applied sciences

MDPI

Review

The Role of Embolization in the Management of Musculoskeletal Tumors

Gianmarco Marcello [1], Roberto Marcello [2,*], Giuseppe Francesco Papalia [3,4,†] and Martina Cuccarelli [5,†]

[1] Orthopaedics and Traumatology Unit, Ospedale dei Castelli, Via Nettunense, Km 11/5, 00040 Ariccia, Italy
[2] Vascular and Interventional Radiology Unit, Radiology Department, Diagnostic Imaging Area, Presidio Ospedaliero San Filippo Neri, Via Giovanni Martinotti 20, 00135 Rome, Italy
[3] Oncological Orthopaedics Department, IFO–IRCCS Regina Elena National Cancer Institute, Via Elio Chianesi 53, 00144 Rome, Italy; giuseppefrancesco.papalia@ifo.it
[4] Research Unit of Orthopaedic and Trauma Surgery, Department of Medicine and Surgery, Campus Bio-Medico University, Via Alvaro del Portillo, 21, 00128 Rome, Italy
[5] Department of Anesthesia and Intensive Care Unit, Trauma and Transplant Centre San Camillo Forlanini, Circonvallazione Gianicolense 87, 00152 Rome, Italy
* Correspondence: roberto.marcello@aslroma1.it
† These authors contributed equally to this work.

Abstract

Musculoskeletal tumors encompass a heterogeneous group of neoplasms that, owing to their location and aggressive nature, present significant therapeutic challenges. Within this context, embolization—a minimally invasive technique aimed at selectively occluding tumor-supplying blood vessels—is emerging as a promising complementary or, in certain instances, primary approach. Its potential to reduce tumor volume, control pain, and facilitate surgical intervention renders it an area of increasing clinical interest. This article explores the current role of embolization in treating diverse musculoskeletal tumors, analyzing available scientific evidence, clinical indications, procedural techniques, and potential complications. Available comparative evidence is most developed for preoperative embolization of hypervascular spinal tumors and metastatic lesions. Some systematic reviews and meta-analyses suggest a reduction in intraoperative blood loss, facilitation of surgical resection and improved pain palliation. Evidence concerning extra-spinal tumors, local tumor control, recurrence prevention, and selected benign lesions is more limited and is derived predominantly from small retrospective series. While complications are generally infrequent, they necessitate meticulous superselective catheterization and multidisciplinary planning to mitigate risks such as non-target embolization. Transarterial embolization has a selective, indication-dependent role in the multidisciplinary management of musculoskeletal tumors, particularly for preoperative devascularization of selected hypervascular lesions, promising improved patient outcomes.

Keywords: embolization; musculoskeletal tumors; interventional radiology; preoperative embolization; pain management

Check for updates

Academic Editor: Stefan H. Bossmann

Received: 22 June 2026
Revised: 31 October 2026
Accepted: 1 November 2026
Published: 3 November 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Musculoskeletal tumors, encompassing both primary neoplasms arising within the bone or soft tissues and secondary metastatic lesions originating from distant sites, represent a complex and heterogeneous group of diseases. Their inherent diversity in histology, biological behavior, and anatomical location underscores the critical importance of adopting multimodal therapeutic approaches that integrate surgical, medical, and radiologic

interventions to optimize patient outcomes and address the multifaceted challenges posed by these oncologic entities [1,2].

Embolization stands as a minimally invasive endovascular technique that has demonstrated considerable utility across a spectrum of medical disciplines, including the management of complex oncologic conditions. This image-guided procedure involves the targeted occlusion of specific blood vessels, thereby offering a precise and less invasive alternative to traditional surgical interventions in selected clinical scenarios.

Within the specific context of musculoskeletal oncology, the rationale for employing embolization is multifaceted and compelling. Primarily, it offers a strategic means to mitigate intraoperative and perioperative hemorrhage, particularly crucial in cases involving highly vascularized tumors. Furthermore, the technique facilitates tumor devascularization, potentially leading to cellular hypoxia and necrosis, thereby exerting a direct anti-tumor effect. Beyond these direct benefits, embolization can also play a significant adjunctive role by downstaging tumors or delineating their margins, thus enhancing the feasibility and efficacy of subsequent definitive treatments such as surgical resection or targeted radiation therapy [3–5].

This review will subsequently elaborate upon the fundamental principles underpinning the embolization technique, delineate its diverse clinical applications across the spectrum of primary and metastatic musculoskeletal tumors, detail the procedural methodologies and imaging considerations integral to its successful implementation, and critically evaluate the extant clinical evidence supporting its efficacy and safety profile within this challenging oncologic domain. Furthermore, a concise overview of potential complications and future directions in this evolving field will be provided, offering a comprehensive perspective on the current and prospective role of embolization in the management of musculoskeletal malignancies.

2. Materials and Methods

This narrative review was conducted through a structured search on PubMed, Scopus and Cochrane Library to identify relevant evidence published during the last 10 years. The final search was performed on 19 August 2026. The search was restricted to reviews, systematic reviews, and meta-analyses and was performed using database-specific strategies, which are reported in Supplementary Materials File S1. The manuscripts were examined for relevance, and were considered eligible when they addressed the indications, procedural techniques, clinical outcomes, complications, or role of therapeutic embolization in musculoskeletal tumors. Additional relevant studies were identified through citation searching and retained to provide historical and technical context.

3. Principles of the Embolization Procedure

Embolization can be precisely defined as a targeted interventional technique involving the deliberate and selective occlusion of the vascular conduits that directly supply a tumorous lesion. This meticulously executed process aims to impede the flow of oxygenated blood and essential nutrients to the neoplastic tissue, thereby initiating a cascade of biological effects that can ultimately contribute to tumor growth control and symptomatic relief.

The armamentarium of embolic agents employed in this technique encompasses a diverse array of biocompatible materials, each possessing distinct physicochemical characteristics tailored to specific clinical scenarios. These include particulate embolic agents, ranging in size and composition (e.g., polyvinyl alcohol particles, trisacryl gelatin microspheres), which induce distal arteriolar occlusion. Metallic coils, often composed of platinum or stainless steel, are utilized for more proximal vessel occlusion, providing a durable mechanical barrier to blood flow. Liquid embolic agents, such as cyanoacrylate-based adhesives or ethylene-vinyl alcohol copolymers, offer the capability for rapid and often irreversible

vascular obliteration, particularly advantageous in high-flow or complex vascular environments. The selection of the appropriate embolic material is predicated upon factors such as the size and location of the target vessels, the desired degree and permanence of occlusion, and the specific clinical objectives of the embolization procedure [6].

The procedural approach to embolization necessitates careful consideration of the vascular anatomy and the specific characteristics of the target lesion, dictating the optimal access route. The most frequently employed pathway is the arterial route, typically accessed percutaneously via the femoral, radial, or brachial artery. This allows for selective catheterization of the arterial branches directly supplying the tumor. However, in specific clinical contexts, such as certain vascular malformations or when targeting venous drainage of a tumor, a venous access may be indicated, often achieved through percutaneous puncture of a femoral or jugular vein. The choice of access site and subsequent catheter navigation are guided by meticulous pre-procedural imaging and real-time fluoroscopic guidance to ensure precise and selective delivery of the embolic agents to the intended vascular territory.

