Malignant Bone Tumors- Part II: a revision of diagnostic aspects with Magnetic Resonance

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Learning objectives

- Provide an insight of the diagnostic approach of malignant bone tumors with MRI.

- Review some of the most important imaging findings of malignant bone tumors.

Background

MALIGNANT BONE TUMORS

- Often present with nonspecific symptoms;
- Incidental finding on standard radiographs;
- Important to recognize signs of an aggressive lesion: early diagnosis and prompt treatment improve outcome;
- Once a malignant tumor is detected, further diagnostic workup is required to better characterize the lesion.

The use of MRI in the diagnois of bone tumors, whether malignant or benign, is fundamental. This modality yields crucial information about location and morphology of bone lesions.

MRI is the preferred imaging technique in case of normal or indeterminate findings on conventional radiograph, specially if the patient has persistent localized sypmtoms. Indeed, it is the most sensitive technique for detecting marrow-based lesions, and the anatomic detail seen on MRI is superior than any other imaging study. Also, MRI may help in the diagnosis of other pathological conditions (e.g., occult fracture, osteonecrosis).

Once a malignant bone tumor is detected, further diagnostic examinations are required in order to characterize the lesion and to determine the extent of the disease.

What should the imaging strategy be?

The following diagram illustrates a diagnostic approach for malignant bone tumors (Fig. 1 on page).

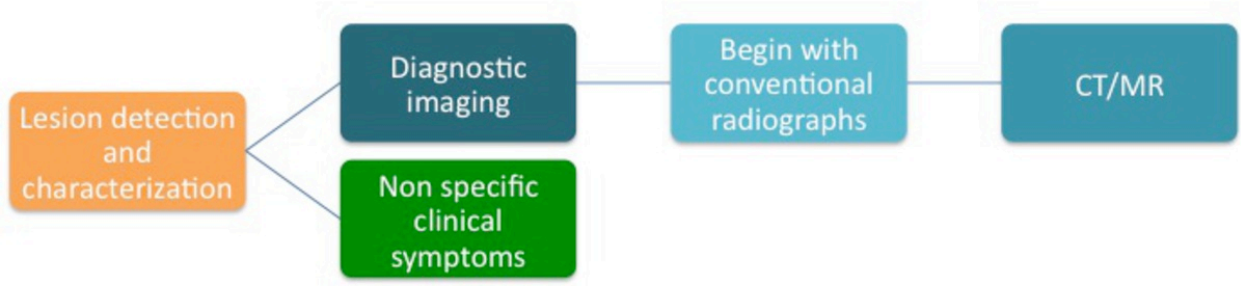

Fig. 1: Suggested approach for initial screening of bone tumors.
References: - Coimbra/PT

Staging of Musculoskeletal Tumors

The primary goal of the oncologic surgeon is to provide local treatment of disease by obtaining adequate tumor margins at the time of resection.

Althought there are different staging systems, they all are based on three components:

1. **Grade of the tumor:** This is a measure of its potential to metastisize and it´s based on histologic features, requiring a preoperative bipsy.
2. **Local extent of the tumor:** Includes its size and degree of involvement of adjacent tissues. A malignant lesion often is not confined to within a pseudocapsule. Instead, it usually extends into adjacent tissues.
3. **Presence/absence of metastases:** The best imaging modalities for this research are: Computed tomography, Radionuclide bone scanning and whole body MRI.

1.

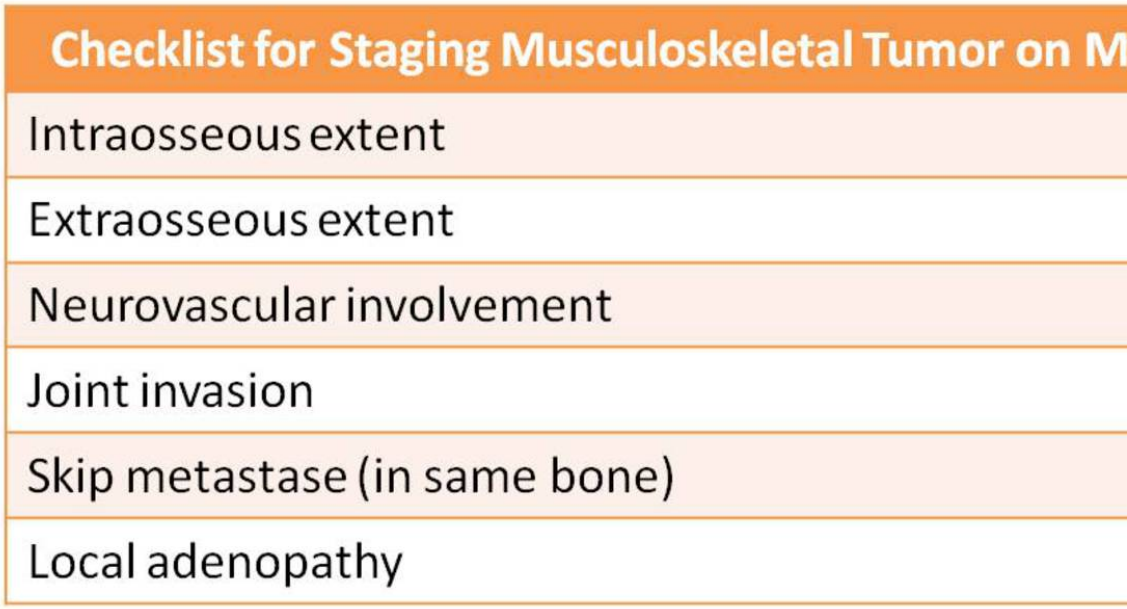

Fig. 2: Checklist for Staging Musculoskeletal Tumor on MRI.
References: - Coimbra/PT

Thus, we intend to provide a simplified diagnostic approach of malignant bone tumors, regarding age group, location and morphology of the lesions.

Imaging findings OR Procedure details

MR features are mostly nonspecific, showing a high signal intensity (SI) on T2-weighted imagens (WI) and a low SI on T1-WI. Nevertheless, some tumors have specific findings on MRI, based on their histological composition and/or location.

Some aspects that suggest a malignant lesion are: irregular borders, type of bone destruction, periosteal response, soft-tissue extension and number of lesions.

Dynamic MRI should be a part of every routine MR-protocol, to evaluate tumor response to neo-adjuvant chemotherapy.

