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CASE REPORT

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Beyond the Field of View: Enhancing Detection of Orthopaedic Metastases in Cancer Staging

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ABSTRACT

The rising prevalence of metastatic bone disease (MBD), driven by improved oncological survival, places increasing demands on accurate staging. Standard computed tomography of the chest, abdomen, and pelvis (CT-CAP) often may fail to identify orthopaedically relevant lesions, which may contribute to pathological fractures and poorer outcomes.

A retrospective single-centre review was conducted of 135 patients who underwent surgery for non-spinal MBD between 2005 and 2024. Preoperative staging imaging was re-evaluated to assess lesion visibility, anatomical distribution, and detection rates across modalities. Lesions were analysed with respect to fracture occurrence, Mirels scores, and postoperative survival. Interobserver agreement for Mirels scoring was calculated. Survival was analysed using Kaplan–Meier methods and a multivariate Cox proportional hazards model.

Lesions not identified on staging imaging were associated with significantly higher rates of pathological fracture ($p = 0.01$) and shorter postoperative survival (median 6 vs. 25 months, $p = 0.03$). CT-CAP detected fewer orthopaedically relevant lesions than alternative imaging modalities in this retrospective real-world cohort ($p < 0.01$). Seven clinically relevant lesions were visible only on CT scout images but lay outside the diagnostic field of view; four subsequently fractured. Detection varied by anatomical region, with proximal femoral lesions identified most frequently.

In this retrospective cohort, reliance on CT-CAP alone was associated with missed clinically significant MBD lesions, particularly outside the standard field of view. Routine review of full-body scout images may improve detection and potentially reduce preventable fractures. Integration of automated analysis techniques could further strengthen diagnostic accuracy.

Keywords: Cancer, metastases, metastatic bone disease, pathological fracture, staging, ct scout.

INTRODUCTION

The prevalence of metastatic bone disease (MBD) is increasing due to improved cancer survival rates[1-4]. Up to 70% of individuals with advanced malignancies will develop bone metastases, contributing to significant morbidity in the form of pain, mechanical instability, and pathological fracture[5-7]. By 2040, an estimated 2.5 million people in the United Kingdom will be living with cancer, 40–70% of whom are expected to develop skeletal metastases[3]. In the United States, the economic burden of MBD was already estimated at USD 13 billion in 2005, representing 17% of total cancer-related expenditure[8,9].

Staging is fundamental not only for assessing eligibility for curative interventions but also in the palliative context, where early identification of skeletal disease is essential to prevent pathological fractures, which carry notable prognostic and financial implications[10]. Over-diagnosis should be avoided, yet under-diagnosis of bone lesions remains a substantial clinical concern.

Advanced imaging modalities—such as whole-body MRI, PET/MRI, and PET/CT—demonstrate superior sensitivity[11]. Nevertheless, routine practice continues to follow guideline-directed protocols: ESMO recommendations endorse CT of the chest and abdomen plus a bone scan for metastatic breast cancer, whereas staging for renal cell carcinoma typically involves CT-CAP[12,13].

The American College of Radiology likewise considers whole-body skeletal imaging only "may be appropriate" for newly diagnosed renal cell carcinoma[14].

Bone scintigraphy, despite its widespread use, is limited by its reliance on osteoblastic activity and reduced sensitivity for purely osteolytic or small intramedullary lesions[15-17]. As a result, it cannot reliably detect all clinically relevant metastatic deposits and does not provide information on visceral disease.

Fracture risk assessment commonly employs Mirels' score, which depends on radiographic features and therefore restricts the utility of highly sensitive cross-sectional modalities that may lack detailed characterisation of cortical breach or lesion morphology[18].

We hypothesised that:

- CT-CAP detects fewer orthopaedically relevant lesions than alternative modalities in routine staging;
- undetected lesions are associated with a higher incidence of pathological fracture and reduced survival; and
- CT scout images contain clinically relevant information that is currently underutilised.

The primary aim of this study was to evaluate the relationship between lesion visibility and the staging modality used in surgically treated MBD. Secondary aims included assessment of modality-specific lesion detection patterns and their potential impact on subsequent management.

MATERIAL AND METHODS

Study Population

A retrospective analysis was performed of all patients undergoing surgery for non-spinal MBD in the context of a previously diagnosed malignancy between January 2005 and December 2024 at our university hospital. Haematological malignancies (lymphoma, multiple myeloma) were included owing to comparable imaging behaviour and orthopaedic management.