The therapeutic efficacy of embolization in the management of musculoskeletal tumors is mediated through several key mechanisms. Firstly, the reduction in hemorrhage represents a critical benefit, particularly in the context of hypervascularized neoplasms where the risk of significant intraoperative or spontaneous bleeding is substantial [3–5]. Hemangiomas, alveolar soft part sarcoma, chondroblastoma, synovial sarcoma, fibrosarcoma, osteoid osteoma, aneurysmal bone cyst, giant cell, thyroid, and renal cell carcinoma are among the well-known hypervascular tumors [7]. Nevertheless, hypervascularity is not exclusively related to these tumor types [8]. It is generally acknowledged that preoperative embolization reduces intraoperative blood loss when tumor hypervascularity is present [9–13]. By occluding the arterial supply, embolization can dramatically decrease blood flow to the tumor bed, thereby facilitating safer surgical resection and minimizing perioperative morbidity. Highly vascular musculoskeletal tumors, including metastatic deposits from renal cell or thyroid carcinoma, are often characterized by a rich network of feeding vessels. Surgical removal of these lesions can lead to substantial blood loss, frequently necessitating extensive blood transfusions. Pre-operative embolization plays a crucial role in significantly reducing the need for transfusions and can substantially shorten the duration of what would otherwise be lengthy and complex surgical procedures [13–15]. While tourniquet application can aid in the excision of such vascular lesions in the limbs, more centrally located tumors unequivocally benefit from embolization to achieve a comparable reduction in intraoperative hemorrhage and facilitate surgical resection. Numerous studies have demonstrated that pre-operative embolization improves resectability and decreases intraoperative blood loss in individuals with spinal metastases before corpectomy [16–19]. Also, tumors that were once thought to be modestly vascular, including multiple myeloma, melanoma, or prostate cancer, have significant angiographic vascularity, which means that intra-operative blood loss may be surprisingly substantial [8]. This may be a significant contributor to both perioperative and postoperative morbidity [20–22].

Secondly, embolization can induce direct tumor devitalization through the deprivation of essential oxygen and nutrients. Furthermore, specialized techniques such as chemoembolization and radioembolization leverage the embolization procedure to deliver high concentrations of chemotherapeutic agents or radioactive isotopes directly into the tumor microenvironment, maximizing local cytotoxic effects while minimizing systemic exposure.

Thirdly, the resultant tumor volume reduction following successful embolization, often referred to as a “downstaging” effect, can render previously unresectable lesions amenable to surgical intervention or enhance the efficacy of subsequent adjuvant therapies [5,23].

Finally, in selected cases, embolization can contribute to pain control, potentially by reducing tumor-related mass effect on surrounding pain-sensitive structures or by inter-

rupting the neovascularization associated with tumor growth and pain generation [23–27]. These multifaceted mechanisms underscore the therapeutic potential of embolization in the comprehensive management of musculoskeletal malignancies.

4. Clinical Applications in Musculoskeletal Tumors

The clinical applications of embolization are presented according to lesion type and principal treatment intent, including preoperative devascularization, palliative treatment, and primary or standalone local therapy.

4.1. Primary Bone Tumors

Within the spectrum of primary osseous neoplasms, embolization demonstrates distinct clinical utility across various histotypes [1]. For osteosarcoma, while not a frequent primary treatment modality, embolization may be considered as an adjunct therapy in carefully selected cases, such as to manage significant hemorrhage or to achieve a degree of tumor devascularization prior to definitive surgery. The integration of transarterial chemoembolization with subsequent limb salvage surgery has demonstrated promising outcomes [28]. Chondrosarcomas, particularly those exhibiting high vascularity or located in anatomically complex sites, may benefit from embolization to mitigate bleeding risks and potentially aid in local disease control.

Furthermore, in the management of aggressive benign bone tumors, such as giant cell tumors, embolization can serve as a primary treatment option to induce tumor regression or as an adjuvant procedure to reduce intraoperative bleeding and simplify subsequent surgical resection, ultimately contributing to improved local control and functional preservation [29]. Serial arterial embolizations have also been proposed as a primary therapeutic strategy in the management of lesions located in the sacrum [30,31] (Figure 1).

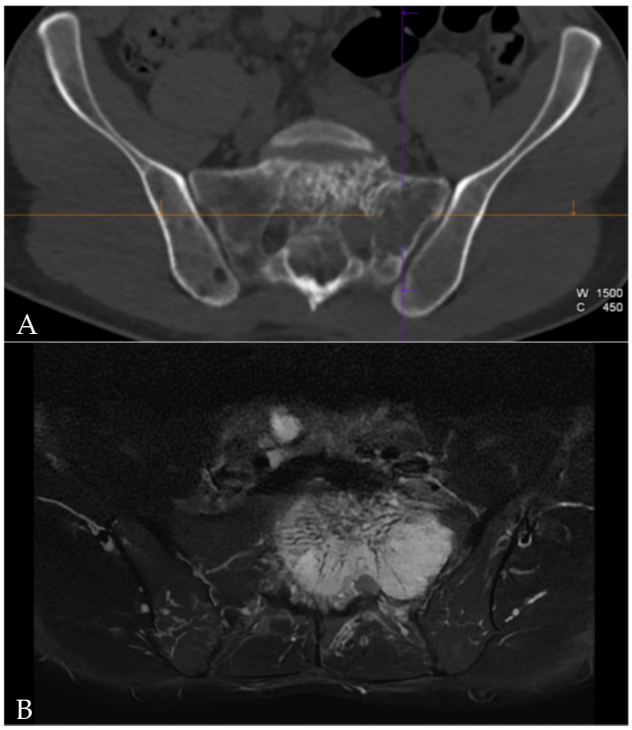


Figure 1. Preprocedural imaging of an epithelioid hemangioma involving the S1 vertebra and left sacral wing. (**A**) Axial CT image demonstrating the aggressive osteolytic nature of the lesion. (**B**) MRI Diffusion-Weighted Imaging (DWI) sequence highlighting the high cellularity and water restriction within the neoplastic tissue.

In addition to being an effective stand-alone treatment in cases challenging to treat surgically, selective embolization of aneurysmal bone cysts has been demonstrated to prevent excessive bleeding when used in conjunction with surgery [29,32–36]. Selective artery embolization should be carried out if the ABC diagnosis is definite and stability is not undermined [37] (Figure 2).

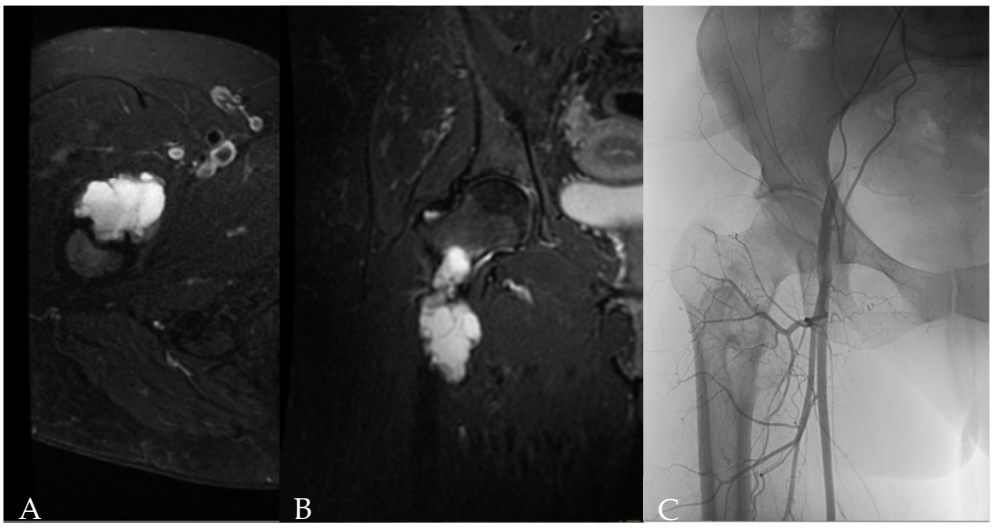


Figure 2. Aneurysmal bone cyst of the proximal right femur. (**A**,**B**) T2-weighted fat-suppressed MRI images showing the multiloculated lesion and characteristic fluid–fluid levels. (**C**) Selective angiography of the right common femoral artery, demonstrating the tumor blush and feeding arterial branches before embolization.