Frequently Malignant bone tumors
Osteosarcoma
Ewing's Sarcoma
Chondrossarcoma
Primary Bone Lymphoma
Plasmocytoma/Multiple Mieloma
Chordoma
Metastasis

Fig. 3: Frequently Malignant bone tumors.
References: - Coimbra/PT

MALIGNANT BONE TUMORS

Osteosarcoma

Key facts

- Produces bony matrix.
- Imaging presentation: Permeative-motheaten pattern of destruction, irregular cortical destruction and aggressive (interrupted) periosteal reaction.
- There are different subtypes depending on location and histological composition. These subtypes determine radiologic appearance of the lesions.
- Conventional osteosarcoma accounts for 75% of cases, which is why we'll focus discussion on this type.
- Conventional Osteosarcoma:

  Location: metaphysis of long bones (knee and shoulder).

  Age: children and adolescents

Appearance on MRI: Heterogeneous bone marrow, cortical disruption. Soft tissue component is almost always present.

- Completely lytic osteosarcoma may represent telangiectatic subtype, composed of multiple cavities filled with blood.

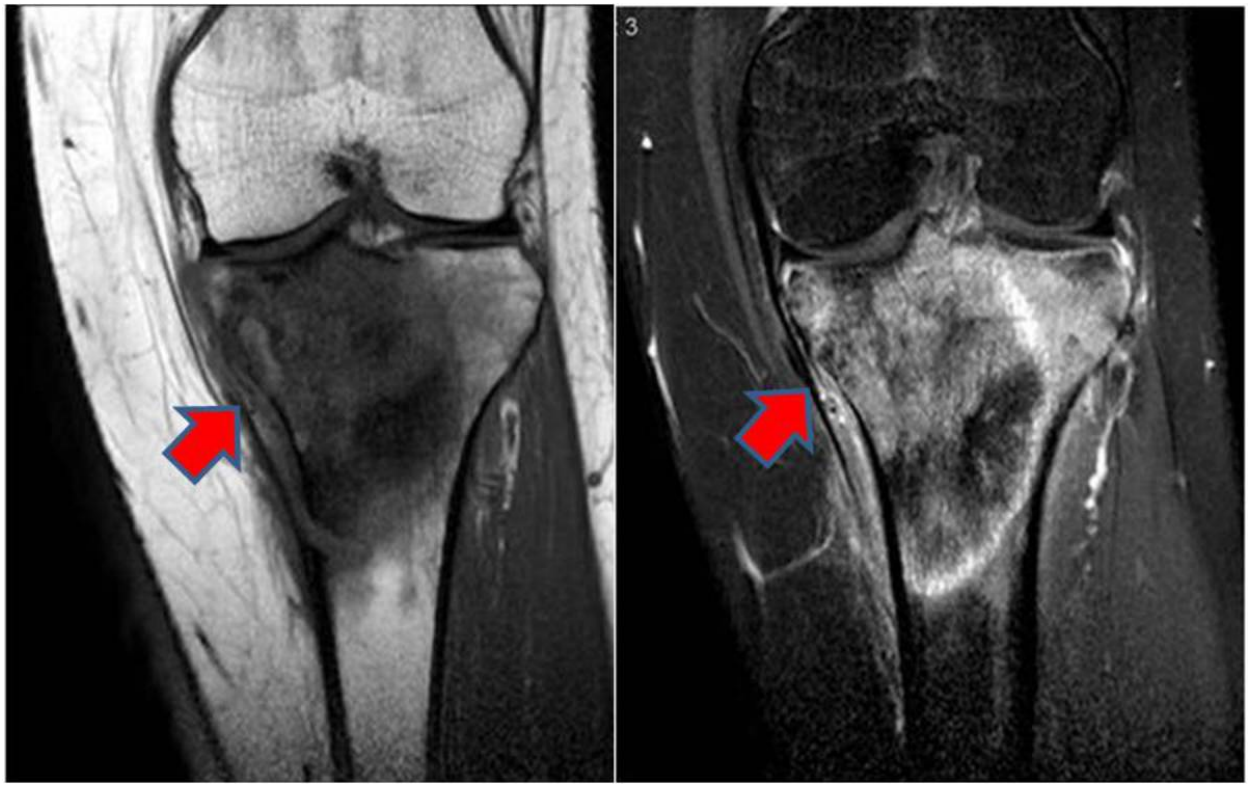

Fig. 4: Proximal tibial epiphysis osteosarcoma that reaches the metaphysis and articular surface. T1 (left) shows heterogeneous and hypointense signal. On the right, the T1WI_fs shows some soft tissue component.

