS CPG Methodology published on the MSTS website. Both the full-evidence report and the discussions about how each recommendation was developed are available in the full guideline. Readers are encouraged to consult the full guideline for the comprehensive evaluation of the available scientific studies. The recommendations were established using methods of evidence-based medicine that rigorously control for bias, enhance transparency, and promote reproducibility. AAOS medical librarians conducted an exhaustive literature search, resulting initially in 307 published studies for full review. The papers were then graded for quality by AAOS CPG methodologists, according to the CPG work group's population, intervention, comparison, and outcome (PICO) questions. For CPG PICO questions that returned no evidence from the systematic literature review that met strict quality inclusion criteria, the work group offered no recommendation.

A strong action statement means that the quality of the supporting evidence is high. A moderate action statement means that the expected treatment benefits exceed the potential harm (or that the potential harm of a treatment clearly exceeds the benefits in the case of a negative recommendation), but the quality/applicability of the supporting evidence is not as strong. A limited-strength action statement means that there is a lack of compelling evidence that has resulted in an unclear balance between benefits and potential harm.

This summary of action statements is not intended to stand alone. Medical care should be based on evidence, a physician's expert judgement, and the patient's circumstances, values, preferences, and rights. A patient-centered discussion leading to an understanding of an individual patient's values and preferences can inform appropriate decision making. This guideline addresses prognostic implications, perioperative management, and surgical versus nonsurgical decision making that can help guide decision making for general/nononcology orthopaedic trained surgeons. A variety of mitigating circumstances, particularly related to patient age, tumor histology, functional level, and prognosis, may also be factors in the shared decision-making process.

Action Statements

Plating/Internal Fixation, Intramedullary Fixation, and/or Photodynamic Polymer

When treating pathologic diaphyseal humerus fractures, clinicians can consider the use of plating/internal fixation, intramedullary fixation, and/or photodynamic polymer because there does not seem to be a notable difference in clinical outcomes or revision surgery rate between these constructs based on limited available evidence.

Strength of Recommendation

- Aggregate Evidence = Limited (3 Low-quality Studies)
- EtD Framework Score = 21
- Combined Strength of Recommendation = Limited

En Bloc Resection, Curettage, Internal Fixation, or Intramedullary Nailing

No studies met inclusion criteria comparing survivorship or other oncologic outcomes between en bloc resection, curettage, internal fixation, or intramedullary nailing. Based on the lack of evidence, no recommendations can be made for or against en bloc resection pertaining to metastatic disease of the humerus.

Strength of Recommendation

- Aggregate Evidence = N/A (No Included Literature)
- EtD Framework Score = 15 (strength cannot be designated lower than N/A)
- Combined Strength of Recommendation = N/A

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.

Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

Patient Selection for Nonsurgical Techniques Versus Surgical Techniques

No studies met inclusion criteria to compare nonsurgical versus surgical treatment in the setting of metastatic disease of the humerus. Based on the lack of definitive evidence, no recommendations can be made for or against patient selection or indication for nonsurgical versus surgical treatment pertaining to metastatic disease of the humerus.

Strength of Recommendation

- Aggregate Evidence = N/A (No Included Literature)
- EtD Framework Score = 26
- Combined Strength of Recommendation = N/A

Cementation Versus No Cementation

In patients undergoing surgical fixation of the humerus for MBD, clinicians may consider cement augmentation. One low-quality study meeting an inclusion criterion suggested the addition of cement to surgical fixation of pathologic fractures of the humerus may provide short-term improvements in pain relief and functional mobility; however, no difference in surgical complications was observed when compared with fixation alone.

Strength of Recommendation

- Aggregate Evidence = Limited (2 Low-quality Study)
- EtD Framework Score (from below) = 23
- Combined Strength of Recommendation = Limited

Reconstruction Approach

In patients undergoing arthroplasty to reconstruct the proximal humerus for MBD, clinicians may consider reverse total shoulder arthroplasty over conventional shoulder arthroplasty and hemiarthroplasty to decrease shoulder instability and improve range-of-motion.

Strength of Recommendation

- Aggregate Evidence = Limited (2 Low-quality Studies)
- EtD Framework Score = 25
- Combined Strength of Recommendation = Limited

Prognostic Markers

Based on low levels of evidence, clinicians should consider the following potential negative socioeconomic prognostic markers when caring for patients with metastatic malignancy of the humerus.

- Age > 60 years
- Have Medicaid insurance compared with commercial insurance
- Black race compared with White race
- Lower income status
- Lower initial performance status
- Male sex
- Rapidly growing tumor histologies versus slow growing

Strength of Recommendation

- Aggregate Evidence = Limited (11 Low-quality Studies)
- EtD Framework Score = 21
- Combined Strength of Recommendation = Limited

VTE Prophylaxis

No studies met inclusion criteria to make a specific recommendation on VTE prophylaxis for MBD of the humerus. In the absence of direct evidence, we refer clinicians to the ASCO, ASH, and ICM-VTE guidelines which indicate that oncology patients are at a higher risk for VTE, and prophylaxis should be considered during the perioperative period.

Strength of Recommendation

- Aggregate Evidence = N/A (No Included Literature)
- EtD Framework Score = 19
- Combined Strength of Recommendation = N/A

References

1. Musculoskeletal Tumor Society: *Management of metastatic humeral disease: clinical practice guideline*, 2023. msts.org/view/download.php/education/cpg-metastatic-humerus

2. Ardakani AHG, Faimali M, Nystrom L, et al.: Metastatic bone disease: Early referral for multidisciplinary care. *Cleveland Clinic J Med* 2022;89:393-399.