Embolization is also indicated in hemangiomas [38,39], and numerous studies have recommended preoperative embolization also in the treatment of osteoid osteomas and osteoblastomas, since these lesions are frequently highly vascular [40,41] (Figure 3).

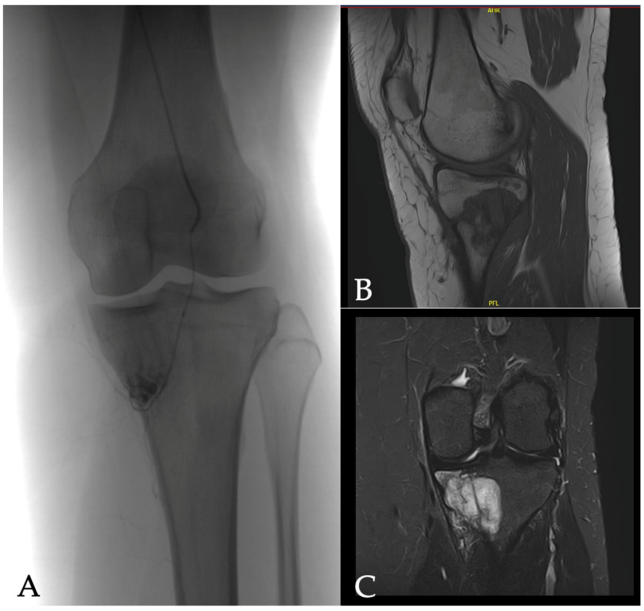


Figure 3. Hemangioma of the proximal left tibia. (**A**) Conventional radiograph showing the subtle trabecular pattern often associated with intraosseous vascular lesions. (**B**) T1-weighted MRI demonstrating the lesion's signal intensity relative to bone marrow. (**C**) T2-weighted FAT-SAT sequence revealing high signal intensity, characteristic of the vascular/fluid component, aiding in the differentiation from other aggressive osseous neoplasms.

4.2. Skeletal Metastases

In the context of skeletal metastases, embolization assumes a significant role in palliative care, particularly for managing symptomatic lesions. Its primary applications include the effective control of pain associated with metastatic deposits [14,42], especially in cases involving highly vascularized metastases originating from primary tumors such as renal cell carcinoma or thyroid carcinoma. By reducing blood flow to the affected bone, embolization can alleviate pain through decreased tumor-related pressure and potentially by interfering with the production of pain-inducing factors [23,25–27]. Clinical evidence concerning the combination of embolization and radiotherapy remains limited. Embolization can potentially enhance the efficacy of subsequent radiation delivery by reducing tumor volume and altering the tumor microenvironment, potentially leading to improved local control and synergistic therapeutic effects [43]. The optimal sequencing and combination of these modalities remain an area of ongoing investigation and clinical refinement.

4.3. Soft Tissue Neoplasms

Regarding soft tissue neoplasms, the application of embolization demonstrates potential utility in specific scenarios. In the management of soft tissue sarcomas, pre-operative embolization may be considered in select cases to achieve a reduction in tumor volume and to minimize intraoperative blood loss, potentially facilitating surgical resection and improving local control, particularly for larger or highly vascularized lesions. Furthermore, in the context of vascular tumors, such as hemangiomas and angiosarcomas, embolization can play a significant role in controlling tumor growth and managing associated bleeding complications. By selectively occluding the feeding vessels, embolization can lead to tumor regression and alleviate symptoms related to their vascularity, offering a valuable therapeutic option in these often challenging clinical entities [44] (Figure 4).

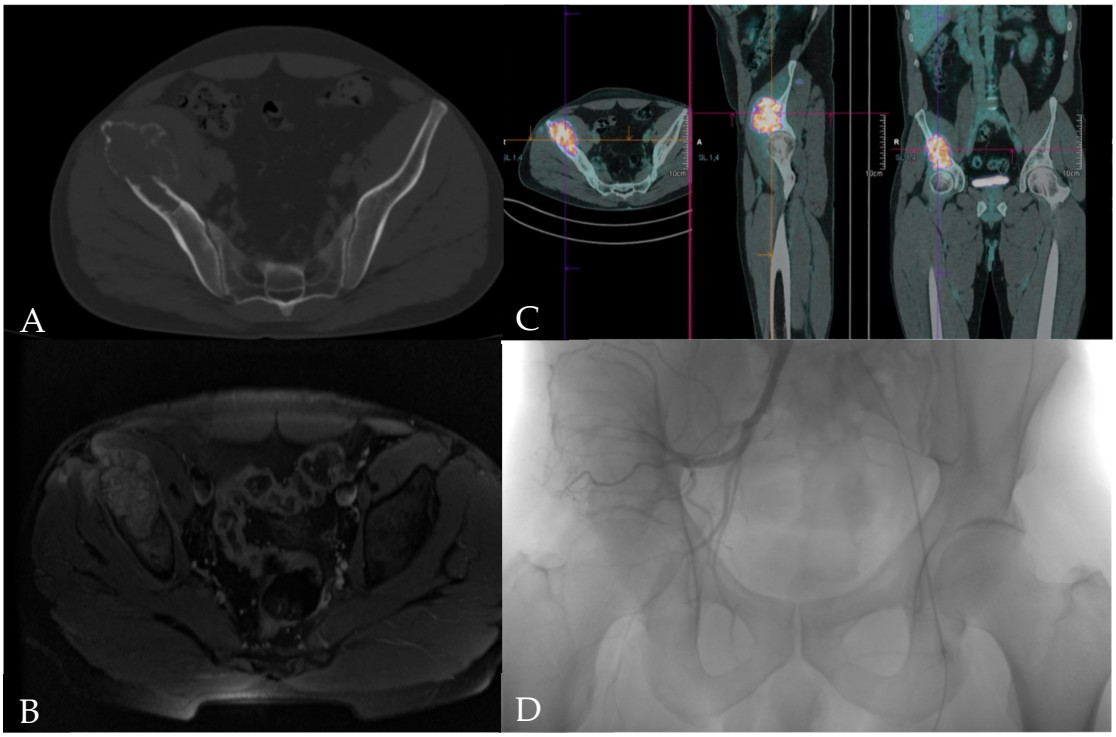


Figure 4. Epithelioid hemangioendothelioma of the right hemipelvis. (**A**) CT scan and (**B**) MRI DWI sequence showing the pelvic involvement. (**C**) PET-CT scan demonstrating the metabolic activity of the lesion. (**D**) Selective angiography of the right internal iliac artery identifying the dominant vascular supply, essential for targeted devascularization and mitigation of intraoperative blood loss.