References: - Coimbra/PT

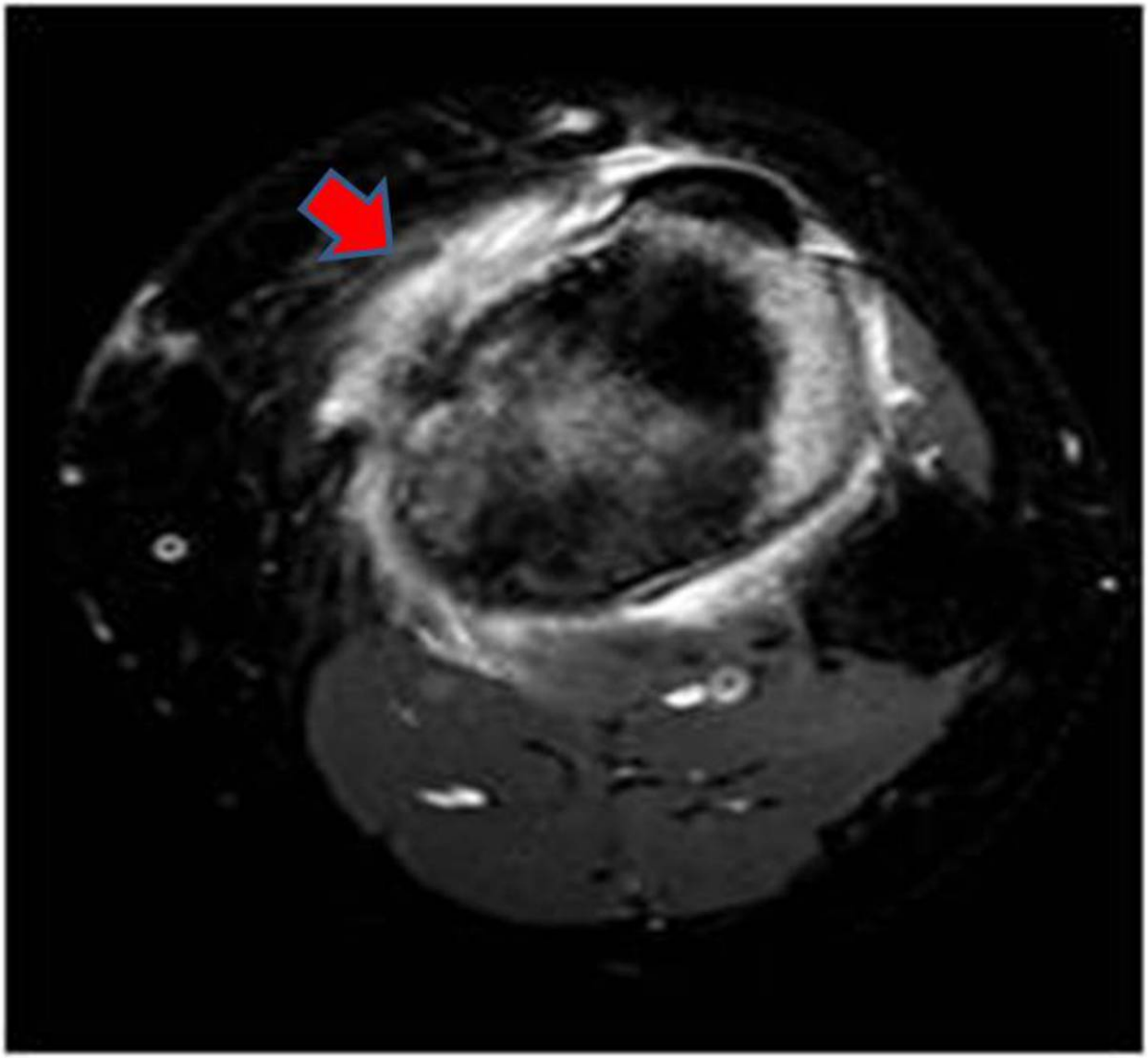

Fig. 5: Proximal tibial epiphysis osteosarcoma. In this DPWI we see heterogeneous medular signal and some soft tissue component.
References: - Coimbra/PT

Ewing's Sarcoma

Key facts:

- Clinical presentation: Child with a lower extremity tumor.
- Imaging presentation: ill-defined osteolytic lesion with a moth-eaten or permeative type of bone destruction, irregular cortical destruction and aggressive periostitis.
- Based on the age, the location and the radiographic appearance the diagnosis of Ewing sarcoma can be made in over 70% of cases.

- In long bones, the tumor is most commonly located centrally in the meta- or diaphysis
- Plain radiographs usually illustrate the malignant nature.
- MR imaging reveals heterogeneous bone marrow, with soft tissue component
- Differential diagnosis: Osteosarcoma ; Primary bone lymphoma; Osteomyelitis or Eosinophilic Granuloma.

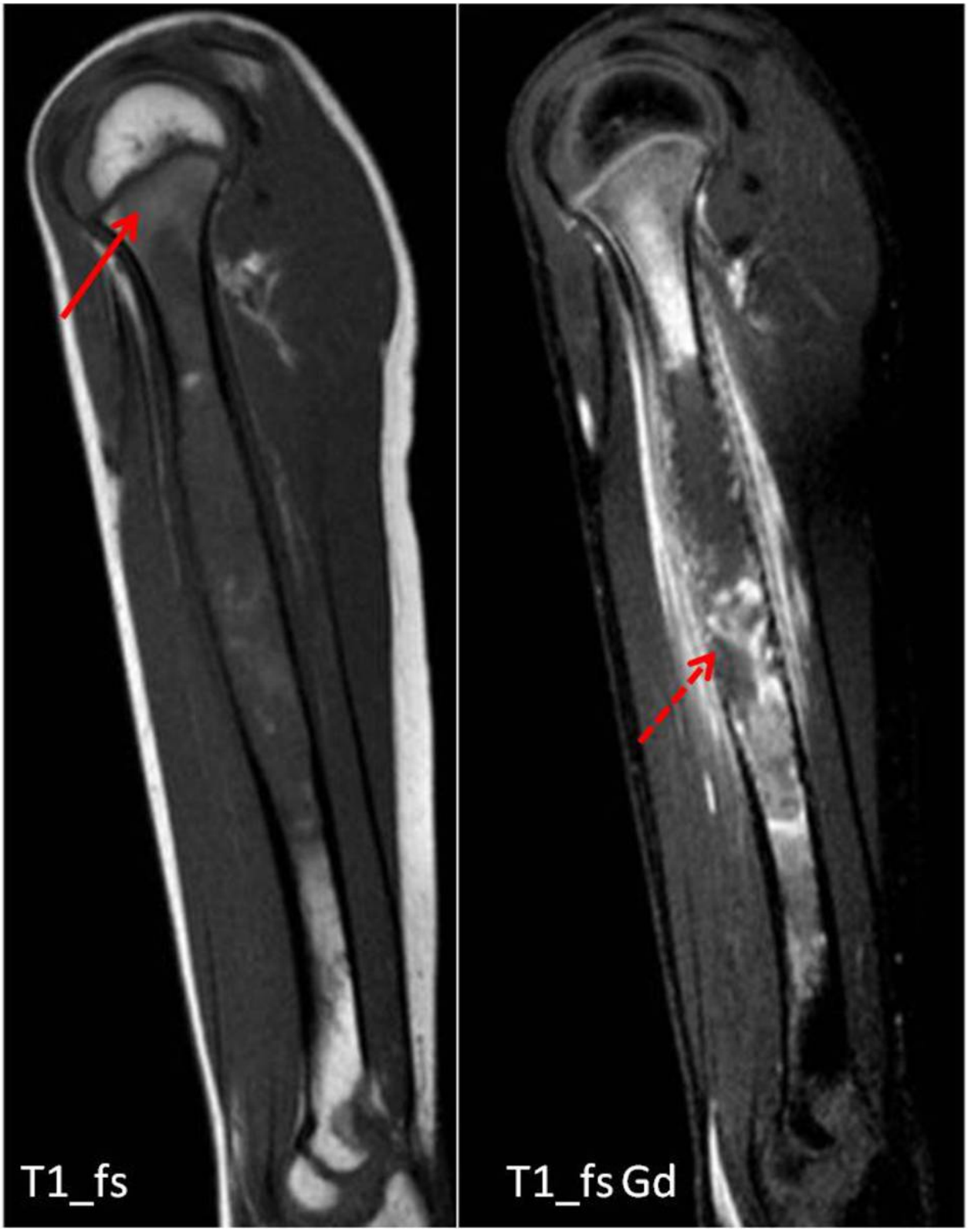

Fig. 6: Ewing sarcoma. The fat suppressed T1-weighted gadolinium enhanced MR image demonstrates the permeative cortical destruction and enhancing soft tissue mass.

