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Pathological hip fracture in the elderly: review and proposal of an algorithm

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Summary

Objective. Current Italian guidelines recommend surgery within 24 hours from admission for hip fractures of the elderly. In such patients, a pathologic fracture of the proximal femur is not an uncommon event and may be consequent to bone metastases or primary tumours. This paper aims to investigate the current literature and to propose an algorithm to manage patients more securely.

Methods. A review of the literature on diagnostic and therapeutic tools in pathologic fractures of the hip was conducted. Evidence from the literature was merged to define a flowchart for a safe clinical-diagnostic pathway.

Results. Proper imaging is essential in the management of bone metastases, along with appropriate laboratory tests and within a multi-disciplinary setting. While bone metastases are the expression of a systemic disease, bone sarcomas have an extremely aggressive local course and an incorrect surgical procedure could heavily affect prognosis of the patient. The surgeon should not rush to treat a suspicion of a pathological fracture without having performed all necessary investigations.

Conclusions. Orthopaedists must doubt a pathologic fracture. An algorithm could help standardise procedures and provide a tool for safe management of these patients.

Key words: pathologic fracture, hip fractures, metastasis, neoplasm, orthopaedic surgery

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Introduction

Proximal femoral fractures in elderly patients are a widely diffused entity in orthopaedic scenery. In fact, more than 250,000 hip fractures are estimated annually in the United States in people over 65 years old. The incidence is expected to increase each year due to increasing life expectancy. This condition is associated with increased morbidity and mortality, with estimated 1-year mortality rates between 14 and 36% [1-4]. This is due to patient-related factors such as pre-existing chronic comorbidities and fracture-related factors like bleeding, anaemia and exposure to proinflammatory conditions that can worsen prognosis [5,6]. Since 2008, the Italian Ministry of Health has introduced the rate of proximal femoral fracture treated within 48 hours as one of the indexes of hospital efficiency [7]. Early treatment aims to minimise the length of time a patient is confined to bed rest, thereby reducing the risk for associated complications, such as pressure sores, deep vein thrombosis (DVT) and urinary tract infections (UTI). A recent meta-analysis conducted by Moja that included over 190,000 patients reported that early surgery for hip fracture provides a survival benefit in comparison with later intervention. Moreover, prompt intervention is associated with a significant reduction in pressure sores [8,9].

Even if it is widely accepted that hip fractures in this group of patients should be treated surgically as soon as possible, there is no consensus about the effective timing of surgery [10-18]. In clinical practice, it is not unusual to delay surgical procedures in elderly, as many variables can interfere with early treatment: daily therapy with oral anti-coagulant or anti-platelet drugs, on course infections, comorbidities like cardiac or renal disease which often require additional preoperative treatments and tests that take time [19]. This unavoidable delay keeps the patient in bed, increasing the risk of pulmonary, skin and urinary tract infections. The timing issue for hip fractures in the elderly can be even more challenging for the orthopaedic surgeon if a pathological fracture is suspected. Managing pathological bone fractures in patients with either primary or metastatic bone tumours represents a difficult task even for the most experienced surgeons. Their management may alter prognosis and affect quality of life and survival of these patients. This kind of pathology can be secondary to either benign lesions (such as Paget disease or giant cell tumour) or malignancies. The latter can be either primary (i.e. osteosarcoma or chondrosarcoma) or secondary in case of metastatic disease, multiple myeloma, or bone lymphoma. The most frequent conditions in the elderly are metastatic diseases and multiple myeloma; local recurrences of a primary bone tumour are not uncommon and secondary sarcomas including pagetic and post-irradiation sarcomas (occurring as late as 20 years after the initial diagnosis) must be considered as a possible diagnosis [20]. Furthermore, entities like aggressive benign bone tumours or tumour-like conditions such as fibrous dysplasia, simple bone cyst, aneurysmal bone cyst and giant cell tumour increase the risk for pathological fracture in the proximal femur, with an incidence at the time of diagnosis of about 12% [21-25]. In addition to fracture-related factors that can worsen prognosis, other factors must be considered such as adjacent joint, soft tissue, nerves and vessel contamination by haematoma formation, or distant haematogenous dissemination due to microcirculation damage [26-28]. In selected cases, an incorrect surgical approach can help to disseminate the malignancy with progression of disease. The orthopaedic traumatologist in the Emergency Department is often the first physician to deal with a patient with a pathologic fracture. A systematic approach to these patients is critical and must be aimed at avoiding complications that could compromise limb salvage or, at worst, affect overall survival/oncologic disease related prognosis. This study aims to investigate the literature about pathological fractures of proximal femur in elderly people and to propose an algorithm improved with reasonable timing to manage such patients in a safer way, and deciding on the effective need for surgery within 48 hours.