Of 155 eligible patients, 20 were excluded due to incomplete records or high-energy trauma unrelated to MBD. The final cohort consisted of 135 patients. Ethical approval was granted (2023/3080-Daten).

Parts of the study population have been included in previous publications from our group addressing anatomical fracture risk patterns and the impact of metastatic burden on survival. The present analysis addresses a distinct research question, focusing on staging imaging, diagnostic field-of-view limitations, and the clinical relevance of CT scout images.

Data Collection

Clinical data, tumour characteristics, operative details, and imaging were extracted from electronic records. For patients with multiple lesions, only the first surgically treated lesion was analysed. Mirels scores were independently assigned by two fellowship-trained orthopaedic oncology consultants; disagreements were resolved through consensus with a third assessor.

Anatomical distribution followed the AO long-bone classification, grouping proximal end and proximal diaphysis as "proximal". All staging imaging—including CT-CAP, CT skeleton, bone scintigraphy, PET/CT, and all CT scout images—was reviewed by two observers blinded to outcomes.

Lesions were classified according to their visibility on staging imaging into three primary categories:

(1) lesion not on staging, defined as lesions not visible on any staging imaging, including neither CT scout images nor diagnostic CT images;
(2) lesion only on scout, defined as lesions visible on CT scout images but located outside the diagnostic CT field of view;
(3) lesion on staging, defined as lesions visible within the diagnostic CT field of view on staging imaging.

Within the category "lesion on staging", a small subgroup of interpretation/reporting misses was identified, defined as lesions visible within the diagnostic field of view but not described in the original radiology report and only recognised during the blinded study re-review. These were analysed separately.

Survival was calculated from surgery to death or last oncological follow-up.

Statistical Analysis

Interobserver reliability for Mirels scoring was evaluated using Cohen's kappa coefficient ($\kappa = 0.504$; moderate agreement). Non-parametric tests were used owing to the distribution of variables (Shapiro–Wilk). Categorical data were compared using $\chi 2$ tests with Cramér's V as effect size. Continuous variables were compared using the Kruskal–Wallis test with Cohen's f reported. Survival was analysed using Kaplan–Meier curves and log-rank testing. Multivariate Cox regression examined whether lesion visibility remained prognostic after adjusting for tumour type. The proportional hazards assumption was assessed graphically and was not violated. A p-value < 0.05 was considered significant.

A completed STROBE checklist for cohort studies is provided as supplementary material to enhance reporting transparency.

RESULTS

Baseline characteristics

The cohort comprised 72 females and 63 males, median age 64 years (IQR 58–72). There was no sex-related age difference (p = 0.29). Baseline characteristics are summarised in Table I.

Correlation Between Lesion Detection on Staging Imaging and Clinical Factors

Seven lesions were classified as field-of-view–related misses, being visible only on CT scout images; four fractured subsequently. Two additional lesions represented interpretation/reporting misses, as they were located within the diagnostic CT field of view but not described in the original reports.

CT-CAP detected significantly fewer lesions than other modalities (p < 0.01; Cramér's V = 0.32). Proximal femoral lesions were detected more frequently than proximal humeral or diaphyseal

Table I. — Baseline characteristics of depiction of bone lesion requiring orthopaedic operation on previous staging imaging; metric data: median with Inter-Quartile-Range, Kruskal-Wallis-Test, Cohen's f for effect size; nominal data: number of cases and percentage of column, χ2-Test, Cramer's V for effect size.