References: - Coimbra/PT

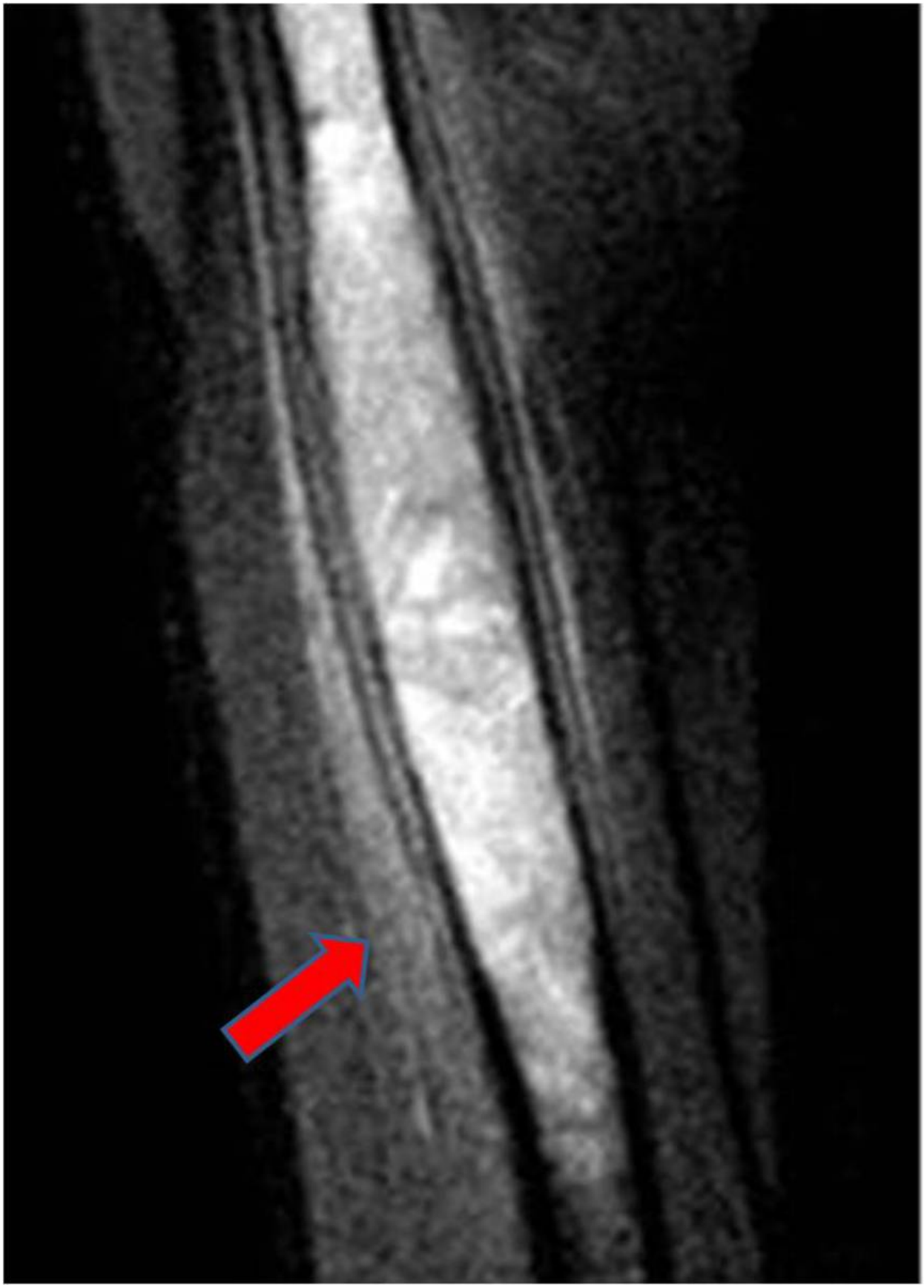

Fig. 7: Ewing sarcoma. Codman triangle delineation.
References: - Coimbra/PT

Chondrossarcoma

Key facts:

- Produces cartilage.
- Clinical presentation: Elderly person with painful swelling.
- Imaging presentation: large osteolytic lesion, scalloping of the inner cortex and rings-and-arcs or popcorn calcifications.
- Secundary chondrosarcoma: most common, arises from enchondroma or osteochondroma.
- Patients at risk: multiple enchondromas like in Ollier's disease and Mafucci's syndrome.
- Low grade tumor: Usually not differentiated from enchondroma based on imaging findings alone.
- High grade tumor: may present as aggressive ill-defined lesion with extention into the soft tissues.

When do we should think of chondrosarcoma instead of enchondroma (one or more of the following):

- Elderly patient
- Location in long bones
- Size > 5 cm
- Uptake on bone scan
- Endosteal scalloping on MRI
- Cortical involvement
- Early enhancement on dynamic contrast enhanced series