Materials and methods

An electronic literature search available up to December 2019 of PubMed, Embase and the Cochrane Review system was performed. The search terms used were "(pathological fracture OR pathological fractures OR pathologic fracture OR pathologic fractures) AND (hip OR femur OR femoral OR long bones)". Identification and selection of the studies was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis criteria (www.prisma-statement.org). The PI(C)O model was as follows: the population consisted of elderly patients with a pathological fracture of the proximal femur (P) who underwent orthopaedic surgery (I). Outcomes of interest were perioperative outcomes and durability at follow-up (O). Filters were added to restrict the search to studies on humans, which were published between January 2003 and December 2019 and whose full text was composed in one of the following languages: English, Italian, French, Spanish and Portuguese. Title and abstracts were first reviewed to ascertain whether they would potentially meet inclusion criteria. For those passing the first screening, a full-text analysis was performed to confirm inclusion. Studies without primary data (letters to the editor or authors, case reports, opinion articles, technique descriptions, and commentaries) as well as conference abstracts were not considered. References of collected studies were manually reviewed to find additional studies of interest. A second electronic literature search was conducted to clarify the validation of 48 hours as a cut-off time for treatment.

Furthermore, the authors propose to design an algorithm for diagnostic and management of elderly patients with a suspicion of pathologic hip fracture, using evidence from the literature, in order to treat these patients even outside a reference centre for musculoskeletal tumour surgery.

This research article was approved by the United Ethical Committee of "Città della Scienza e della Salute", Turin, Italy and was in accordance with the Declaration of Helsinki.

Results

1912 articles were identified from the search engines. These articles were critically reviewed for evidence according to the PRISMA protocols (Fig. 1). Studies focused solely on impending fractures were ignored and articles on bisphosphonate fractures were excluded: the main entities considered in this study are listed in Table I. Six additional items were identified through other sources, so that 14 articles [29-42] were finally considered pertinent for the aim of the study. Very few studies focused on the preoperative management of these patients, while almost none concentrated on the timing for surgery. Unfortunately, no guidelines were pertinent as well as a consistent portion of the literature. Given the mostly non-comparative design of the studies identified, the evidence was performed in a descriptive and narrative manner and summarised in Table II. Moreover, several studies concerning traumatic hip fractures explained the importance of performing the treatment as soon as possible to avoid complications that could worsen the outcome, but hardly any studies clarified the exact timing [8,10-19].