5. Contraindications

Embolization is generally not indicated for avascular tumors. Absolute contraindications to elective tumor embolization include uncorrectable severe coagulopathy and vascular anatomy in which embolization would compromise the arterial supply to critical structures. Moreover, embolization should be avoided when angiography demonstrates a shared or otherwise unsafe arterial supply to the spinal cord, brainstem, or intracranial circulation that cannot be reliably protected or selectively avoided using superselective techniques [45,46]. Coagulation abnormalities, thrombocytopenia, and anemia should be regarded as relative contraindications. According to interventional radiology guidelines, a platelet count of at least 50×10^9/L should generally be maintained, and an international normalized ratio (INR) above 1.5 should be corrected before procedures associated with moderate or high bleeding risk [47,48]. No embolization-specific hemoglobin threshold has been established; however, severe or symptomatic anemia should be corrected according to the patient's clinical condition and anticipated procedural blood loss. These parameters should be individualized according to procedural urgency, comorbidities, and institutional protocols.

6. Pre-Procedural Imaging and Evaluation

Meticulous pre-procedural imaging plays a pivotal role in the planning and execution of embolization procedures for musculoskeletal tumors. Cross-sectional imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) are indispensable for a comprehensive evaluation of the tumor's extent and its spatial relationship with adjacent critical neurovascular structures, bone, and soft tissues in order to identify the affected anatomical structures and the likely blood supply [49]. High contrast enhancement, involvement of big feeder arteries, flow voids, aggressive violation of anatomic barriers and intralesional bleeding are the typical MRI features that indicate hypervascularity [7]. Angiography, often performed via digital subtraction angiography (DSA), remains the gold standard for providing a detailed vascular mapping, elucidating the arterial and venous anatomy supplying the tumor. To give a comprehensive map of the lesion's vascular supply, a nonselective angiogram of the region should be carried out first, followed by selective angiography. In addition to precisely identifying the lesion supply, it is crucial to identify the vessels supplying the tumor and their supply to normal structures. This allows for the precise identification of target vessels for embolization and the crucial recognition of potential collateral pathways that may need to be addressed to achieve complete tumor devascularization [49].

This multi-modal imaging approach ensures accurate procedural planning, facilitates safe and effective catheter navigation, and optimizes the delivery of embolic agents to the intended target while minimizing the risk of non-target embolization and associated complications (Figure 5).

Patients need laboratory testing to make sure that platelet counts and clotting times are within the normal range. Due to the lengthy nature of these procedures and the possibility of massive contrast injections, renal function must be evaluated and the patient must be kept adequately hydrated, preferably beginning at least 12 h prior to the procedure [49].

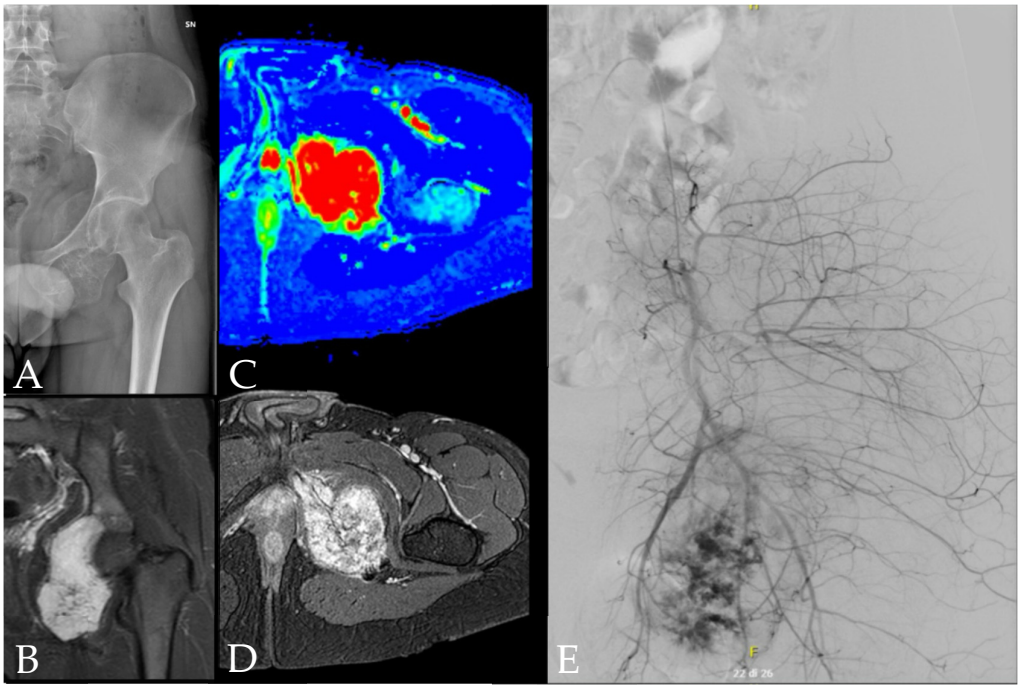


Figure 5. Multimodal imaging evaluation of a hemangioma in the left ischiopubic branch. (**A**) Conventional radiograph and (**B**) T2-weighted FAT-SAT MRI displaying the lesion's characteristic hyperintense signal. (**C**) MRI perfusion sequence and (**D**) T1-weighted post-contrast image illustrating the intense intralesional vascularity. (**E**) Selective digital subtraction angiography (DSA) of the left internal iliac artery confirms the presence of multiple arterial feeders, providing the definitive vascular map for embolization planning.

7. Embolization Techniques

The repertoire of embolization techniques employed in the treatment of musculoskeletal tumors encompasses several distinct approaches, each tailored to specific clinical scenarios and therapeutic goals. Selective and superselective arterial embolization involves the precise catheterization of the arterial vessels directly supplying the tumor, followed by the targeted deployment of embolic agents to achieve vascular occlusion while preserving flow to adjacent normal tissues. In the context of delivering localized chemotherapy, transarterial chemoembolization (TACE) involves the intra-arterial administration of chemotherapeutic agents, often emulsified with an oil-based contrast medium, followed by embolization of the feeding vessels to prolong drug exposure within the tumor [23,28]. A refinement of this technique, drug-eluting bead transarterial chemoembolization (DEB-TACE), utilizes microspheres that are pre-loaded with chemotherapeutic drugs, allowing for a more controlled and sustained release of the therapeutic agent directly within the tumor microenvironment. Finally, transarterial radioembolization (TARE), also known as selective internal radiation therapy (SIRT), involves the intra-arterial delivery of microspheres containing radioactive isotopes directly to the tumor vasculature, delivering targeted radiation therapy from within the tumor while limiting systemic radiation exposure. However, clinical evidence supporting DEB-TACE and TARE/SIRT in musculoskeletal oncology remains limited, without indication-specific recommendations.

Percutaneous transcatheter arterial embolization of bone tumors typically employs coaxial catheter systems, utilizing a direct, superselective approach to target the lesion. Following the establishment of a transfemoral access via a 5–6 French sheath, a 4–6 French catheter is advanced for initial angiographic visualization of the tumor. The selection of the catheter and the route of embolic material administration are contingent upon the tumor's anatomical location. For spinal and pelvic tumors, initial flush aortography is generally

performed. In cases of "peripheral" tumors, a selective catheter is navigated to the primary supplying artery of the affected extremity; for femoral bone tumors, an ipsilateral antegrade approach is frequently preferred.

Subsequently, appropriate selective angiographic catheters are advanced to, or, when vessel size permits, directly into the arterial feeders of the tumor. In spinal tumors, the angiographic evaluation must include visualization of the arteries at least two vertebral levels above and below the tumor site. Furthermore, it is essential to identify or exclude the presence of lumbar or thoracic supplementary vertebral arteries originating from the tumor-feeding vessels. Once a stable selective catheter position is achieved, a microcatheter (2.7 French) is introduced through the selective catheter.

