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(CASE REPORT)

Radiological study of femoral osteosarcoma. Clinical case report and literature review

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Abstract

Introduction: Osteosarcoma is the most common primary malignant bone tumor in adolescents and young adults, predominantly located in the metaphyses of long bones, particularly the distal femur. Radiological imaging is essential for early diagnosis, local and distant staging, surgical planning, and assessment of response to chemotherapy. However, the literature is scattered across studies that address different modalities (radiography, computed tomography, magnetic resonance imaging, and PET-CT) with heterogeneous designs.

Clinical Case: A 13-year-old female patient presented for consultation due to persistent discomfort and noticeable swelling in her right knee, a symptom she had been experiencing for a year. However, it was noted that these symptoms had worsened considerably over the course of the previous month. During the clinical evaluation, an increase in overall size with poorly defined edges, measuring approximately 6 centimeters by 4 centimeters, was noted on the lateral femoral condyle on the right side.

Conclusions: The integration of X-ray, MRI, CT, and PET-CT provides a comprehensive assessment of femoral osteosarcoma. MRI is key for surgical planning and assessment of local extension, while CT and PET-CT complement the structural and metabolic assessment, respectively. , prospective, multicenter studies are needed to standardize imaging criteria and correlate radiological findings with histological and clinical outcomes.

Keywords: Osteosarcoma; Femur; Radiography; Magnetic Resonance Imaging; Computed Tomography; PET-CT

1. Introduction

Osteosarcoma is a malignant bone tumor characterized by the production of immature osteoid by neoplastic cells. It is the most common primary bone tumor in children and adolescents, with a peak incidence between the second decade of life and a second, less marked peak in older adults associated with Paget's disease or previous irradiation. The femur, especially its distal segment, is one of the most commonly affected anatomical sites, followed by the proximal tibia and proximal humerus.

The management of femoral osteosarcoma requires a multidisciplinary approach that integrates clinical, imaging, pathology, and oncology. From a radiological point of view, proper evaluation of the tumor is essential to establish an early diagnosis, define local and systemic spread, select the best therapeutic strategy, and assess response to

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neoadjuvant chemotherapy. Correct interpretation of the images allows osteosarcoma to be differentiated from other aggressive bone lesions, safe oncological margins to be established, and the limb to be preserved when possible.

Multiple imaging modalities are used in clinical practice: conventional radiography continues to be the initial and guiding tool; computed tomography (CT) provides detailed information on the bone cortex, tumor mineralization, and pulmonary metastases; magnetic resonance imaging (MRI) provides excellent characterization of intramedullary and soft tissue extension; and positron emission tomography combined with CT (PET-CT) provides useful metabolic data for staging and evaluating therapeutic response.

Despite the central role of imaging in the management of femoral osteosarcoma, the available evidence is fragmented across studies with diverse designs and objectives. This systematic review aims to organize and synthesize current knowledge on the radiological findings of femoral osteosarcoma, highlighting the value of each modality at different stages of the diagnostic-therapeutic process.

2. Clinical case

A 16-year-old female patient came to the doctor's office due to discomfort and noticeable swelling in her right knee. This problem had been present for a full year, but had worsened significantly in the last month. During the clinical examination, a generalized enlargement lacking well-defined edges was detected, measuring approximately 6 by 4 centimeters, located specifically on the right lateral femoral condyle. Approximately six months ago, the patient underwent a histopathological diagnosis, revealing that she had osteosarcoma, a particular type of bone cancer.

Various types of imaging tests are performed based on his diagnosis, which will be listed and described below to provide a better understanding of the procedures performed.

2.1. Simple non-contrast axial computed tomography of the right femur (different planes)

Axial Pano of the right femur (Figure 1)