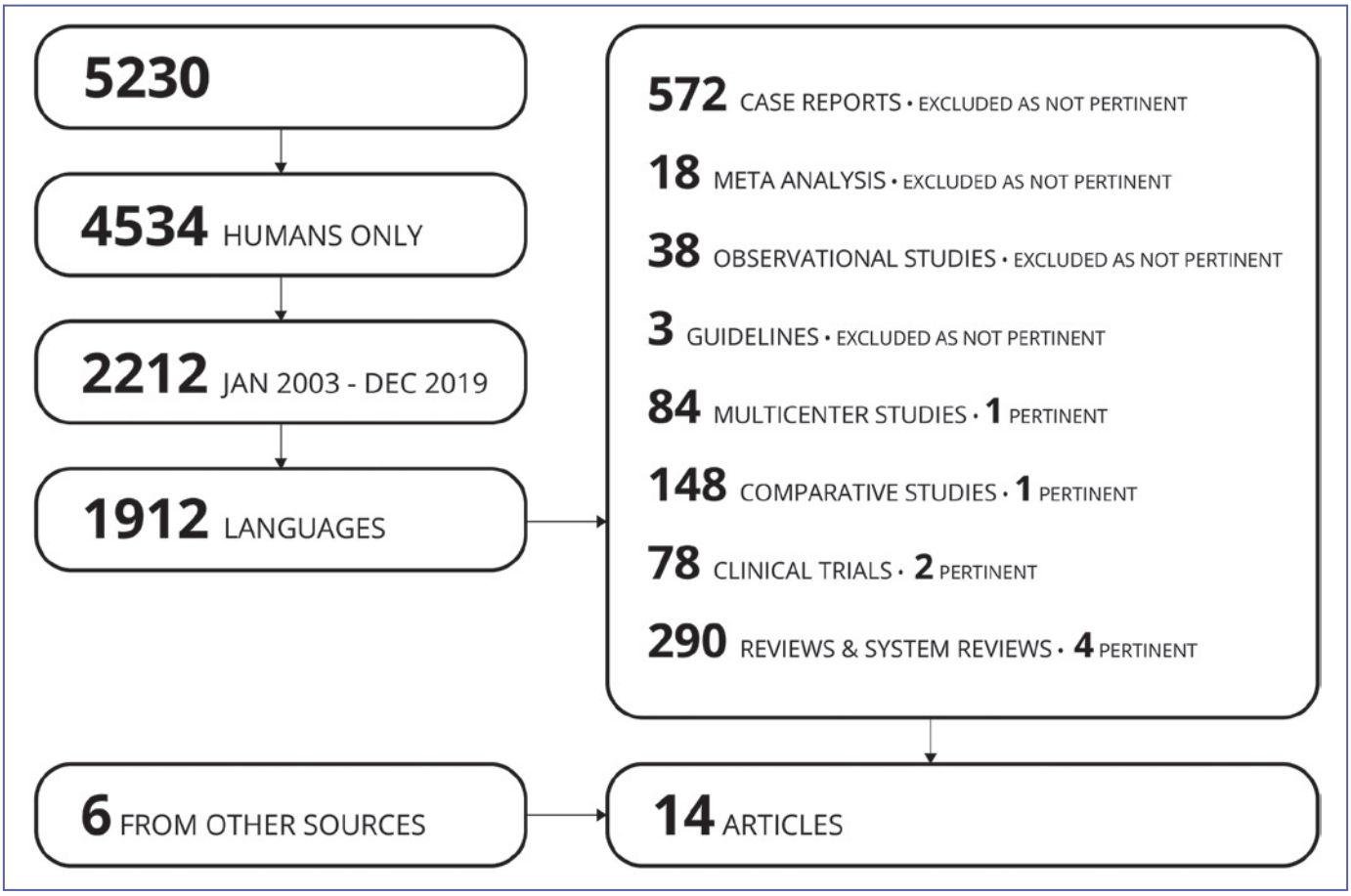

Figure 1. Flow-chart of literature search and study selection.

Table I. Main entities considered in the study.

Benign and tumour-like lesions	Benign aggressive lesions	Malignant lesions
Non-ossifying fibroma	Desmoplastic fibroma	Metastases
Enchondroma	Fibrous dysplasia	Osteosarcoma
Unicameral bone cyst	Osteoblastoma	Chondrosarcoma
Aneurysmal bone cyst	Chondromixofibroma	Ewing's sarcoma
Paget disease	Chondroblastoma	Malignant fibrous histiocytoma
	Giant cell tumor	Multiple myeloma
		Bone lymphoma

Discussion

Even though the concern about pathologic fracture has progressively increased over the last decades, the literature is still quite poor and rarely provides management algorithms validated by large international studies. Most of the literature is focused on the specific options for surgical treatment, while there is a lack in establishing applicable guidelines or algorithms that can help the surgeon in the preoperative general investigation of the patient. In 2004, Jacofsky and Haidukewych suggested a diagnostic and treatment algorithm [32] of a patient with a pathologic fracture of the hip and no history of cancer. The protocol concentrates on the preoperative steps that the patient should undergo, yet lacks a reasonable timing for each of the steps. The authors of this study critically merged evidence from the