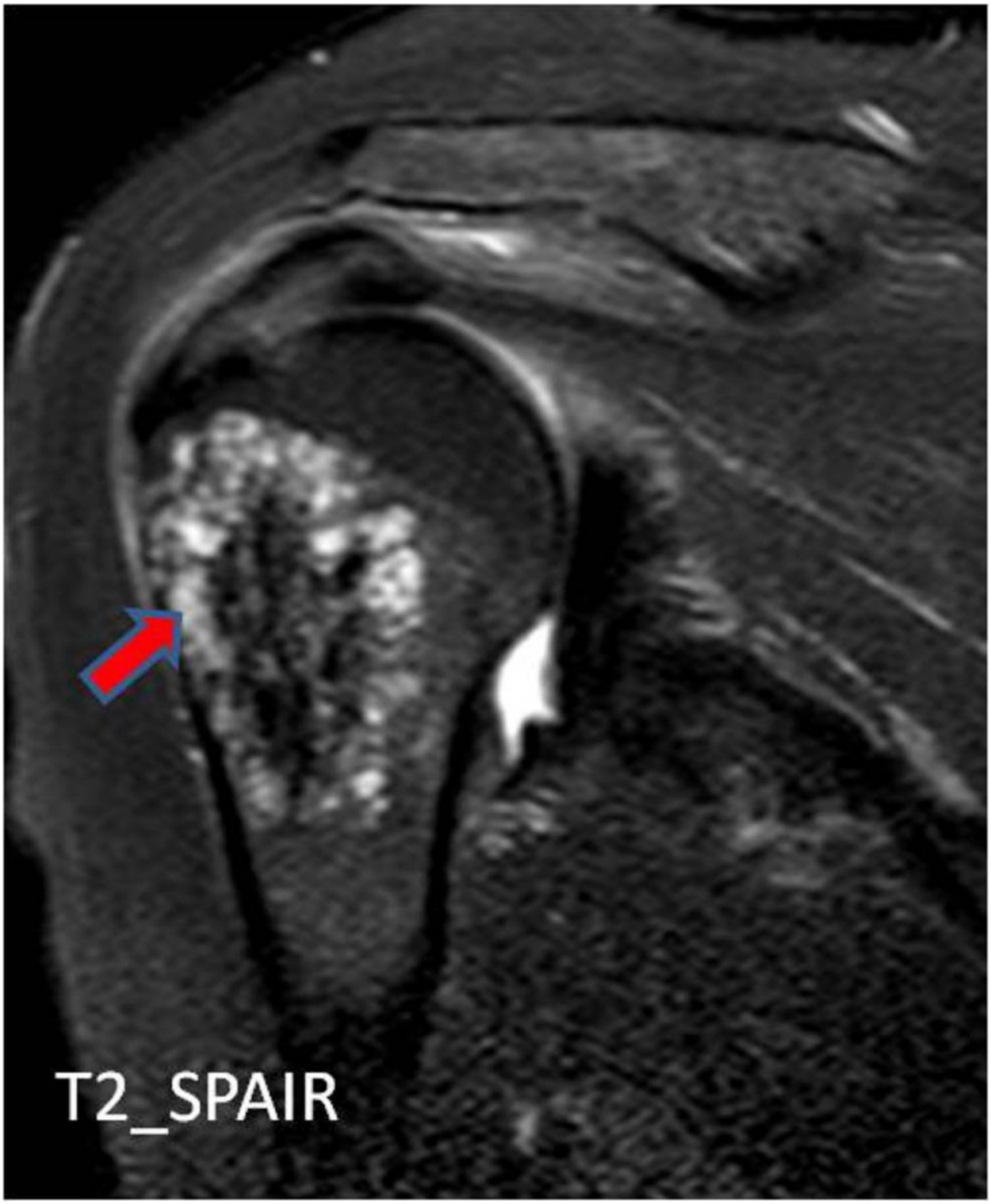

Fig. 8: Low-grade chondrosarcoma confirmed on post surgical excision. The large diameter and the scalloping (arrow) favor the diagnosis of a chondrosarcoma.
References: - Coimbra/PT

Primary Bone Lymphoma

Key facts

- Rare (< 5% all primary bone tumors).
- Clinical presentation: Insidious and intermittent bone pain, systemic symptoms and pathological fracture.
- Preferential sites: femur and humerus.
- Imaging presentation: Virtually normal to severely permeative. On the MR notice the linear cortica abnormalities and circumferential soft tissue mass.
- Differential diagnosis: Ewing's sarcoma; Metastasis and plasmacytoma.