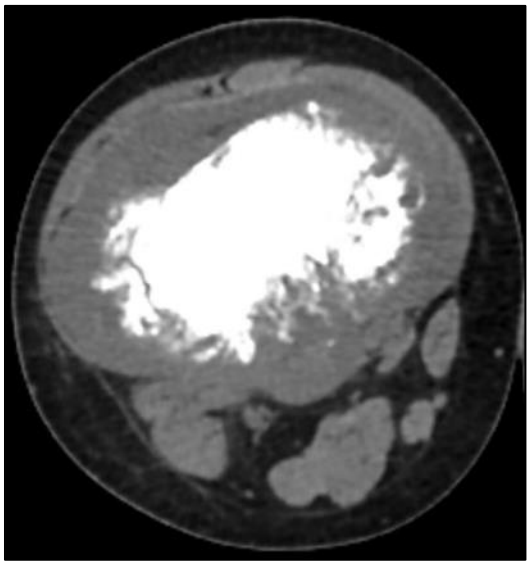

Figure 1 A large infiltrative bone mass lesion, centered in the lower diaphysis of the right femur

Coronal plane without contrast of the right femur (Figure 2)

Figure 2 A moth-eaten pattern of destruction of the overlying cortex

3D AP volume representation of the right femur (Figure 3)

Figure 3 Moth-eaten destruction of the right distal femur

CT scan report: A significant infiltrative lesion with characteristics of a bone mass is observed, located mainly in the lower diaphysis of the right femur. This lesion exhibits a pattern of destruction reminiscent of the activity of wood-eating insects, known as woodworm, affecting the cortical bone above it. In addition, it is hypothesized that this lesion could be associated with a periosteal reaction, suggesting a response from the surrounding bone tissue, as well as the possible formation of a Codman's triangle, a radiological sign that may indicate tumor activity. The image reveals a markedly sclerotic feature of the lesion, which presents a heterogeneous bone neoformation extending into the adjacent soft tissues.

2.2. Magnetic resonance imaging of the right femur (different planes)

Axial T1 Plane (Figure 4)

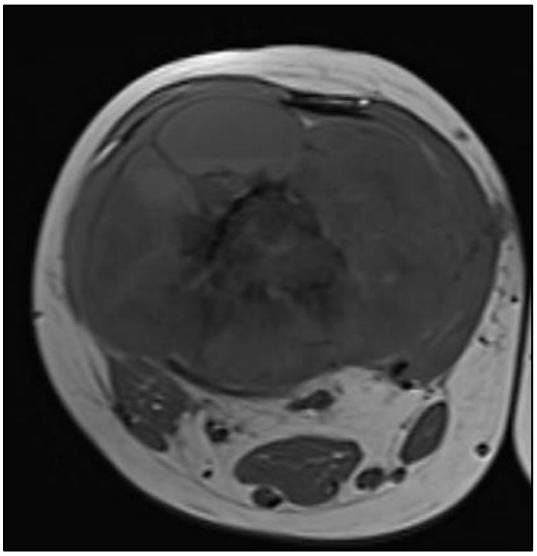

Figure 4 Presents heterogeneous signals, from iso- to hypointense on T1

Coronal T1 Plane (Figure 5)

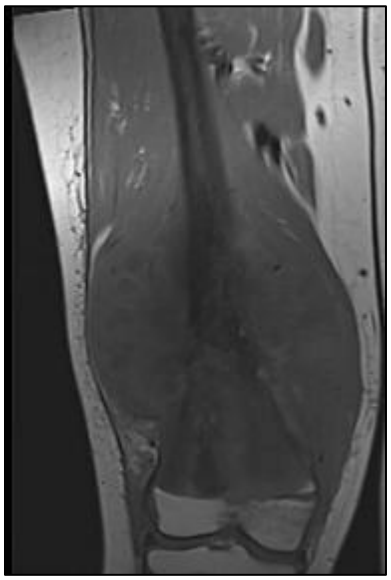

Figure 5 A poorly defined infiltrative spinal cord lesion is observed

Axial T2 Plane (Figure 6)

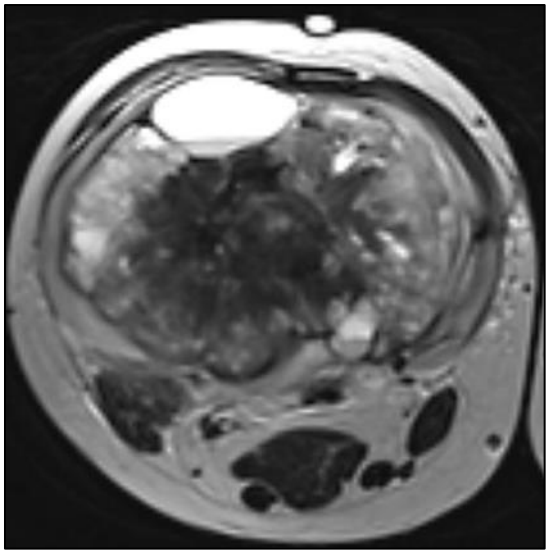

Figure 6 Intralesional cystic areas with fluid-fluid leveling, more noticeable in T2 sequences