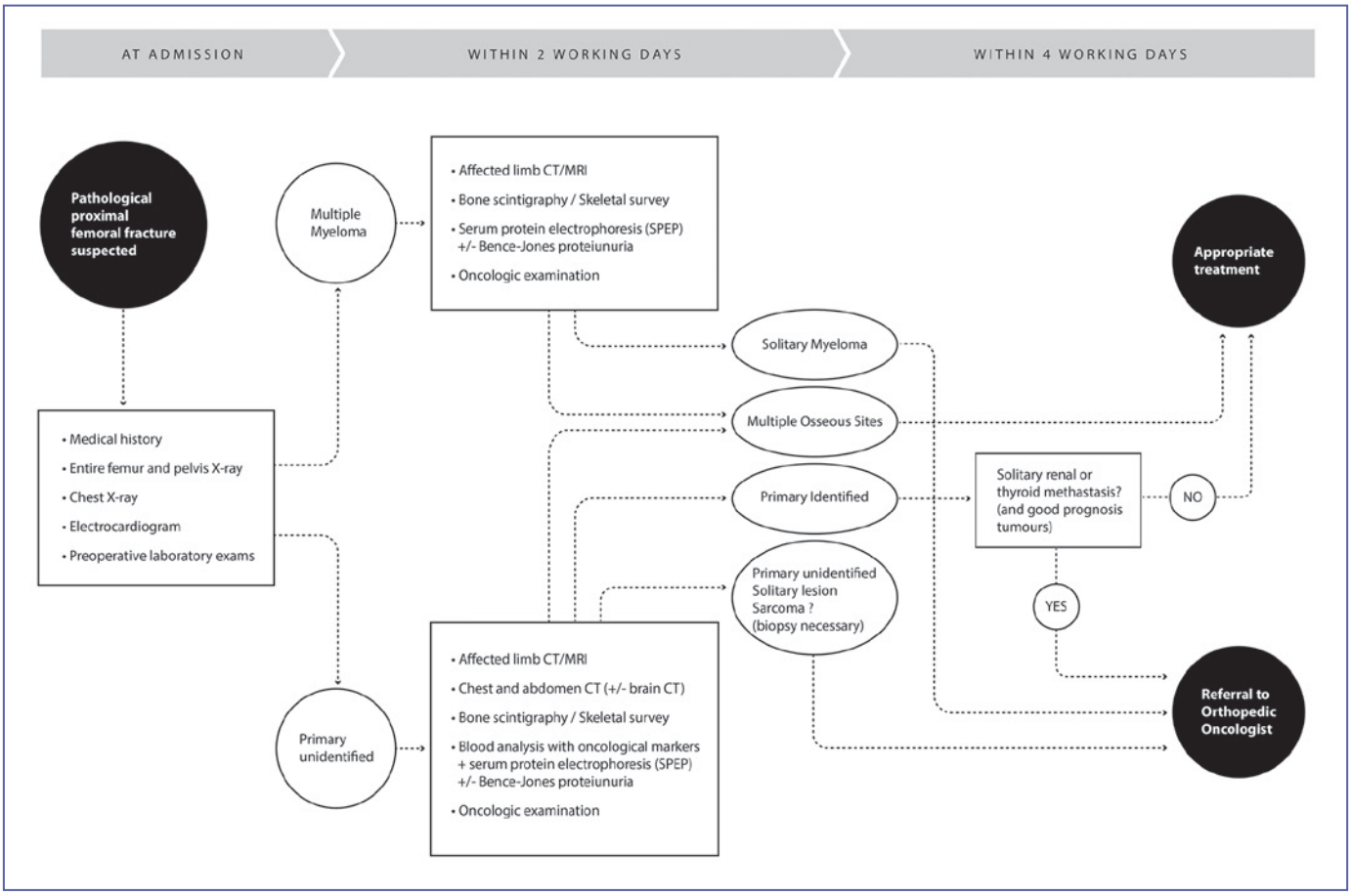

Figure 2. Implemented Jacofsky and Haidukewych's diagnostic and treatment algorithm.

literature to propose an algorithm for a safe approach to these patients. This implemented decisional algorithm is illustrated in Figure 2 and described in detail below.

At admission, clinical history and anamnesis should be examined accurately to detect the pathologic nature of the fracture. History of non-traumatic injury and previous weight-loss should be judged as suspicious, if the patient presents a negative oncological anamnesis. Radiologic imaging is the first and crucial step for diagnosis: these patients must undergo mandatory X-ray evaluation with both anteroposterior and lateral radiographs of the affected entire femur [32,39-41] and the pelvis at admission, along with the routine preoperative tests. The evaluation of the entire affected bone has remarkable importance to detect multiple lesions or possible skip lesions within the same bone. Management is difficult and immobilisation hard to achieve: if necessary, skin or trans-tuberosity skeletal traction are preferred to avoid compartmental contamination [42]. If a myeloma is suspected, serum protein electrophoresis (SPEP) should be always requested and if abnormal peaks are detected, Bence-Jones proteinuria (BJP) should be investigated. A systematic skeletal radiographs or whole-body low-dose computed tomography (WBLDCT) [32,39,43] need to be performed to stage the disease and investigate its extent. Even if its role is debated [44], bone scintigraphy may be helpful to screen for additional skeletal lesions if the patient has a positive oncological medical history [32,39]. An oncological/haematological examination should be also performed. Such general evaluations should be accurately run in any trauma centre within two days from admission; patients with solitary lesions ideally referred to orthopaedic oncologists and multiple lesions should be treated within four days.

Apart from those affected by multiple myeloma, all patients should undergo computed tomography (CT) of the chest and abdomen to investigate a possible primary malignancy and for staging purposes[32,34,35,39,40-42]. A CT scan of the brain could be performed if the primary tumour is at high risk for brain metastases (e.g. lung cancer). Imaging workup must be completed with CT and/or MRI scan of the affected limb to evaluate the local extension of the lesion and conditions of the cortical bone [35,42]. Furthermore, chemical blood analysis along with oncological markers (CEA, Ca 19.9, Ca 125, Ca 15.3, AFP, PSA) should be run. SPEP and BJP should be requested in a selected

group of patients. Even if indications for surgery in this patient population are well described in the literature[45-47], an oncologist could help the surgeon with no expertise in muscoloskeletal surgery and metastatic disease – or in case of doubt – to address the patient to palliative care, medical treatments, or surgery. Alternatively, the case should be discussed in the local multidisciplinary team (MDT) for bone metastases [29-32,34,35,39-42]. Whenever surgery is advocated within two days from admission [7,8], the authors consider the same timing as reasonable for all the above-mentioned workups to avoid incorrect surgeries and guarantee the most adequate treatment for each patient. It must be considered that some primary bone tumours, such as chondrosarcoma, frequently affect the proximal femur and it is not uncommon for patients to undergo an intramedullary nailing stabilisation or a hip replacement, with the pathologist eventually reporting a primary bone sarcoma [41]. Even if it is widely accepted that early surgery increases the probability of walking again after femur fracture, the 48 hour deadline for surgery seems arbitrary timing [18,19] and not completely suitable as a performance indicator for good practise: a recent study [17] including two major Italian hospitals reported 5 to 6 days between surgery and returning to ambulation for elderly patients treated for a hip fracture even if surgery was performed within 2 days from admission.

When choosing the best treatment for each patient, several variables should be considered. Towards this end, Willeumier et al. [46] defined a flowchart (OPTIMAL) for stratification of patients with long bone metastases with different levels of prognosis depending on the clinical profile, Karnofsky score and presence of visceral/brain metastases. Piccioli et al. [47] recently validated another tool (PATHFx) for estimation of survival in patients with metastatic bone disease in the Italian population. Furthermore, if the patient is eligible for surgery, a recent questionnaire survey study to institutions participating in the Bone and Soft Tissue Tumor Study Group of the Japan Clinical Oncology Group [36] listed a number of factors influencing the type of surgery and pathologic fractures of the proximal femur reported in Table II.

If the surgery is feasible in a peripheral hospital or a standard traumatological unit, such as in case of multiple lesions or single lesion from a poor prognosis solid neoplasm [32], it should be reasonably performed within 4 working days from admission

Table II. Resume of the literature considered pertinent with the study.