The choice of embolic material is heavily influenced by the unique characteristics of the tumor vasculature, including the presence or absence of arteriovenous shunts, vessel caliber irregularities, collateral supply to or from adjacent healthy tissue, and other relevant factors. Both liquid embolic agents, such as cyanoacrylates, and particulate embolic materials represent viable options for achieving vascular occlusion in embolization procedures [50]. Liquid embolic agents present the possibility of achieving a more thorough devascularization of tumors; however, this potential benefit is accompanied by an elevated risk of unintended retrograde embolization or catheter adhesion, particularly with tissue adhesives such as cyanoacrylates [1]. In contrast, particulate embolic materials are generally easier to manipulate. Nevertheless, the use of inappropriately sized particles can lead to transvenous migration, potentially resulting in pulmonary embolism, or, similarly, to retrograde embolization if administered in excessively large sizes or quantities, or at an excessively rapid injection rate [51].

Coils can be used to obstruct the feeding segmental arteries proximally during embolization, particles can be used to obstruct the tumor feeding arteries distally, or a combination of these two techniques can be used.

Although coils may be used if the patient is being transferred to the operating theater right away and in case of very few arteries feeding a tumor, particles are commonly used for embolization. It is generally advised to avoid placing coils proximally since tumors frequently have a large collateral supply, and if a coil blocks catheter placement farther distally, it may prevent additional efforts at embolization.

Given the complex vascular architecture of osseous neoplasms, which almost invariably exhibit multiple major arterial feeders, a correspondingly intricate procedural approach, often involving several distinct steps, is necessitated irrespective of the tumor's anatomical location. Whenever safely feasible, the procedural objective should be maximal selective tumor devascularization while preserving the arterial supply to adjacent critical structures [52].

8. Clinical Results and Scientific Evidence

Published clinical outcomes following embolization in musculoskeletal tumors suggest potential benefits across several therapeutic endpoints, although the strength of the supporting evidence varies considerably among indications. Notably, the procedure has demonstrated its ability to achieve significant hemorrhage control, proving particularly valuable in managing highly vascular lesions and minimizing intraoperative blood loss during subsequent surgical resection [53–55]. Furthermore, a reduction in tumor volume following embolization has been reported, potentially facilitating surgical downstaging or improving the response to adjuvant therapies [55]. The application of pre-operative embolization has also been associated with improved surgical outcomes, including enhanced resectability and reduced local recurrence rates in some tumor types [56]. Finally, the analgesic effects of embolization have been recognized, with patients experiencing significant pain relief,

particularly in the context of metastatic bone disease where tumor-related vascularity and mass effect contribute to symptomatic burden [57].

The strength of the available evidence varies considerably across indications. Comparative evidence is most developed for the preoperative embolization of hypervascular spinal tumors and metastases. In a systematic review and meta-analysis of 17 studies, Qiao et al. reported mean intraoperative blood losses of 1716.4 mL in embolized patients and 1786.3 mL in nonembolized patients. The pooled analysis favored preoperative embolization, with a standardized mean difference of 0.398 (95% CI 0.114–0.682). Major complications did not differ significantly between the groups (OR 1.426, 95% CI 0.760–2.674), while the additional rate of embolization-related complications was 1.53% [19]. Conversely, a more recent meta-analysis by Daher et al., including 15 comparative studies and 565 patients, found no consistent overall benefit of embolization when surgical invasiveness was balanced ($p = 0.75$), whereas the apparent reduction in blood loss was confined to unbalanced studies, suggesting residual confounding [16]. The apparently differing conclusions of these meta-analyses may be explained by differences in study selection and the analytical handling of surgical complexity.

Evidence concerning extra-spinal musculoskeletal tumors, including pelvic and long-bone metastases, is less consistent. Sare et al. reported a single-center cohort of 58 patients undergoing preoperative embolization of hypervascular musculoskeletal tumors, with a median estimated blood loss of 500 mL and a median transfusion requirement of 1 unit. In their accompanying systematic review of nine studies and 118 patients, the mean estimated blood loss was 976.9 mL; no complications related to nontarget embolization were reported [12]. In a systematic review of seven level-III studies on long-bone metastases, Geraets et al. found that three of six studies involving renal-cell carcinoma metastases demonstrated reduced blood loss or transfusion requirements, whereas the remaining three did not. Embolization-related complication rates ranged from 0% to 9%, and no supporting comparative evidence was identified for thyroid, breast, lung, or prostate carcinoma metastases [13].

Regarding embolic agents, a systematic review and meta-analysis of Onyx embolization for spinal tumors showed complete reduction in tumor blush in 52% of evaluable cases (95% CI 16–88%), while three studies reported a median devascularization rate of 91%. Among the 63 patients for whom complication data were available, two complications were reported, corresponding to a pooled rate of 1% (95% CI 0–6%), with no procedure-related deaths [50].

Data supporting embolization for pain palliation, local tumor control, recurrence prevention, and the treatment of benign lesions are derived predominantly from small retrospective series and case reports. A systematic review of nine studies including 44 patients with sacral or pelvic giant cell tumors treated with serial selective arterial embolization reported an 81.8% radiographic response rate, a 75% local control rate, and an 81.8% overall survival rate after a mean follow-up of 85.8 months. No bowel, bladder, or sexual dysfunction was reported, although three patients developed distant metastases and subsequently died [31]. Similarly, a patient-level meta-analysis of aggressive vertebral hemangiomas included 16 studies, 149 patients, and 150 lesions, with a mean follow-up of 49.8 months. The pooled recurrence rate was 7.9%, symptom resolution was achieved in 43.4% of patients, and Frankel-grade improvement occurred in 68.4% [39].

For pain palliation, Forauer et al. reported a clinical response in 36 of 39 renal-cell carcinoma bone metastases treated in 21 patients, with a mean response duration of 5.5 months [57]. A systematic review evaluating embolization combined with radiotherapy included only three studies, 74 patients, and 103 painful bone metastases, with a median follow-up of 6 months (range 0.5–103 months). The combined approach was associated

with faster and more durable pain relief than radiotherapy alone [43]. Postembolization pain and fever were the most frequently reported complications.

The principal clinical studies and quantitative evidence syntheses supporting the indications discussed in this review are summarized in Table S1. However, the available evidence is heterogeneous in terms of tumor histology, anatomical location, treatment intent, embolization technique, surgical procedure, and outcome definition.

9. Complications

While generally considered a safe and well-tolerated procedure, embolization is not without potential complications, which can be broadly categorized as local or systemic. Post-embolization syndrome, characterized by pain at the treatment site resulting from a transient increase in the tumor volume caused by post-embolization edema, fever, and gastrointestinal symptoms such as nausea and vomiting, is a relatively common occurrence, typically self-limiting but occasionally requiring symptomatic management [1,44]. More significant complications include the risk of vascular damage, such as arterial dissection or thrombosis at the access site or within the treated vessels. Furthermore, there exists the potential for non-target embolization, where embolic agents inadvertently migrate to and occlude unintended vascular territories, potentially leading to ischemia or infarction in normal tissues. Devastating adverse consequences such as ischemic neuropraxia, tissue sloughing, ulceration, or limb loss are frequently caused by nontarget embolization. In the context of vertebral bone embolization, spinal cord infarction represents the most significant potential complication [45,46,49]. To mitigate this risk, meticulous and repeated angiographic visualization of the target vascular territory is mandatory, as spinal artery feeders, including potentially the artery of Adamkiewicz, may become apparent due to hemodynamic redistribution effects. Because of this, particles that are over 300 μm in diameter are often used and liquid agents like alcohol, which can cause extensive necrosis, are avoided. To this end, cyanoacrylate can be beneficial, if the operator is familiar in using it [49].