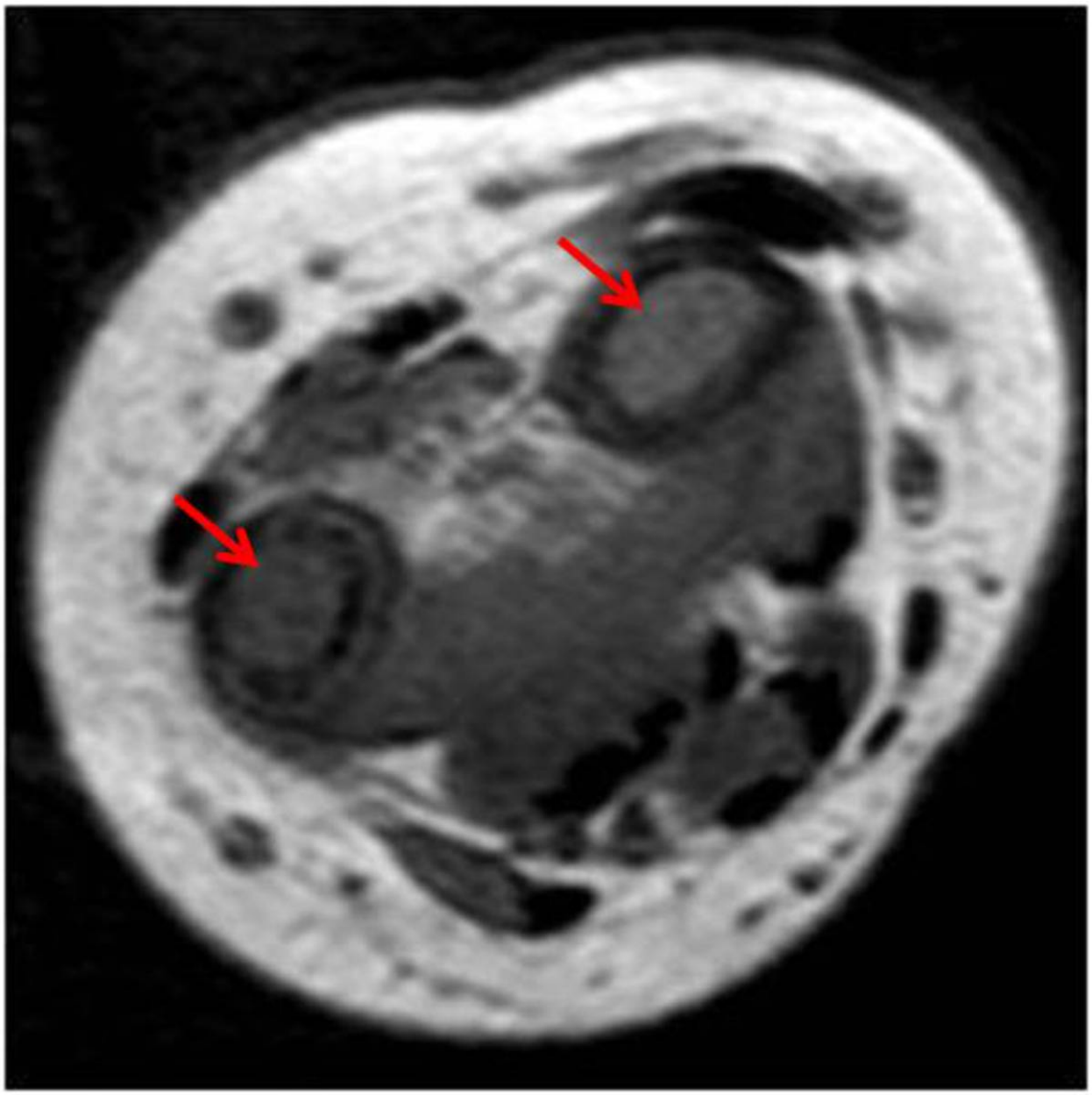

Fig. 9: Primary bone lymphoma. Marrow infiltration of the radius and ulna. Homogeneous hypointensity in T1WI. Notice tunneling of the cortical bone.

References: - Coimbra/PT

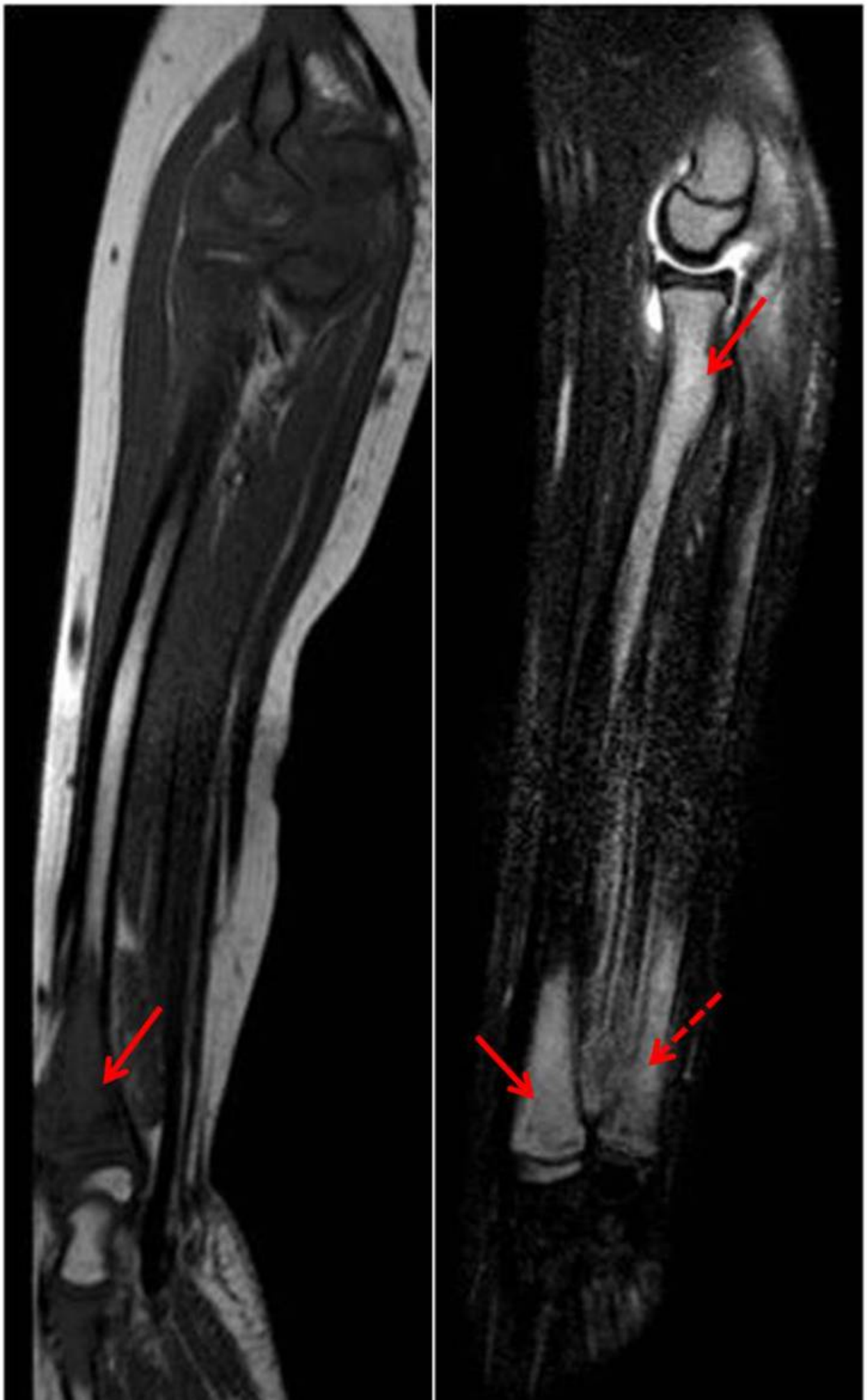

Fig. 10: Primary bone lymphoma. Marrow infiltration of the radius (smooth arrow) and ulna (dashed arrow). Homogeneous hypointensity on T1WI and hyperintensity on STIR).
References: - Coimbra/PT