	Overall	Lesion not on staging	Lesion only on scout	Lesion on staging	p-values	Effect size
Gender, male Gender, female	63 (47%) 72 (53%)	24 (51%) 23 (49%)	3 (43%) 4 (57%)	36 (44%) 45 (56%)	0.75	0.07
Age in years	64 (58-72)	66 (61-72)	78 (73-84)	63 (57-71)	<0.01	0.34
CT chest/abdomen/pelvis	83 (61%)	40 (85%)	7 (100%)	36 (44%)		
CT, whole body skeleton	17 (13%)	2 (4%)	0 (0%)	15 (19%)	<0.01	0.32
Bone scan	12 (9%)	0 (0%)	0 (0%)	12 (15%)		
PET-CT	23 (17%)	5 (11%)	0 (0%)	18 (22%)		
Proximal Femur	52 (39%)	5 (11%)	6 (86%)	41 (51%)		
Proximal Humerus	14 (10%)	9 (19%)	1 (14%)	4 (5%)	<0.01	0.33
Other localization	69 (51%)	33 (70%)	0 (0%)	36 (44%)		
Proximal shaft segment	23 (21%)	11 (26%)	7 (100%)	5 (8%0	<0.01	0.55
Any other bone segment	88 (79%)	31 (74%)	0 (0%)	57 (92%)		
Pathological fracture	83 (61%)	37 (79%)	4 (57%)	42 (52%)	0.01	0.26
No pathological fracture	52 (39%)	10 (21%)	3 (43%)	39 (48%)		
Mirels' scores	9 (8-10)	9 (8-9)	10 (8-10)	9 (8-10)	0.05	0.20
Operation after staging in months	1 (1-3)	1 (1-4)	3 (2-6)	1 (1-3)	0.25	0.08
Renal cell carcinoma	33 (25%)	12 (26%)	4 (57%)	17 (21%)		
Multiple myeloma	24 (18%)	8 (17%)	0 (0%)	16 (20%)		
Breast cancer	29 (21%)	8 (17%)	1 (14%)	20 (25%)	0.55	0.16
Lung cancer	12 (9%)	5 (10%)	0 (0%)	7 (8%)		
Other cancers	37 (27%)	14 (30%)	2 (29%)	21 (26%)		
Visceral metastases	59 (55%)	21 (57%)	5 (71%)	33 (52%)	0.58	0.10
No visceral metastases	49 (45%)	16 (43%)	2 (29%)	31 (48%)		
Single bone metastasis	19 (18%)	5 (14%)	1 (14%)	13 (20%)		
1-5 bone metastases	11 (10%)	2 (5%)	1 (14%)	8 (13%)	0.63	0.11
>5 bone metastases	78 (72%)	30 (81%)	5 (72%)	43 (67%)		
Wide resection	28 (21%)	9 (19%)	1 (14%)	18 (22%)	0.84	0.05
Intralesional operation	107 (79%)	38 (81%)	6 (86%)	63 (78%)		

lesions ($p < 0.01$; Cramér's $V = 0.33$). Lesions in the proximal shaft were markedly under-represented within routine CT-CAP fields, with seven scout-only lesions located in this region ($p < 0.01$; Cramér's $V = 0.55$).

Missed lesions were significantly associated with pathological fracture ($p = 0.01$; Cramér's $V = 0.26$; see Figure 1). Mirels scores differed significantly between detected and undetected lesions ($p = 0.05$; $f = 0.20$). No associations were found with tumour type, visceral metastases, staging–surgery interval, or surgical intent.

Staging Imaging and Postoperative Survival

Median survival was 25 months (95% CI 0–51) for detected lesions and 6 months (95% CI 3–9) for undetected lesions ($p = 0.03$; see Figure 2). Lesion visibility remained an independent prognostic factor after adjusting for tumour type in multivariate Cox regression (see Table II).

DISCUSSION

This study demonstrates that, in this retrospective real-world cohort, CT-CAP detected fewer orthopaedically relevant bone metastases than other staging modalities, consistent with previous evidence suggesting higher sensitivity of PET/CT or whole-body MRI (n=135)[11]. These differences likely reflect real-world staging practice, indication bias, and protocol-related field-of-view limitations rather than intrinsic diagnostic inferiority. Nevertheless, these remain resource-intensive, whereas CT-CAP is widely available and routinely used. Bone scintigraphy, though commonly performed, has reduced sensitivity for purely osteolytic lesions, in keeping with the tracer's reliance on osteoblastic response[15-17].