Finally, the spectrum of site-specific and technique-dependent complications can vary considerably based on the location of the tumor being treated and the specific embolic materials and delivery methods employed, necessitating meticulous procedural planning and execution to mitigate these risks. It is crucial to understand that the significant collateral vessels frequently make it challenging to completely devascularize the tumors, and that occasionally the outcome can be unsatisfactory, even though many patients show relief in their symptoms even in these situations.

The mitigation of potential complications associated with embolization necessitates the implementation of meticulous preventative strategies and well-defined management protocols. Careful patient selection, thorough pre-procedural imaging and planning, precise catheter navigation under fluoroscopic guidance, and the judicious selection and deployment of embolic agents are paramount in minimizing the risk of adverse events. Post-procedural care includes vigilant monitoring for signs and symptoms of complications, prompt initiation of supportive measures for post-embolization syndrome, and immediate intervention in the event of more serious sequelae such as vascular injury or non-target embolization. The optimal management of these complex procedures and their potential complications underscores the critical importance of an experienced multidisciplinary team, comprising interventional radiologists, oncologists, orthopedic surgeons, and allied healthcare professionals. Their collective expertise ensures comprehensive patient assessment, meticulous procedural execution, and timely and effective management of any arising complications, ultimately contributing to improved patient safety and outcomes.

10. The Future of Embolization in Musculoskeletal Tumors

The field of embolization in musculoskeletal oncology is poised for significant advancements driven by ongoing research and technological innovation. The development of novel embolic materials with enhanced biocompatibility, biodegradability, and imaging characteristics, alongside innovative drug delivery techniques, holds the promise of improving the precision and efficacy of local therapies. Furthermore, the potential role of artificial intelligence (AI) in pre-procedural planning, including automated vascular segmentation and treatment simulation, as well as intra-procedural guidance, could enhance the accuracy and efficiency of embolization procedures. A key area of evolution lies in the integration of embolization within more sophisticated multimodal therapeutic protocols, potentially in synergistic combinations with immunotherapy, targeted agents, and advanced radiation techniques. Ultimately, the future trajectory aims towards a greater degree of treatment personalization, tailoring the choice of embolic agents, delivery techniques, and combination therapies based on the unique molecular and imaging characteristics of individual tumors and the specific clinical profile of each patient.

11. Limitations

This review has several limitations. First, the narrative design may have led to selection and publication bias. Second, the available literature is markedly heterogeneous in terms of tumor type, anatomical location, treatment intent, embolization technique, embolic agent, outcome definition, and duration of follow-up, limiting direct comparisons across studies. Moreover, for several uncommon indications, particularly primary bone and soft-tissue tumors and the use of embolization as a standalone treatment, the available evidence is derived predominantly from retrospective cohorts, which limits the generalizability of the reported findings. Finally, the rapid evolution of embolic materials and multimodal treatment strategies may affect the applicability of current evidence over time.

12. Conclusions

Transarterial embolization emerges as a promising minimally invasive approach, and may have a selective, indication-dependent role in the multidisciplinary management of musculoskeletal tumors. Its primary application is the preoperative devascularization of selected hypervascular spinal tumors and metastases. For extra-spinal tumors, pain palliation, local tumor control, recurrence prevention, and the standalone treatment of benign lesions, the available findings are promising but remain insufficient to support definitive conclusions. Therefore, treatment decisions should be individualized according to tumor histology, vascularity, anatomical location, therapeutic intent, and procedural risk.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app162110883/s1, Supplementary Materials File S1: Database-specific search strategies. Table S1: Structured synthesis of the principal clinical evidence.

Author Contributions: Conceptualization, G.M. and R.M.; methodology, G.F.P. and M.C.; validation, R.M. and G.F.P.; formal analysis, G.M.; investigation, M.C.; resources, G.F.P.; data curation, G.M.; writing—original draft preparation, G.M. and R.M.; writing—review and editing, G.F.P. and M.C.; visualization, R.M.; supervision, G.F.P. Martina Cuccarelli and Giuseppe Francesco Papalia contributed equally to this work and share last authorship. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Radeleff, B.; Eiers, M.; Lopez-Benitez, R.; Noeldge, G.; Hallscheidt, P.; Grenacher, L.; Libicher, M.; Zeifang, F.; Meeder, P.J.; Kauffmann, G.W.; et al. Transarterial Embolization of Primary and Secondary Tumors of the Skeletal System. *Eur. J. Radiol.* **2006**, *58*, 68–75. [CrossRef]
2. Key, B.M.; Callstrom, M.R.; Filippiadis, D. Musculoskeletal Interventional Oncology: A Contemporary Review. *Am. J. Roentgenol.* **2023**, *221*, 503–516. [CrossRef]
3. Wirbel, R.J.; Roth, R.; Schulte, M.; Kramann, B.; Mutschler, W. Preoperative Embolization in Spinal and Pelvic Metastases. *J. Orthop. Sci. Off. J. Jpn. Orthop. Assoc.* **2005**, *10*, 253–257. [CrossRef]
4. Chatziioannou, A.N.; Johnson, M.E.; Pneumaticos, S.G.; Lawrence, D.D.; Carrasco, C.H. Preoperative Embolization of Bone Metastases from Renal Cell Carcinoma. *Eur. Radiol.* **2000**, *10*, 593–596. [CrossRef]
5. Guzman, R.; Dubach-Schwizer, S.; Heini, P.; Lovblad, K.-O.; Kalbermatten, D.; Schroth, G.; Remonda, L. Preoperative Transarterial Embolization of Vertebral Metastases. *Eur. Spine J. Off. Publ. Eur. Spine Soc. Eur. Spinal Deform. Soc. Eur. Sect. Cerv. Spine Res. Soc.* **2005**, *14*, 263–268. [CrossRef]
6. Owen, R.J.T. Embolization of Musculoskeletal Bone Tumors. *Semin. Interv. Radiol.* **2010**, *27*, 111–123. [CrossRef]
7. Bode, K.S.; Radcliff, K.E.; Vaccaro, A.R. MRI Characterization of Vascular Spinal Tumors. *J. Spinal Disord. Tech.* **2015**, *28*, E590–E594. [CrossRef]
8. Thiex, R.; Harris, M.B.; Sides, C.; Bono, C.M.; Frerichs, K.U. The Role of Preoperative Transarterial Embolization in Spinal Tumors. A Large Single-Center Experience. *Spine J. Off. J. N. Am. Spine Soc.* **2013**, *13*, 141–149. [CrossRef]
9. Manke, C.; Bretschneider, T.; Lenhart, M.; Strotzer, M.; Neumann, C.; Gmeinwieser, J.; Feuerbach, S. Spinal Metastases from Renal Cell Carcinoma: Effect of Preoperative Particle Embolization on Intraoperative Blood Loss. *AJNR Am. J. Neuroradiol.* **2001**, *22*, 997–1003.
10. Berkefeld, J.; Scale, D.; Kirchner, J.; Heinrich, T.; Kollath, J. Hypervascular Spinal Tumors: Influence of the Embolization Technique on Perioperative Hemorrhage. *AJNR Am. J. Neuroradiol.* **1999**, *20*, 757–763.
11. Breslau, J.; Eskridge, J.M. Preoperative Embolization of Spinal Tumors. *J. Vasc. Interv. Radiol. JVIR* **1995**, *6*, 871–875. [CrossRef]
12. Sare, A.; Jain, N.; Chandra, V.; Beidas, A.-K.; Kumar, A.; Shukla, P.A. Perioperative Blood Loss after Embolization of Hypervascular Musculoskeletal Tumors Outside of the Spine: A Single-Center Ten Year Experience and Systematic Review of the Literature. *Clin. Imaging* **2021**, *79*, 24–29. [CrossRef]
13. Geraets, S.E.W.; Bos, P.K.; Van Der Stok, J. Preoperative Embolization in Surgical Treatment of Long Bone Metastasis: A Systematic Literature Review. *EFORT Open Rev.* **2020**, *5*, 17–25. [CrossRef]
14. Haber, Z. Transarterial Embolization of Bone Metastases. *Tech. Vasc. Interv. Radiol.* **2023**, *26*, 100883. [CrossRef]
15. Ma, J.; Tullius, T.; Van Ha, T.G. Update on Preoperative Embolization of Bone Metastases. *Semin. Interv. Radiol.* **2019**, *36*, 241–248. [CrossRef]
16. Daher, M.; Nahle, T.; Abi Farraj, S.; Cottrill, E.J.; Sebaaly, A.; Passias, P.G.; Daniels, A.H.; Eward, W.C. Benefits of Preoperative Embolization in Surgery for Hypervascular Spinal Tumors: A Meta-Analysis. *Spine* **2026**, *51*, E229–E239. [CrossRef]
17. Facchini, G.; Parmeggiani, A.; Peta, G.; Martella, C.; Gasbarrini, A.; Evangelisti, G.; Miceli, M.; Rossi, G. The Role of Percutaneous Transarterial Embolization in the Management of Spinal Bone Tumors: A Literature Review. *Eur. Spine J.* **2021**, *30*, 2839–2851. [CrossRef]
18. Omid-Fard, N.; Fisher, C.G.; Heran, M.K. The Evolution of Pre-Operative Spine Tumour Embolization. *Br. J. Radiol.* **2019**, *92*, 20180899. [CrossRef]
19. Qiao, R.; Ma, R.; Zhang, X.; Lun, D.; Li, R.; Hu, Y. Comparison of Intraoperative Blood Loss and Perioperative Complications between Preoperative Embolization and Nonembolization Combined with Spinal Tumor Surgeries: A Systematic Review and Meta-Analysis. *Eur. Spine J.* **2023**, *32*, 4272–4296. [CrossRef]
20. Kawada, S.; Nishiura, T.; Maruo, T.; Takayama, K.; Ogihara, K.; Gotoh, M.; Tsuno, K. Preoperative embolization of metastatic spinal tumors. *No Shinkei Geka* **2004**, *32*, 699–705.
21. Bernd, L.; Ewerbeck, V.; Richter, G. Arterial embolization as a therapeutic possibility of tumors of the skeletal system. *Aktuelle Traumatol.* **1994**, *24*, 87–90.
22. Rossi, C.; Ricci, S.; Boriani, S.; Biagini, R.; Ruggieri, P.; De Cristofaro, R.; Roversi, R.A.; Khalkhali, I. Percutaneous Transcatheter Arterial Embolization of Bone and Soft Tissue Tumors. *Skelet. Radiol.* **1990**, *19*, 555–560. [CrossRef]
23. Chiras, J.; Adem, C.; Vallée, J.-N.; Spelle, L.; Cormier, E.; Rose, M. Selective Intra-Arterial Chemoembolization of Pelvic and Spine Bone Metastases. *Eur. Radiol.* **2004**, *14*, 1774–1780. [CrossRef]