Coronal T2 plane (Figure 7)

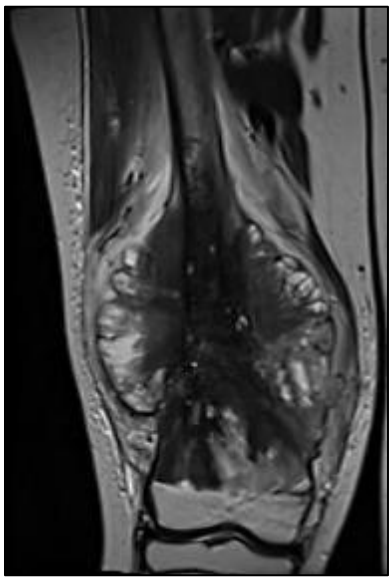

Figure 7 Mixed intermediate and hyperintense signals on T2 and fat saturation on T2, with constant hypointense areas corresponding to bone neoformation

Magnetic resonance imaging report: A spinal lesion can be seen that is infiltrative in nature and lacks well-defined boundaries, affecting the metaphyseal area of the femur, specifically its distal right part. This anomaly has maximum dimensions estimated at approximately 4 centimeters wide, 6 centimeters high, and 8 centimeters long. It shows a variety of heterogeneous signals, ranging from isointense to hypointense in the T1 sequence. In addition, it presents mixed signals that are of intermediate intensity and also some that are hyperintense in the image obtained by T2. In the same T2 image, fat saturation is observed, accompanied by areas that remain consistently hypointense, which correspond to bone neoformation.

Cystic areas are observed within the lesions, which present a characteristic fluid leveling and are more clearly evident in the images obtained using T2 and T2 magnetic resonance sequences with fat suppression. The lesion showed an increase in contrast uptake in a heterogeneous manner and of moderate intensity after the administration of the contrast medium.

The lesion in question shows a significant association with an abundant soft tissue component that circumferentially surrounds the distal diaphysis of the femur. In addition, there is notable infiltration of the vastus intermedius muscle and, to a lesser extent, the vastus medialis muscle. There is also localized invasion in the growth plate area of the distal femur. The neurovascular bundle is in optimal condition and has not been affected. Upon examination of the left thigh, no detectable alterations or abnormalities are observed.

3. Results

3.1. Overview of the included studies

The initial search identified a large number of records, of which 14 studies met the inclusion criteria for qualitative synthesis. Most were retrospective observational series and narrative reviews focusing on long bone osteosarcoma, with specific sub-analyses of the femur. The sample size of the original studies ranged from 20 to more than 100 patients with femoral osteosarcoma.

3.2. Conventional radiography

Plain radiography remains the initial diagnostic tool for the evaluation of localized bone pain. In the studies reviewed, radiographic findings characteristic of femoral osteosarcoma included eccentric or concentric metaphyseal lesions of osteoblastic, osteolytic, or mixed pattern, accompanied by cortical destruction and soft tissue mass with mineralized osteoid matrix. Aggressive periosteal reaction in a "sunburst" pattern, Codman's triangle, and onion-skin layers were described as highly suggestive signs of bone malignancy.

3.3. Computed tomography

CT played an important role in the detailed assessment of the cortex, tumor mineralization, and extraosseous extension. Studies agreed that CT is superior to radiography for delineating areas of cortical destruction and detecting foci of mineralization in soft tissue masses, which can be useful in differentiating osteosarcoma from other non-bone-forming lesions. Likewise, chest CT was established as the standard for the search for pulmonary metastases, which are common at the time of diagnosis and during follow-up.