A notable result of this study is the identification of seven clinically relevant lesions visible only on CT scout images (see Figures 3 and 4). Four later fractured,

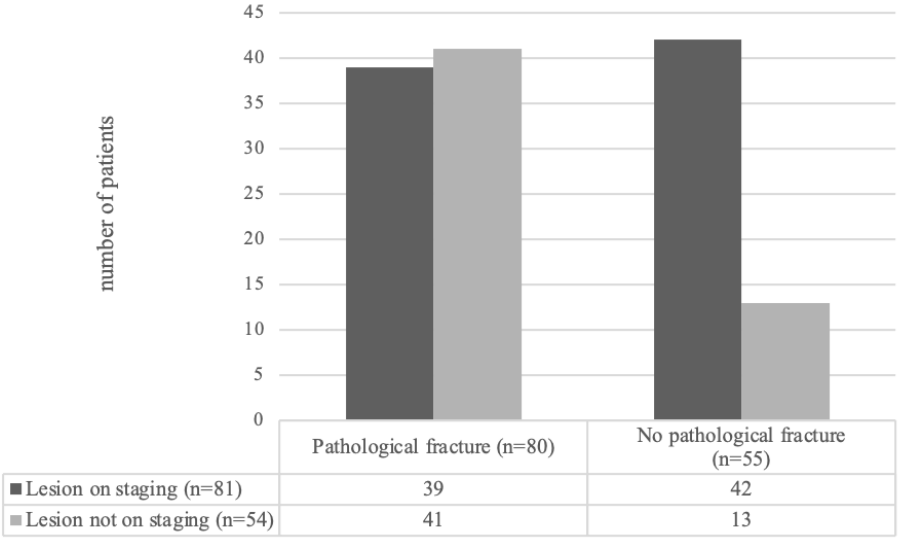

Fig. 1 — Number of patients sustaining a pathological fracture depending on depicting lesion on staging.

Table II. — Multivariate Cox regression model of postoperative survival with depiction of lesion on staging and tumour type as covariates ("breast cancer" used as reference for categorical covariate "tumour type").

Factor	Significance	Hazard Ratio	95% Confidence interval
Depiction of lesion on staging	0.018	0.56	0.35 – 0.88
Tumour type			
- Breast Cancer	0.001		
- Multiple Myeloma	0.077	2.08	0.92 – 4.70
- Renal Cell Carcinoma	0.24	1.62	0.72 – 3.62
- Lung Cancer	0.010	3.30	1.36 – 8.14
- Other cancer	<0.001	4.02	1.94 – 8.33

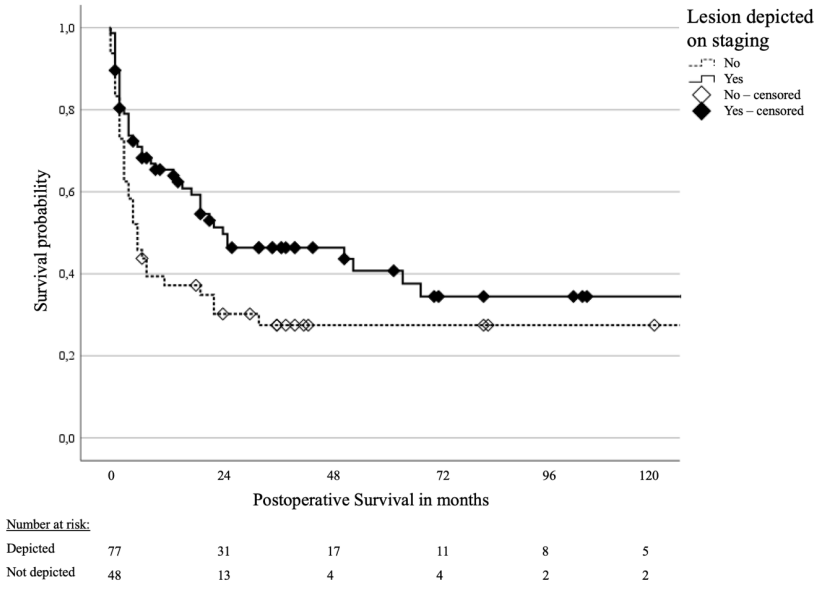

Fig. 2 — Postoperative survival of patients by detection of bone lesion on staging imaging.