References	Study design	Main concerns	Main findings
Araki et al., J Orthop Sci, 2017	Questionnaire survey to Japanese BSTTSG	Factors influencing the type of surgery in PPFF	Factors listed in descending order: life expectancy, performance status before fracture, degree of bone loss, walking ability before fracture, general complications, number of bone metastases in other sites, and visceral metastasis status
Chandrasekar et al., ISRN Oncology, 2012	Retrospective study	PPFF in osteosarcoma	Poor prognosis and scares possibility of limb salvage surgery Avoiding preoperative CHT in a lytic lesion at high risk for fracture should be considered to avoid a PF
Ebeid et al., Cancer Control, 2005	Retrospective case series	Middle-term complications in PF from primary bone tumours	A pathologic fracture of primary bone tumor is not a contraindication for limb salvage The oncologic outcome appears acceptable *(study from 2005)*
Errani et al., Eur J Orthop Surg Traumatol, 2017	Systematic review and proposal of algorithm	Treatment in LBPF	IMN in generally preferred HHA reconstruction in multiple lesions or metaphyseal defects Isolated bone metastases require en bloc resection
Faisham et al., Med J Malaysia, 2003	Retrospective study	Middle-term complications in PPFF	Good quality of life for treated patients, even if no improve in survival *(study from 2003)*
Guzik, BMC Surgery, 2018	Retrospective study	Oncological and functional outcome after PPFF	Patients need to be studied preoperatively in a multidisciplinary approach Good outcomes in resection of tumor and implant modular prostheses

Table II *(continue)*

References	Study design	Main concerns	Main findings
Jacofsky et al., J Orthop Trauma 2004	Review of literature and proposal of algorithm	Management of patients with a PPFF	Careful and multidisciplinary approach may give patients increased chances for a better prognosis Delayed surgeries are acceptable if the case needs to be studied Algorithms could help surgeons to manage patients in safer way
Khattak et al., Ann Med Surg (Lond), 2018	Review of literature	Management of patients with metastatic involvement of the hip	Careful preoperative study of the patient Surgery must be planned in coordination with oncologists and physicians for comprehensive perioperative management
Ruggieri et al., Injury, Int J Care Injured, 2010	Review of literature and proposal of algorithm	Management algorithm for LBPF	Treatment decision requires complete staging and oncological principles Tumour response to CHT, RT, fracture union, and wide resection are significant predictive factors for overall survival and local disease control
Szendrői et al., EFORT Open Rev, 2017	Review of literature and proposal of algorithm	Management of patients with bone metastatic disease	Few algorithms are proposed in literature and none of them has been validated Type of surgical intervention could be crucial on patients' prognosis
Varady et al., J Surg Oncol, 2019	Multicentre retrospective study	Comparison between HHA-THA and IMN in PPFF	Trend in favour of IMN in the US Longer preoperative time and hospitalization than for traumatic fractures Need for more communication between orthopaedic oncologists and the rest of the orthopaedic community
Varady et al., Clin Orthop Relat Res, 2019	Multicentre retrospective study	Short-term complications in delayed surgery in PPFF	No increase in short-term complication if surgery after more than 48 hours The association between delayed surgery and complications seen for patients with standard hip fractures may not exist in PPFF
Willeumier et al., EFORT Open Rev, 2016	Review of literature	Management and treatment of LBPF	Treatment highly depends on the fracture risk in relation to expected survival A careful and multidisciplinary approach is advisable
Zacherl et al., International Orthopaedics (SICOT), 2011	Retrospective, comparative, double-centre study	Type of surgery in PPFF	Study excluded head and neck fractures Resection of bone metastases has no impact on overall survival Long-term survivals are at risk of implant-related complications

Note: BSTTSG: Bone and Soft Tissue Tumor Study Group; PPFF: pathologic proximal femur fracture; CHT: chemotherapy; PF: pathologic fracture; LBPF: long bone pathologic fracture; RT: radiant therapy; HHA: hip hemiarthroplasty; THA: total hip arthroplasty; IMN: intramedullary nailing

after all due workups and if comorbidities and daily therapies allow. For all other conditions, such as a solitary metastasis from a primary tumour with good prognosis (e.g. thyroid or renal cancer), single myeloma lesion, primary tumour unidentified, or solitary lesion or suspicion of sarcoma, the patient should be referred to the closest centre for orthopaedic oncology [32] within 4 working days from admission. The outcome and overall survival of patients with a solitary bone metastasis

treated with wide resection are claimed to be better in several studies, especially for primary tumours with good prognosis [48-51]. Wide resection of the metastatic bone and megaprosthetic replacement of the joint is frequently performed by orthopaedic oncologist surgeons and should be performed in referral centres. The surgical treatment in orthopaedic oncology is a very delicate issue and care must be taken when approaching these patients. The definition of a decisional algorithm could be a useful tool to avoid the three most common mistakes in this surgery: incorrect operations (also known as "whoops surgery" [52]), over- and undertreatment [53]. Indeed, a preoperative biopsy is mandatory in patients with unknown malignancies and a solitary bone lesion as well as in patients with suspicion of a primary bone tumour. It is advisable to perform the biopsy in a specialized centre to identify the most correct type of biopsy (needle aspiration, core needle biopsy, or incisional biopsy) and avoid technical mistakes such as incorrect approach and compartmental contamination [54-56].