3. Schulman KL, Kohles J: Economic burden of metastatic bone disease in the U.S. *US Cancer* 2007;109:2334-2342.

4. Mariotto AB, Enewold L, Zhao J, Zeruto CA, Yabroff KR: Medical care costs associated with cancer survivorship in the United States. *Cancer Epidemiol Biomarkers Prev* 2020;29:1304-1312.

5. Hughes N, Birlingmair J, Baker J, Tideman G, Sweeney K: Evaluating factors affecting length of hospital stay in patients with metastatic bone tumors. *J Orthop* 2022;29:28-30.

6. Rovere G, Meschini C, Piazza P, et al.: Proximal humerus fractures treatment in adult patients with bone metastasis. *Eur Rev Med Pharmacol Sci* 2022;26:100-105.

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.

Downloaded from https://journals.lww.com/jaaos by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/06/2024

7. Hoellwarth JS, Weiss K, Goodman M, Heyl A, Hankins ML, McGough R: Evaluating the reoperation rate and hardware durability of three stabilizing implants for 105 malignant pathologic humerus fractures. *Injury* 2020;51: 947-954.

8. Hennessy DW, Raskin KA, Schwab JH, Lozano-Calderón SA: Endoprosthetic reconstruction of the upper extremity in oncologic surgery. *J Am Acad Orthop Surg* 2020;28:e319-e327.

9. Nota S, Teunis T, Kortlever J, et al: Functional outcomes and complications after oncologic reconstruction of the proximal humerus. *J Am Acad Orthop Surg* 2018;26:403-409.

10. Voskuil RT, Mayerson JL, Scharschmidt TJ: Management of metastatic disease of the upper extremity. *J Am Acad Orthop Surg* 2021;29: e116-e125.

11. Dijkstra S, Stapert J, Boxma H, Wiggers T: Treatment of pathological fractures of the humeral shaft due to bone metastases: A comparison of intramedullary locking nail and plate osteosynthesis with adjunctive bone cement. *Eur J Surg Oncol* 1996;22:621-626.

12. Sarahrudi K, Wolf H, Funovics P, Pajenda G, Hausmann JT, Vecsei V: Surgical treatment of pathological fractures of the shaft of the humerus. *J Trauma* 2009;66:789-794.

13. Laitinen M, Nieminen J, Pakarinen TK: Treatment of pathological humerus shaft fractures with intramedullary nails with or without cement fixation. *Arch Orthop Trauma Surg* 2011;131:503-508.

14. Sarahrudi K, Wolf H, Funovics P, Pajenda G, Hausmann JT, Vecsei V: Surgical treatment of pathological fractures of the shaft of the humerus. *J Trauma* 2009;66:789-794.

15. Houdek MT, Bukowski BR, Athey AG, et al: Comparison of reconstructive techniques following oncologic intraarticular resection of proximal humerus. *J Surg Oncol* 2021;123:133-140.

16. Grosel TW, Plummer DR, Everhart JS, et al: Reverse total shoulder arthroplasty provides stability and better function than hemiarthroplasty following resection of proximal humerus tumors. *J Shoulder Elbow Surg* 2019;28:2147-2152.

17. Herget G, Saravi B, Schwarzkopf E, et al: Clinicopathologic characteristics, metastasis-free survival, and skeletal-related events in 628 patients with skeletal metastases in a tertiary orthopedic and trauma center. *World J Surg Oncol* 2021;19:62.

18. Huang Z, Du Y, Zhang X, Liu H, Liu S, Xu T: Clear cell renal cell carcinoma bone metastasis: What should be considered in prognostic evaluation. *Eur J Surg Oncol*2019;45:1246-1252.

19. Hung B, Pennington Z, Hersh AM, et al: Impact of race on nonroutine discharge, length of stay, and postoperative complications after surgery for spinal metastases. *J Neurosurg Spine* 2021;0:1-8.

20. Rades D, Haus R, Janssen S, Schild SE: An easy-to-use scoring system to estimate the survival of patients irradiated for bone metastases from lung cancer. *Translational Lung Cancer Res* 2020;9: 1067-1073.

21. Rades D, Haus R, Janssen S, Schild SE: Interval between cancer diagnosis and radiotherapy - an Independent prognostic factor of survival in patients irradiated for bone metastases from kidney cancer. *In vivo* 2020; 34:767-770.

22. Rades D, Haus R, Schild SE, Janssen S: Prognostic factors and a new scoring system for survival of patients irradiated for bone metastases. *BMC Cancer* 2019;19:1156.

23. Scott E, Klement MR, Brigman BE, Eward WC: Beyond mirels: Factors influencing surgical outcome of metastasis to the extremities in the modern era. *J Surg Orthop Adv* 2018;27:178-186.

24. Vos M, Ho VKY, Oosten AW, Verhoef C, Sleijfer S: Minimal increase in survival throughout the years in patients with soft tissue sarcoma with synchronous metastases: Results of a population-based study. *Oncologist* 2019;24:e526-e535.

25. Wisanuyotin T, Sirichativapee W, Sumnanoont C, et al: Prognostic and risk factors in patients with metastatic bone disease of an upper extremity. *J Bone Oncol* 2018;13:71-75.

26. Wong E, Chow E, Zhang L, et al: Factors influencing health related quality of life in cancer patients with bone metastases. *J Palliat Med* 2013; 16:915-921.

27. Yanamandra U, Sharma R, Shankar S, et al: Survival outcomes of newly diagnosed multiple myeloma at a tertiary care center in north India (IMAGe: 001A study). *JCO Glob Oncol* 2021;7:704-715.

Copyright © the American Academy of Orthopaedic Surgeons. Unauthorized reproduction of this article is prohibited.