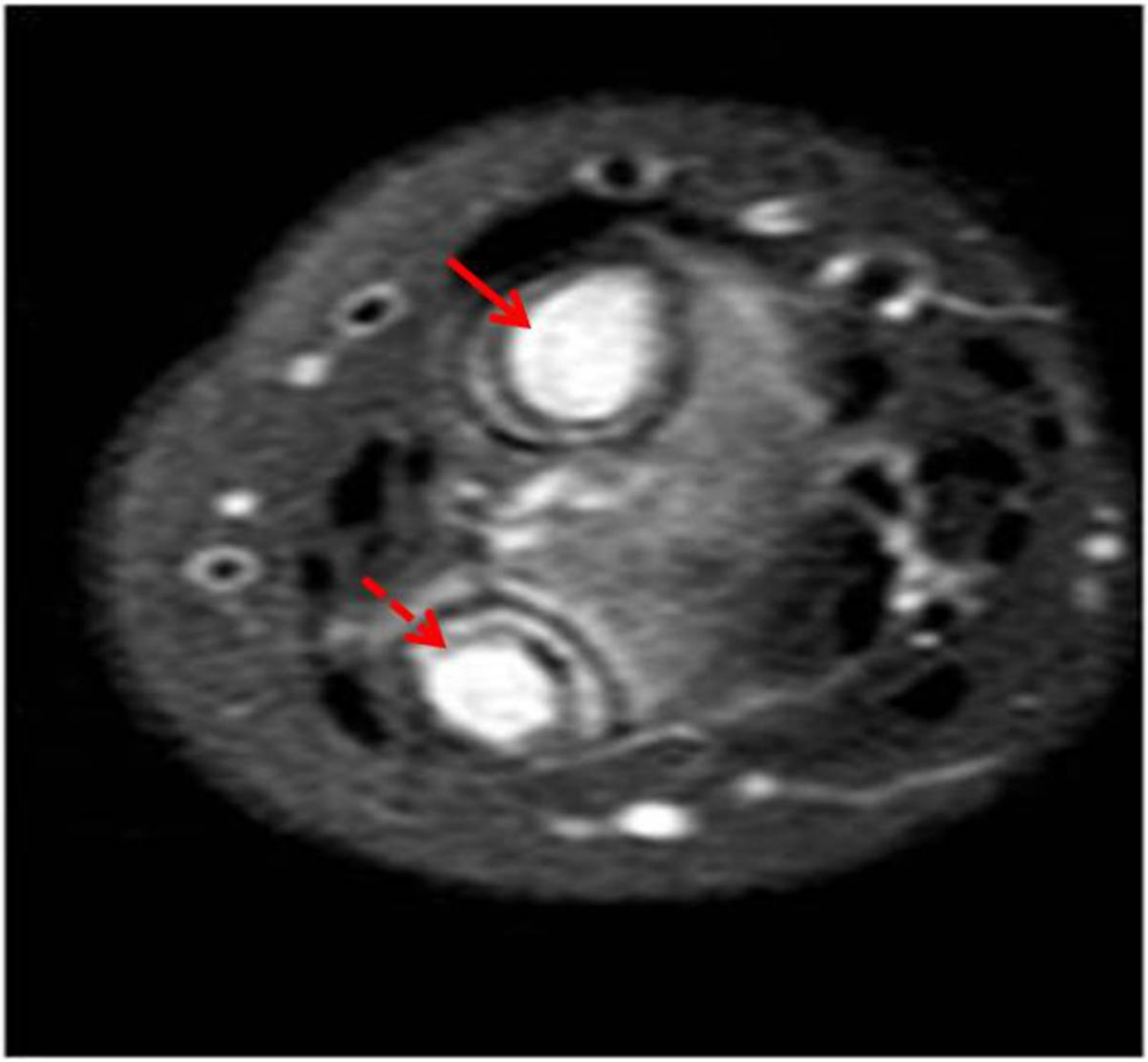

Fig. 11: Primary bone lymphoma. Marrow infiltration of the radius (smooth arrow) and ulna (dashed arrow). Homogeneous hyperintensity on T2WI).
References: - Coimbra/PT