3.4. Magnetic resonance imaging

MRI was positioned as the reference method for local staging of femoral osteosarcoma. The studies analyzed showed that T1-, T2-, STIR-, and contrast-weighted sequences allow for the precise definition of intramedullary longitudinal extension, metaphyseal-epiphyseal involvement, physis involvement in growing patients, infiltration of adjacent musculature, and the relationship with major vessels and nerves. In addition, MRI was superior to radiography and CT in detecting skip lesions in the same bone or adjacent segments.

Some studies explored the use of advanced techniques such as diffusion (DWI) and perfusion, finding associations between quantitative parameters and the degree of tumor necrosis after neoadjuvant chemotherapy, which could provide complementary prognostic information.

3.5. PET-CT and other functional techniques

PET-CT with 18F-FDG was evaluated in several studies as a tool for systemic staging and therapeutic response. Increased FDG uptake in the primary tumor and metastases allows the identification of subclinical disease not visible on radiography or CT, especially in bones and lymph nodes. The reduction in metabolic uptake after chemotherapy was correlated in some studies with higher percentages of tumor necrosis, although differences in optimal cut-off points were noted depending on the series analyzed.

Complementarily, applications of techniques such as bone scintigraphy and SPECT-CT have been described, although their use tends to be displaced by PET-CT in centers where this technology is available.

3.6. Surgical planning and limb preservation

Studies agree that the combination of MRI and CT is essential for planning oncological resections and prosthetic reconstructions of the femur. MRI defines the length of resection required to obtain adequate margins, while CT facilitates the assessment of bone anatomy and the selection of prosthetic components. Detailed radiological information supports decision-making between limb-preserving surgery and amputation, as well as the choice of surgical approaches.

4. Discussion

This systematic review highlights the central importance of imaging in the management of femoral osteosarcoma. Although the definitive diagnosis continues to depend on histopathological confirmation, radiological findings can guide clinical suspicion, delimit tumor extent, and guide complex therapeutic decisions.

Plain radiography retains an irreplaceable role as an initial, low-cost, and widely available study. The identification of aggressive lesion patterns with characteristic periosteal reaction should prompt rapid referral to specialized centers. However, it alone is not sufficient for treatment planning.

MRI has become the modality of choice for local staging. Its ability to characterize bone marrow and soft tissues, as well as to assess neurovascular involvement, makes it an indispensable tool for planning limb-preserving surgery. The development of advanced techniques such as diffusion and perfusion imaging opens the door to a more accurate assessment of tumor response and prognosis.

CT, meanwhile, complements MRI in cortical assessment and evaluation of lung metastases. The availability of high-resolution multiplanar reconstructions improves anatomical understanding for the surgeon. At the same time, PET-CT offers a comprehensive metabolic view of the patient, which is useful for identifying distant disease and monitoring response to neoadjuvant chemotherapy.

Despite these advances, the reviewed literature highlights several limitations. Many studies are retrospective, with limited sample sizes and without fully standardized imaging protocols. Comparison between modalities is hampered by variability in technical parameters and interpretation criteria. In addition, there is a relative lack of studies that systematically integrate radiological findings with long-term outcomes such as overall survival, event-free survival, or limb function.

Future research should focus on multicenter, prospective studies that use uniform imaging protocols and incorporate quantitative biomarkers, including parameters derived from advanced MRI and PET-CT. The integration of artificial intelligence and radiomics tools could help extract more information from images, with the potential to improve risk stratification and personalize treatment.

5. Conclusions

The radiological study of femoral osteosarcoma requires the integration of different imaging modalities, each with a specific role in the diagnostic and therapeutic process. Plain radiography continues to be the gateway to diagnosis, while magnetic resonance imaging is established as the reference technique for local staging and surgical planning. Computed tomography provides essential information on the bone cortex and pulmonary metastases, and PET-CT adds a valuable metabolic component for systemic staging and response evaluation.

The available evidence supports a multidisciplinary approach in which radiologists, orthopedic oncologists, and medical oncologists collaborate closely to interpret imaging findings and define individualized management strategies. The development of standardized imaging protocols and the incorporation of advanced techniques will further optimize the role of radiology in the prognosis and quality of life of patients with femoral osteosarcoma.

Prospective, multicenter studies with greater statistical power are needed to correlate radiological findings with hard clinical outcomes, as well as research exploring the potential of artificial intelligence and radiomic analysis in the characterization of osteosarcoma.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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