Surgical procedures should be carefully selected for each patient avoiding overtreatment and undertreatment. On occasion, aggressive surgical treatments can worsen the patient's prognosis: the goal is to maximise function and quality of life for the longest amount of time. Patients with short life expectancy may require less invasive surgery, including intramedullary nailing or other fixation techniques (plating and reinforcement with bone cement, mini-invasive photodynamic stabilisation). In contrast, patients with longer life expectancy are normally thought to require more durable reconstructive options that increase both perioperative risk and duration of rehabilitation [57-59]. Nevertheless, in patients with long life expectancy, durable reconstructions are the best option to assure a long-lasting and good quality of life.

Conclusions

The surgeon must be aware of the indications for biopsy and the criteria for resection versus internal fixation, as well as the options for reconstruction. A diagnostic algorithm with a systemic approach along with workups and implemented with timing can help the surgeon to best deal with a patient affected by a pathologic fracture. Good clinical management of bone tumour or skeletal metastases improves pain management, can reduce disease progression and avoid errors that could harm or worsen prognosis. Surgery must be tailored to the patient and several options for reconstruction must be considered.

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References

1 Zuckerman JD. Hip fracture. N Engl J Med 1996;334:1519-25. https://doi.org/10.1056/NEJM199606063342307

2 Brauer CA, Coca-Perraillon M, Cutler DM, et al. Incidence and mortality of hip fractures in the United States. JAMA 2009;302:1573-9. https://doi.org/10.1001/jama.2009.1462

3 Johnell O, Kanis J. An estimate of the worldwide prevalence, mortality and disability associated with hip fracture. Osteoporos Int 2004;15:897-902. https://doi.org/10.1007/s00198-004-1627-0

4 Laforgia R, Maggi S, Marzari C, et al. Epidemiology of femoral neck fracture in old people in Italy. J Bone Joint Surg Br 2006;88(Suppl 1):42.

5 Beloosesky Y, Grinblat J, Pirotsky A, et al. Different C-reactive protein kinetics in postoperative hip-fractured geriatric patients with and without complications. Gerontology 2004;50:216-22. https://doi.org/10.1159/000078350

6 Beloosesky Y, Hendel D, Weiss A, et al. Cytokines and C-reactive protein production in hip-fracture-operated elderly patients. J Gerontol A Biol Sci Med Sci 2007;62:420-6. https://doi.org/10.1093/gerona/62.4.420

7 Ministero della salute – Agenzia Nazionale per i Servizi Sanitari Regionali. National Outcome Evaluation Program, PNE, Italian (http://95.110.213.190/PNEed17/risultati/tipo1/intr_struasl1_HC.php?ind=42&tipo=2&area=5).

8 Moja L, Piatti A, Pecoraro V, et al. Timing matters in hip fracture surgery: patients operated within 48 hours have better outcomes. A meta-analysis and meta-regression of over 190,000 patients. PLoS One 2012;7:e46175. https://doi.org/10.1371/journal.pone.0046175

9 Johnson SK, Knobf MT. Surgical interventions for cancer patients with impending or actual pathologic fractures. Orthop Nurs 2008;27:160-71; quiz 172-3. https://doi.org/10.1097/01.NOR.0000320543.90115.d5

10 Ricci WM, Brandt A, McAndrew C, et al. Factors affecting delay to surgery and length of stay for patients with hip fracture. J Orthop Trauma 2015;29:e109-14. https://doi.org/10.1097/BOT.0000000000000221

11 Charalambous CP, Yarwood S, Paschalides C, et al. Factors delaying surgical treatment of hip fractures in elderly patients. Ann R Coll Surg Engl 2003;85:117-9. https://doi.org/10.1308/003588403321219911

12 Fantini MP, Fabbri G, Laus M, et al. Determinants of surgical delay for hip fracture. Surgeon 2011;9:130-4. https://doi.org/10.1016/j.surge.2010.11.031

13 Ryan DJ, Yoshihara H, Yoneoka D, et al. Delay in hip fracture surgery: an analysis of patient-specific and hospital-specific risk factors. J Orthop Trauma 2015;29:343-8. https://doi.org/10.1097/BOT.0000000000000313

14 Ventura C, Trombetti S, Pioli G, et al. Impact of multidisciplinary hip fracture program on timing of surgery in elderly patients. Osteoporos Int 2014;25:2591-7. https://doi.org/10.1007/s00198-014-2803-5

15 Zeltzer J, Mitchell RJ, Toson B, et al. Determinants of time to surgery for patients with hip fracture. ANZ J Surg 2014;84:633-8. https://doi.org/10.1111/ans.12671

16 Nijland LMG, Karres J, Simons AE, et al. The weekend effect for hip fracture surgery. Injury 2017;48:1536-41. https://doi.org/10.1016/j.injury.2017.05.017

17 Aprato A, Casiraghi A, Pesenti G, et al. 48 h for femur fracture treatment: are we choosing the wrong quality index? J Orthop Traumatol 2019;20:11. https://doi.org/10.1186/s10195-019-0518-2