24. Chuang, V.P.; Wallace, S.; Swanson, D.; Zornoza, J.; Handel, S.F.; Schwarten, D.A.; Murray, J. Arterial Occlusion in the Management of Pain from Metastatic Renal Carcinoma. *Radiology* **1979**, *133*, 611–614. [CrossRef]
25. Kato, T.; Nemoto, R.; Mori, H.; Takahashi, M.; Tamakawa, Y.; Harada, M. Arterial Chemoembolization with Microencapsulated Anticancer Drug. An Approach to Selective Cancer Chemotherapy with Sustained Effects. *JAMA* **1981**, *245*, 1123–1127. [CrossRef]
26. Courtheoux, P.; Alachkar, F.; Casasco, A.; Adam, Y.; Derlon, J.M.; Courtheoux, F.; L'Hirondel, J.L.; Theron, J. Chemoembolization of Lumbar Spine Metastases. A Preliminary Study. *J. Neuroradiol. J. Neuroradiol.* **1985**, *12*, 151–162.
27. Eustatia-Rutten, C.F.A.; Romijn, J.A.; Guijt, M.J.; Vielvoye, G.J.; van den Berg, R.; Corssmit, E.P.M.; Pereira, A.M.; Smit, J.W.A. Outcome of Palliative Embolization of Bone Metastases in Differentiated Thyroid Carcinoma. *J. Clin. Endocrinol. Metab.* **2003**, *88*, 3184–3189. [CrossRef]
28. Chu, J.-P.; Chen, W.; Li, J.-P.; Zhuang, W.-Q.; Huang, Y.-H.; Huang, Z.-M.; Yang, J.-Y. Clinicopathologic Features and Results of Transcatheter Arterial Chemoembolization for Osteosarcoma. *Cardiovasc. Interv. Radiol.* **2007**, *30*, 201–206. [CrossRef]
29. De Cristofaro, R.; Biagini, R.; Boriani, S.; Ricci, S.; Ruggieri, P.; Rossi, G.; Fabbri, N.; Roversi, R. Selective Arterial Embolization in the Treatment of Aneurysmal Bone Cyst and Angioma of Bone. *Skelet. Radiol.* **1992**, *21*, 523–527. [CrossRef]
30. Hosalkar, H.S.; Jones, K.J.; King, J.J.; Lackman, R.D. Serial Arterial Embolization for Large Sacral Giant-Cell Tumors: Mid- to Long-Term Results. *Spine* **2007**, *32*, 1107–1115. [CrossRef]
31. He, S.; Xu, W.; Sun, Z.; Liu, W.; Liu, Y.; Wei, H.; Xiao, J. Selective Arterial Embolization for the Treatment of Sacral and Pelvic Giant Cell Tumor: A Systematic Review. *Orthop. Surg.* **2017**, *9*, 139–144. [CrossRef]
32. Cottalorda, J.; Bourelle, S. Modern Concepts of Primary Aneurysmal Bone Cyst. *Arch. Orthop. Trauma Surg.* **2007**, *127*, 105–114. [CrossRef]
33. Liu, J.K.; Brockmeyer, D.L.; Dailey, A.T.; Schmidt, M.H. Surgical Management of Aneurysmal Bone Cysts of the Spine. *Neurosurg. Focus* **2003**, *15*, E4. [CrossRef]
34. Mohit, A.A.; Eskridge, J.; Ellenbogen, R.; Shaffrey, C.I. Aneurysmal Bone Cyst of the Atlas: Successful Treatment through Selective Arterial Embolization: Case Report. *Neurosurgery* **2004**, *55*, 982. [CrossRef]
35. Wathiong, J.; Brys, P.; Samson, I.; Maleux, G. Selective Arterial Embolization in the Treatment of an Aneurysmal Bone Cyst of the Pelvis. *JBR-BTR Organe Soc. R. Belge Radiol. SRBR Orgaan Van K. Belg. Ver. Voor Radiol.* **2003**, *86*, 325–328.
36. Van Geloven, T.P.G.; Van De Sande, M.A.J.; Van Der Heijden, L. The Treatment of Aneurysmal Bone Cysts. *Curr. Opin. Pediatr.* **2023**, *35*, 131–137. [CrossRef]
37. Boriani, S.; De Iure, F.; Campanacci, L.; Gasbarrini, A.; Bandiera, S.; Biagini, R.; Bertoni, F.; Picci, P. Aneurysmal Bone Cyst of the Mobile Spine: Report on 41 Cases. *Spine* **2001**, *26*, 27–35. [CrossRef]
38. Acosta, F.L.; Sanai, N.; Chi, J.H.; Dowd, C.F.; Chin, C.; Tihan, T.; Chou, D.; Weinstein, P.R.; Ames, C.P. Comprehensive Management of Symptomatic and Aggressive Vertebral Hemangiomas. *Neurosurg. Clin. N. Am.* **2008**, *19*, 17–29. [CrossRef]
39. Gebeyehu, T.F.; Matsoukas, S.; Gonzalez, G.A.; Mong, E.; Sokol, Z.; Failla, G.; Heller, J.E.; Vaccaro, A.R.; Jallo, J.; Prasad, S.K.; et al. Outcomes Following Different Treatment Modalities of Aggressive Vertebral Hemangiomas: A Systematic Review and Patient-Level Meta-Analysis. *Neurosurgery* **2026**, *98*, 737–751. [CrossRef]
40. Silva, M.L.; Brunelle, F. Embolisation of Vascular Lesions of the Spinal Column in Childhood: A Report of Three Cases. *Neuroradiology* **1996**, *38*, 809–811. [CrossRef]
41. Denaro, V.; Denaro, L.; Papalia, R.; Marinozzi, A.; Di Martino, A. Surgical Management of Cervical Spine Osteoblastomas. *Clin. Orthop.* **2007**, *455*, 190–195. [CrossRef]
42. Papalia, G.F.; Brigato, P.; Sisca, L.; Maltese, G.; Faiella, E.; Santucci, D.; Pantano, F.; Vincenzi, B.; Tonini, G.; Papalia, R.; et al. Artificial Intelligence in Detection, Management, and Prognosis of Bone Metastasis: A Systematic Review. *Cancers* **2024**, *16*, 2700. [CrossRef]
43. Vizzuso, A.; Renzulli, M.; Lancellotta, V.; Posa, A.; Cornacchione, P.; Fionda, B.; Mazzarella, C.; Leoni, D.D.; Tagliaferri, L.; Giampalma, E.; et al. The Role of Transarterial Embolization Plus Radiotherapy Compared to Radiotherapy or Transarterial Embolization Alone in the Management of Painful Bone Metastases: Results of a Systematic Review. *Cancers* **2024**, *16*, 4183. [CrossRef]
44. Mavrogenis, A.F.; Rossi, G.; Calabrò, T.; Altimari, G.; Rimondi, E.; Ruggieri, P. The Role of Embolization for Hemangiomas. *Musculoskelet. Surg.* **2012**, *96*, 125–135. [CrossRef]
45. Houten, J.K.; Swiggett, S.J.; Hadid, B.; Choueka, D.M.; Kinon, M.D.; Buciuc, R.; Zumofen, D.W. Neurologic Complications of Preoperative Embolization of Spinal Metastasis: A Systemic Review of the Literature Identifying Distinct Mechanisms of Injury. *World Neurosurg.* **2020**, *143*, 374–388. [CrossRef]
46. Papalexis, N.; Peta, G.; Carta, M.; Quarchioni, S.; Di Carlo, M.; Miceli, M.; Facchini, G. How Arterial Embolization Is Transforming Treatment of Oncologic and Degenerative Musculoskeletal Disease. *Curr. Oncol.* **2024**, *31*, 7523–7554. [CrossRef]
47. Mahnken, A.H.; Boullosa Seoane, E.; Cannavale, A.; De Haan, M.W.; Dezman, R.; Kloeckner, R.; O'Sullivan, G.; Ryan, A.; Tsoumakidou, G. CIRSE Clinical Practice Manual. *Cardiovasc. Interv. Radiol.* **2021**, *44*, 1323–1353. [CrossRef]