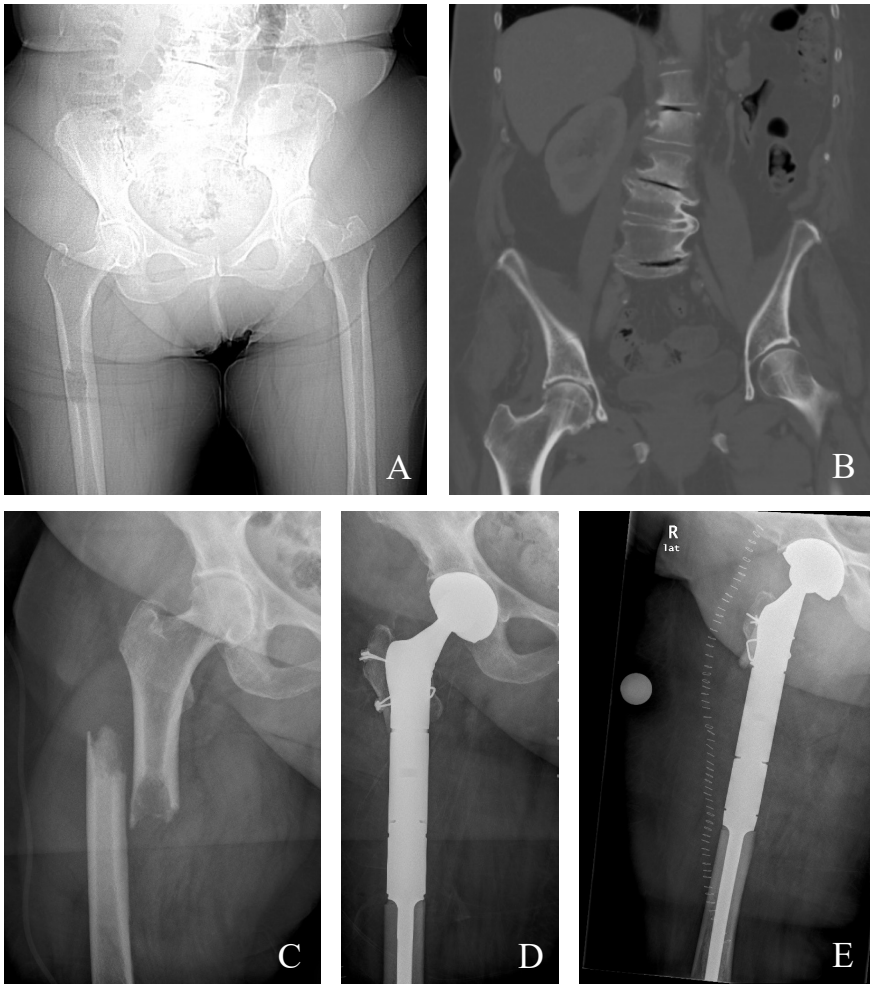

Fig. 3 — Example of 77-year-old female with known metastatic renal cell carcinoma.
(A) Scout of CT chest/abdomen/pelvis staging showing osteolytic bone lesion in right proximal femoral shaft missed on report; (B) caudal extent of actual CT-slides; (C) Radiograph of pathological proximal femoral shaft fracture 3 months after staging; (D, E) Postoperative anteroposterior and lateral radiograph of right proximal femur after resection and proximal femur replacement.