18 Wong SHJ, Fang XC, Yee KHD, et al. Hip fracture time-to-surgery and mortality revisited: mitigating comorbidity confounding by effect of holidays on surgical timing. Int Orthop 2018;42:1789-94. https://doi.org/10.1007/s00264-017-3737-2

19 Correoso Castellanos S, Lajara Marco F, Díez Galán MM, et al. Analysis of surgical delay and its influence on morbimortality in patients with hip fracture. Rev Esp Cir Ortop Traumatol 2019;63:246-51. https://doi.org/10.1016/j.recot.2018.07.002

20 Kuttesch JF Jr, Wexler LH, Marcus R, et al. Second malignancies after Ewing's sarcoma: radiation dose-dependency of secondary sarcomas. J Clin Oncol 1996;14:2818-25. https://doi.org/10.1200/JCO.1996.14.10.2818

21 Jaffe KA, Launer EP, Scholl BM. Use of a fibular allograft strut in the treatment of benign lesions of the proximal femur. Am J Orthop 2002;31:575-8.

22 George B, Abudu A, Grimer RJ, et al. The treatment of benign lesions of the proximal femur with non-vascularised autologous fibular strut grafts. J Bone Joint Surg Br 2008;90B:648-51. https://doi.org/10.1302/0301-620X.90B5.20330

23 Shih HN, Chen YJ, Huang TJ, et al. Treatment of fibrous dysplasia involving the proximal femur. Orthopedics 1998;21:1263-6.

24 Zhao JG, Wang J, Shang J et al. Interventions for treating simple bone cysts in the long bones of children. Cochrane Database Syst Rev 2017;2:CD010847. https://doi.org/10.1002/14651858.CD010847.pub2

25 Shih HN, Cheng CY, Chen YJ, et al. Treatment of the femoral neck and trochanteric benign lesions. Clin Orthop Relat Res 1996;328:220-6. https://doi.org/10.1097/00003086-199607000-00034

26 Fuchs B, Valenzuela RG, Sim FH. Pathologic fracture as a complication in the treatment of Ewing's sarcoma. Clin Orthop Relat Res 2003;415:25-30. https://doi.org/10.1097/01.blo.0000093893.12372.9d

27 Rosenstock JG, Jones PM, Pearson D, et al. Ewing's sarcoma, adjuvant chemotherapy and pathologic fracture. Eur J Cancer 1978;14:799-803. https://doi.org/10.1016/0014-2964(78)90012-9

28 Wagner LM, Neel MD, Pappo AS, et al. Fractures in pediatric Ewing sarcoma. J Pediatric Hematol Oncol 2001;23:568-71. https://doi.org/10.1097/00043426-200112000-00003

29 Varady NH, Ameen BT, Schwab P, et al. Trends in the surgical treatment of pathological proximal femur fractures in the United States. J Surg Oncol 2019:1-14. https://doi.org/10.1002/jso.25669.

30 Errani C, Mavrogenis AF, Donati D et al. Treatment for long bone metastases based on a systematic literature review. Eur J Orthop Surg Traumatol 2017;27:205-11. https://doi.org/10.1007/s00590-016-1857-9

31 Varady NH, Ameen BT, Chen AF. Is delayed time to surgery associated with increased short-term complications in patients with pathologic hip fractures? Clin Orthop Relat Res 2019;00:1-9. https://doi.org/10.1097/CORR.0000000000001038

32 Jacofsky DJ, Haidukewych GJ. Management of pathologic fractures of the proximal femur state of the art. J Orthop Trauma 2004;18:459-69. https://doi.org/10.1097/00005131-200408000-00013

33 Faisham WI, Zulmi W, Biswal BM, et al. Metastatic disease of the proximal femur. Med J Malaysia 2003;58:120-4.

34 Guzik G. Treatment outcomes and quality of life after the implantation of modular prostheses of the proximal femur in patients with cancer metastases. BMC Surgery 2018;18:5. https://doi.org/10.5604/15093492.1212867

35 Szendrői M, Antal I, Varga PP et al. Diagnostic algorithm, prognostic factors and surgical treatment of metastatic cancer diseases of the long bones and spine. EFORT Open Rev 2017;2:372-81. https://doi.org/10.1302/2058-5241.2.170006

36 Araki N, Chuman H, Matsunobu T, et al. Factors associated with the decision of operative procedure for proximal femoral bone metastasis: questionnaire survey to institutions participating the Bone and Soft Tissue Tumor Study Group of the Japan Clinical Oncology Group. J Orthop Sci 2017;22:938-45. https://doi.org/10.1016/j.jos.2017.05.012

37 Ebeid W, Amin S, Abdelmegid A. Limb salvage management of pathologic fractures of primary malignant bone tumors. Cancer Control 2005;12:57-61. https://doi.org/10.1177/107327480501200107

38 Zacherl M, Gruber G, Glehr M, et al. Surgery for pathological proximal femoral fractures, excluding femoral head and neck fractures: resection vs stabilisation. Int Orthop 2011;35:1537-43. https://doi.org/10.1007/s00264-010-1160-z