48. Patel, I.J.; Rahim, S.; Davidson, J.C.; Hanks, S.E.; Tam, A.L.; Walker, T.G.; Wilkins, L.R.; Sarode, R.; Weinberg, I. Society of Interventional Radiology Consensus Guidelines for the Periprocedural Management of Thrombotic and Bleeding Risk in Patients Undergoing Percutaneous Image-Guided Interventions—Part II: Recommendations. *J. Vasc. Interv. Radiol.* **2019**, *30*, 1168–1184.e1. [CrossRef]
49. Munk, P.L.; Legiehn, G.M. Musculoskeletal Interventional Radiology: Applications to Oncology. *Semin. Roentgenol.* **2007**, *42*, 164–174. [CrossRef]
50. Batista, S.; Fim Andreão, F.; Sousa, M.P.; Oliveira, L.D.B.; Palavani, L.B.; Melo Silva, G.; De Abreu, L.V.; Bertani, R.; Gomes Quadros, D. Spinal Tumor Embolization with Onyx: A Systematic Review and Meta-Analysis. *Interv. Neuroradiol.* **2026**, *32*, 1660–1668. [CrossRef]
51. Brown, K.T. Fatal Pulmonary Complications after Arterial Embolization with 40–120-Mm Tris-Acryl Gelatin Microspheres. *J. Vasc. Interv. Radiol.* **2004**, *15*, 197–200. [CrossRef]
52. Kickuth, R.; Waldherr, C.; Hoppe, H.; Bonel, H.M.; Ludwig, K.; Beck, M.; Triller, J. Interventional Management of Hypervascular Osseous Metastasis: Role of Embolotherapy Before Orthopedic Tumor Resection and Bone Stabilization. *Am. J. Roentgenol.* **2008**, *191*, W240–W247. [CrossRef]
53. Fenoy, A.J.; Greenlee, J.D.W.; Menezes, A.H.; Donovan, K.A.; Sato, Y.; Hitchon, P.W.; Chaloupka, J.C. Primary Bone Tumors of the Spine in Children. *J. Neurosurg.* **2006**, *105*, 252–260. [CrossRef]
54. Reuter, M.; Heller, M.; Heise, U.; Beese, M. Transcatheter embolization of tumors of the muscular and skeletal systems. *ROFO Fortschr. Geb. Rontgenstr. Nukl.* **1992**, *156*, 182–188. [CrossRef]
55. Gellad, F.E.; Sadato, N.; Numaguchi, Y.; Levine, A.M. Vascular Metastatic Lesions of the Spine: Preoperative Embolization. *Radiology* **1990**, *176*, 683–686. [CrossRef]
56. Lin, P.P.; Guzel, V.B.; Moura, M.F.; Wallace, S.; Benjamin, R.S.; Weber, K.L.; Morello, F.A.; Gokaslan, Z.L.; Yasko, A.W. Long-Term Follow-up of Patients with Giant Cell Tumor of the Sacrum Treated with Selective Arterial Embolization. *Cancer* **2002**, *95*, 1317–1325. [CrossRef]
57. Forauer, A.R.; Kent, E.; Cwikiel, W.; Esper, P.; Redman, B. Selective Palliative Transcatheter Embolization of Bony Metastases from Renal Cell Carcinoma. *Acta Oncol.* **2007**, *46*, 1012–1018. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.