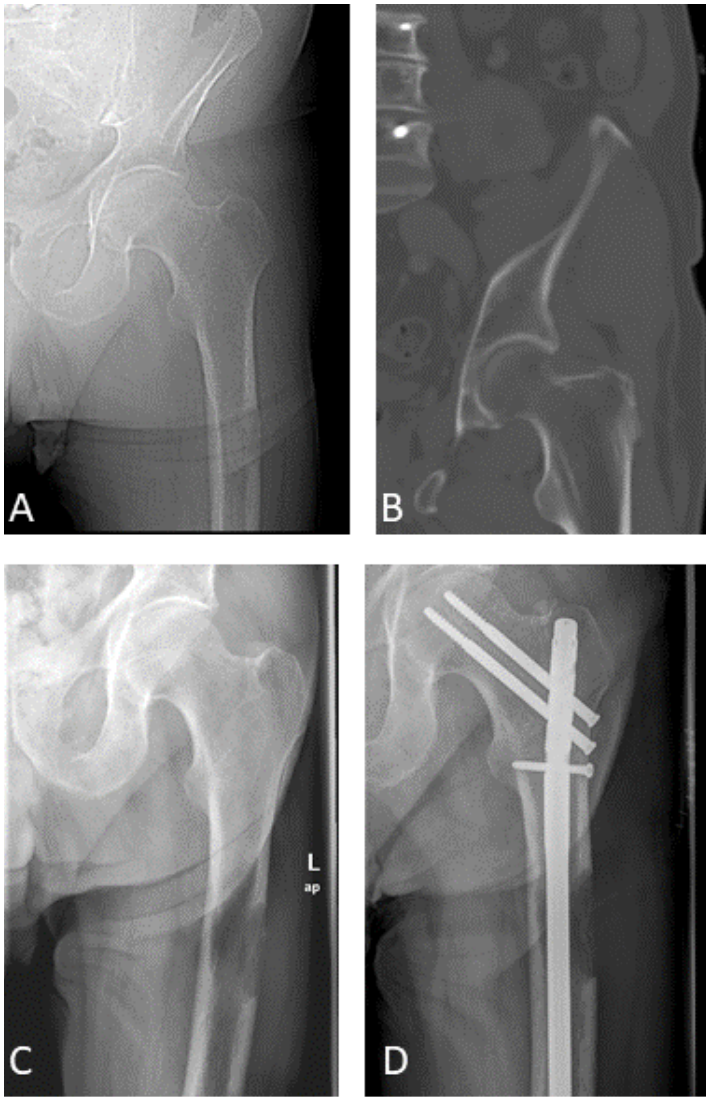

Fig. 4 — Example of a 78-year-old male with known polymetastatic renal cell carcinoma.
(A) Scout of CT chest/abdomen/pelvis staging demonstrating an osteolytic lesion in the left proximal femoral shaft, not mentioned in the original report. (B) Caudal extent of the actual CT slices. (C) Radiograph obtained two months later showing an impending pathological fracture of the proximal femoral shaft, performed due to immobilising pain. (D) Postoperative anteroposterior radiograph after prophylactic fixation with a cephalomedullary nail.

demonstrating the practical importance of this overlooked resource. Given the low additional radiation burden under our institutional protocol (approximately 0.3–0.4 mSv), full-body scout acquisition and structured reporting may represent a practical means of improving diagnostic safety; however, scout dose is institution- and protocol-dependent and should not be generalised[19].

Mirels scoring showed moderate interobserver reliability, similar to previous reports[20]. Detected lesions tended to score higher, likely due to the predominance of proximal femoral lesions in standard CT-CAP fields. Modified scoring systems may offer enhanced precision, although true fracture-risk assessment must remain clinically led[21,22].

Although lesion visibility remained associated with postoperative survival after adjustment for tumour entity, residual confounding cannot be excluded. Factors such as fracture status at presentation, overall metastatic burden, and urgency of surgery were not fully captured. The survival analysis should therefore be regarded as exploratory and hypothesis-generating.

Artificial intelligence may allow automated detection of long-bone lesions on scout imaging, potentially serving as an early warning mechanism prompting targeted clinical review[23,24].

Strength and limitations

Strengths include consistent single-centre protocols and blinded image review. Limitations include retrospective design, tumour heterogeneity, and the modest number of scout-only lesions. The surgically selected nature of the cohort may limit generalisability to non-operative patients. Tumour-specific analyses may require larger multicentre cohorts. Interobserver reliability for Mirels scoring remained moderate.

CONCLUSIONS

This retrospective analysis suggests that reliance on standard CT-CAP alone may be insufficient for detecting orthopaedically relevant bone metastases, particularly outside the diagnostic field of view. Structured review of full-body CT scout images may improve lesion detection in routine clinical practice. The observed associations with fracture occurrence and postoperative survival are exploratory and should be interpreted cautiously. Prospective studies are warranted to further evaluate the clinical impact of optimised staging protocols.