39 Ruggieri P, Mavrogenis AF, Casadei R, et al. Protocol of surgical treatment of long bone pathological fractures. Injury 2010;41:1161-7. https://doi.org/10.1016/j.injury.2010.09.018

40 Willeumier JJ, van der Linden YM, van de Sande MAJ, et al. Treatment of pathological fractures of the long bones. EFORT Open Rev 2016;1:136-45. https://doi.org/10.1302/2058-5241.1.000008

41 Khattak MJ, Ashraf U, Nawaz Z, et al. Surgical management of metastatic lesions of proximal femur and the hip. Ann Med Surg (Lond) 2018;36:90-5. https://doi.org/10.1016/j.amsu.2018.09.042

42 Chandrasekar CR, Grimer RJ, Carter DR, et al. Pathological fracture of the proximal femur in osteosarcoma: need for early radical surgery? ISRN Oncol 2012;2012:512389. https://doi.org/10.5402/2012/512389

43 Ippolito D, Besostri V, Bonaffini PA, et al. Diagnostic value of whole-body low-dose computed tomography (WBLDCT) in bone lesions detection in patients with multiple myeloma (MM). Eur J Radiol 2013;82:2322-7. https://doi.org/10.1016/j.ejrad.2013.08.036

44 Rethnam U, Sheeja YR. Bone scintigraphy – a wasteful resource in fractures of the neck of the femur. Int Orthop 2007;31:135. https://doi.org/10.1007/s00264-006-0210-z

45 Forsberg JA, Wedin R, Bauer HC, et al. External validation of the Bayesian Estimated Tools for Survival (BETS) models in patients with surgically treated skeletal metastases. BMC Cancer 2012;12:493. https://doi.org/10.1186/1471-2407-12-493

46 Willeumier JJ, Van der Linden YM, Dijkstra PDS. An easy-to-use prognostic model for survival estimation for patients with symptomatic long bone metastases. J Bone Joint Surg Am 2018;100:196-204. https://doi.org/10.2106/JBJS.16.01514

47 Piccioli A, Spinelli MS, Capanna R et al. How do we estimate survival? External validation of a tool for survival estimation in patients with metastatic bone disease – decision analysis and comparison of three international patient populations. BMC Cancer 2015;15:424. https://doi.org/10.1186/s12885-015-1396-5

48 Hosaka S, Katagiri H, Honda Y, et al. Clinical outcome for patients of solitary bone only metastasis. J Orthop Sci 2016;21:226-9. https://doi.org/10.1016/j.jos.2015.12.005

49 Grünwald V, Eberhardt B, Bex A, et al. An interdisciplinary consensus on the management of bone metastases from renal cell car-

cinoma. Nat Rev Urol 2018;15:511-21. https://doi.org/10.1038/s41585-018-0034-9

50 Satcher RL, Lin P, Harun N, et al. Surgical management of appendicular skeletal metastases in thyroid carcinoma. Int J Surg Oncol 2012;2012:417086. https://doi.org/10.1155/2012/417086

51 Zhao T, Gao Z, Wu W, et al. Effect of synchronous solitary bone metastasectomy and lung cancer resection on non-small cell lung cancer patients. Oncol Lett 2016;11:2266-70. https://doi.org/10.3892/ol.2016.4190

52 Harrison WD, Sargazi N, Yin Q, et al. Delayed diagnosis in primary care – the main cause of sarcoma litigation in the United Kingdom. J Surg Oncol 2016;113:361-3. https://doi.org/10.1002/jso.24149

53 Potter BK, Forsberg JA, Conway S, et al. Pitfalls, errors, and unintended consequences in musculoskeletal oncology: how they occur and how they can be avoided. JBJS Rev 2013;1. https://doi.org/10.2106/JBJS.RVW.M.00028

54 Traina F, Errani C, Toscano A, et al. Current concepts in the biopsy of musculoskeletal tumors: AAOS exhibit selection. J Bone Joint Surg Am 2015;97:e7. https://doi.org/10.2106/JBJS.N.00661

55 Bickels J, Jelinek JS, Shmookler BM, et al. Biopsy of musculoskeletal tumors. Current concepts. Clin Orthop Relat Res 1999;368:212-9.

56 Oliveira MP, Lima PM, de Mello RJ. Tumor contamination in the biopsy path of primary malignant bone tumors. Rev Bras Ortop 2015;47:631-7. https://doi.org/10.1016/S2255-4971(15)30015-X

57 Lin PP, Mirza AN, Yasko AW et al. Patient survival after surgery for osseous metastases from renal cell carcinoma. J Bone Joint Surg Am 2007;89:1794-801. https://doi.org/10.2106/JBJS.F.00603

58 Forsberg JA, Sjoberg D, Chen QR, et al. Treating metastatic disease: which survival model is best suited for the clinic? Clin Orthop Relat Res 2013;471:843-50. https://doi.org/10.1007/s11999-012-2577-z

59 Reif TJ, Strotman PK, Kliethermes SA, et al. No consensus on implant choice for oligometastatic disease of the femoral head and neck. J Bone Oncol 2018;12:14-8. https://doi.org/10.1016/j.jbo.2018.02.006