REFERENCES

1. Eastley N, Newey M, Ashford RU. Skeletal metastases - the role of the orthopaedic and spinal surgeon. Surg Oncol. Sep 2012;21(3):216-22.
2. Ratasvuori M, Wedin R, Keller J, et al. Insight opinion to surgically treated metastatic bone disease: Scandinavian Sarcoma Group Skeletal Metastasis Registry report of 1195 operated skeletal metastasis. Surg Oncol. Jun 2013;22(2):132-8
3. Trompeter A. Management of metastatic bone disease (MBD). Injury. Dec 2022;53(12):3869-3871.
4. Tsukamoto S, Errani C, Kido A, Mavrogenis AF. What's new in the management of metastatic bone disease. Eur J Orthop Surg Traumatol. Dec 2021;31(8):1547-1555.
5. Coleman RE. Metastatic bone disease: clinical features, pathophysiology and treatment strategies. Cancer Treat Rev. Jun 2001;27(3):165-76.
6. Coleman RE. Clinical features of metastatic bone disease and risk of skeletal morbidity. Clin Cancer Res. Oct 15 2006;12(20 Pt 2):6243s-6249s.
7. Mavrogenis AF, Angelini A, Vottis C, et al. Modern palliative treatments for metastatic bone disease: awareness of advantages, disadvantages, and guidance. Clin J Pain. Apr 2016;32(4):337-50.
8. Biermann JS, Holt GE, Lewis VO, Schwartz HS, Yaszemski MJ. Metastatic bone disease: diagnosis, evaluation, and treatment. J Bone Joint Surg Am. Jun 2009;91(6):1518-30.
9. Schulman KL, Kohles J. Economic burden of metastatic bone disease in the U.S. Cancer. Jun 1 2007;109(11):2334-42.
10. Blank AT, Lerman DM, Patel NM, Rapp TB. Is prophylactic intervention more cost-effective than the treatment of pathologic fractures in metastatic bone disease? Clin Orthop Relat Res. Jul 2016;474(7):1563-70.
11. Isaac A, Dalili D, Weber MA. State-of-the-art imaging for diagnosis of metastatic bone disease. Radiologe. Nov 2020;60(Suppl 1):1-16.
12. Gennari A, André F, Barrios CH, et al. ESMO clinical practice guideline for the diagnosis, staging and treatment of patients with metastatic breast cancer. Ann Oncol. Dec 2021;32(12):1475-1495.
13. Escudier B, Porta C, Schmidinger M, et al. Renal cell carcinoma: ESMO clinical practice guidelines for diagnosis, treatment and follow-up. Ann Oncol. May 01 2019;30(5):706-720.
14. Ganeshan D, Khatri G, Ali N, et al. ACR appropriateness criteria® staging of renal cell carcinoma: 2022 update. J Am Coll Radiol. May 2023;20(5S):S246-S264.
15. Yang HL, Liu T, Wang XM, Xu Y, Deng SM. Diagnosis of bone metastases: a meta-analysis comparing 18FDG PET, CT, MRI and bone scintigraphy. Eur Radiol. Dec 2011;21(12):2604-17.
16. Lecouvet FE, Michoux N, Nzeusseu Toukap A, et al. The increasing spectrum of indications of whole-body MRI beyond oncology: imaging answers to clinical needs. Semin Musculoskelet Radiol. Sep 2015;19(4):348-62.
17. Even-Sapir E. Imaging of malignant bone involvement by morphologic, scintigraphic, and hybrid modalities. J Nucl Med. Aug 2005;46(8):1356-67.
18. Piccioli A, Spinelli MS, Maccauro G. Impending fracture: a difficult diagnosis. Injury. Dec 2014;45 Suppl 6:S138-41.
19. Golbus AE, Schuzer JL, Steveson C, et al. Reduced dose helical CT scout imaging on next generation wide volume CT system decreases scan length and overall radiation exposure. Eur J Radiol Open. Dec 2023;13:100578.
20. Howard EL, Shepherd KL, Cribb G, Cool P. The validity of the Mirels score for predicting impending pathological fractures of the lower limb. Bone Joint J. Aug 2018;100-B(8):1100-1105.
21. Amendola RL, Miller MA, Kaupp SM, Cleary RJ, Damron TA, Mann KA. Modification to Mirels scoring system location component improves fracture prediction for metastatic disease of the proximal femur. BMC Musculoskelet Disord. Jan 24 2023;24(1):65.
22. Desai VS, Amendola RL, Mann KA, Damron TA. Internal validation of modified Mirels' scoring system for pathologic femur fractures. BMC Musculoskelet Disord. Sep 06 2024;25(1):719.
23. Fink N, Sperl JI, Rueckel J, et al. Artificial intelligence-based automated matching of pulmonary nodules on follow-up chest CT. Eur Radiol Exp. May 02 2025;9(1):48.
24. Miller R, Battle M, Wangerin K, et al. Evaluating automated tools for lesion detection on. Radiol Imaging Cancer. May 2025;7(3):e240253.