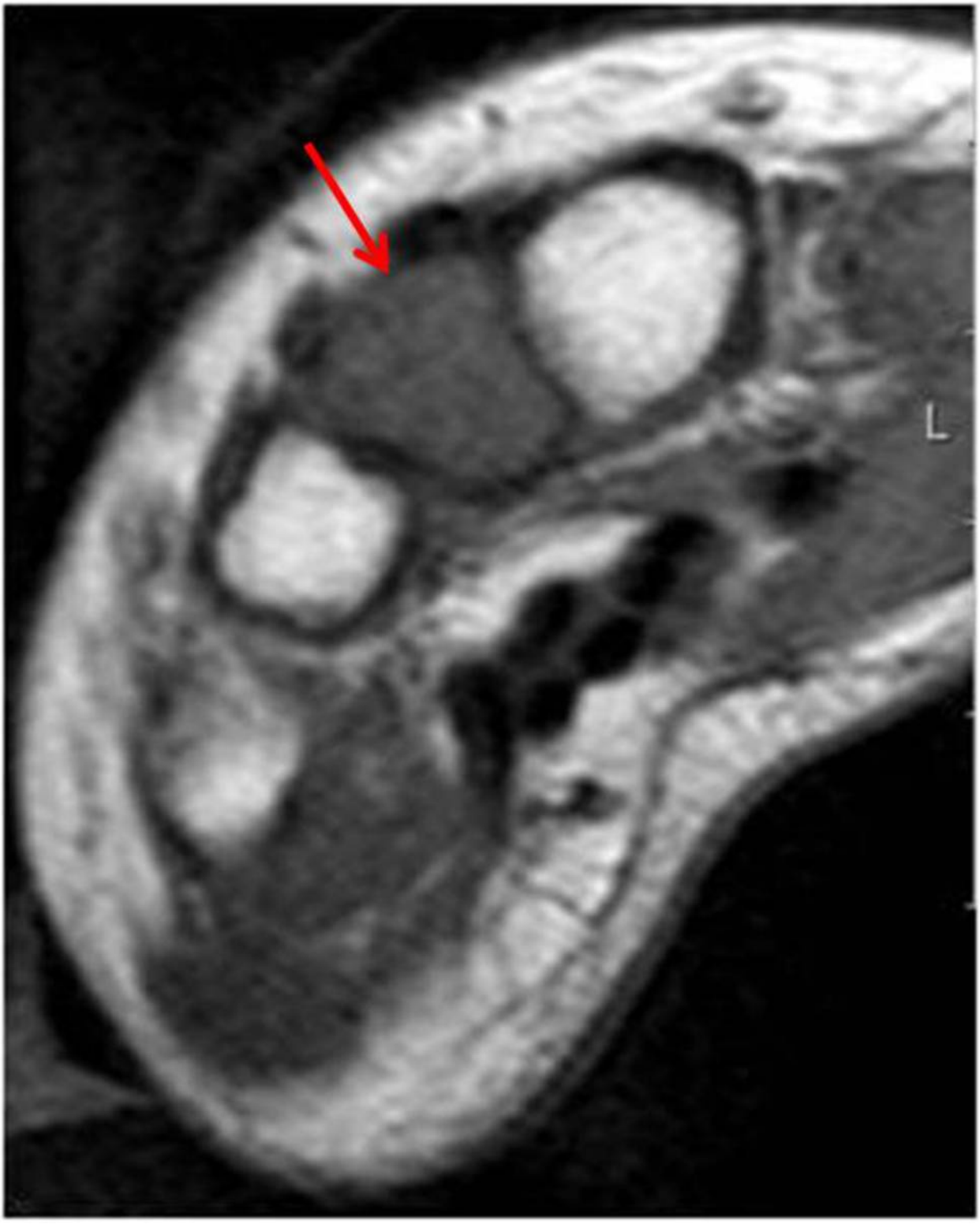

Fig. 12: Primary bone lymphoma. Lunate bone metastasis.
References: - Coimbra/PT

Plasmocytoma/Multiple Mieloma

Key facts

- Clinical presentation: infections, bone pain, renal insufficiency, pathological vertebral fractures with cord compression.
- Age: elderly population.
- Imaging presentation: multiple well circumscribed osteolytic lesions ("punched-out"), diffuse mineralization of the skeleton (osteopenia).
- If solitary - plasmacytoma.
- Bone scan: Usually no increased uptake.
- Most common location: Axial skeleton (spine, skull, pelvis and ribs) and in the diaphysis of long bones (femur and humerus).
- Differential diagnosis: Must be included in any lytic bone lesion, either well-defined or ill-defined in age > 40.

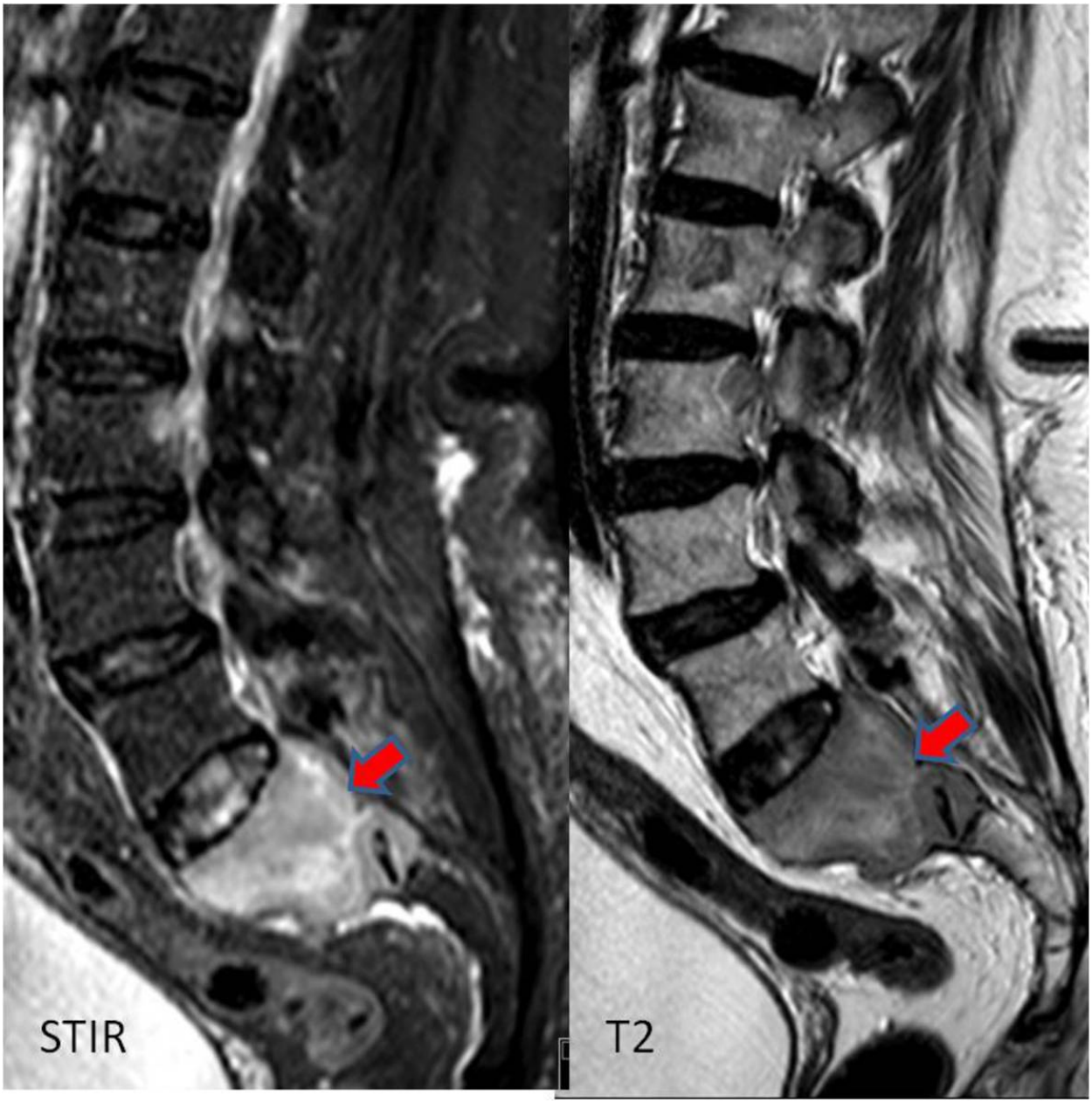

Fig. 13: Plasmocytoma. Expansive lesion involving S1 and S2. Hypointensity on T2WI and hyperintensity on STIR.
References: - Coimbra/PT

Chordoma

Key facts:

- Rare. (2-4% of all primary bone tumors)

- Clinical presentation: Low-grade malignant tumor, usually in older patients. Symptoms depend on the location; rectal dysfunction, urinary incontinence (sacral) and headaches, cranial nerve palsy (clivus).
- Imaging presentation: expansile, destructive bone lesion that may be associated with a soft-tissue mass.
- Site of origin:
  - Sacro-cocygeal
  - Skull base / clivus
  - Anywhere in the spine, most commonly in body and arch.
- MRI T2-weighted images will show very high SI, more or less lobulated like a chondrosarcoma.
- Differential diagnosis: Chondrosarcoma.

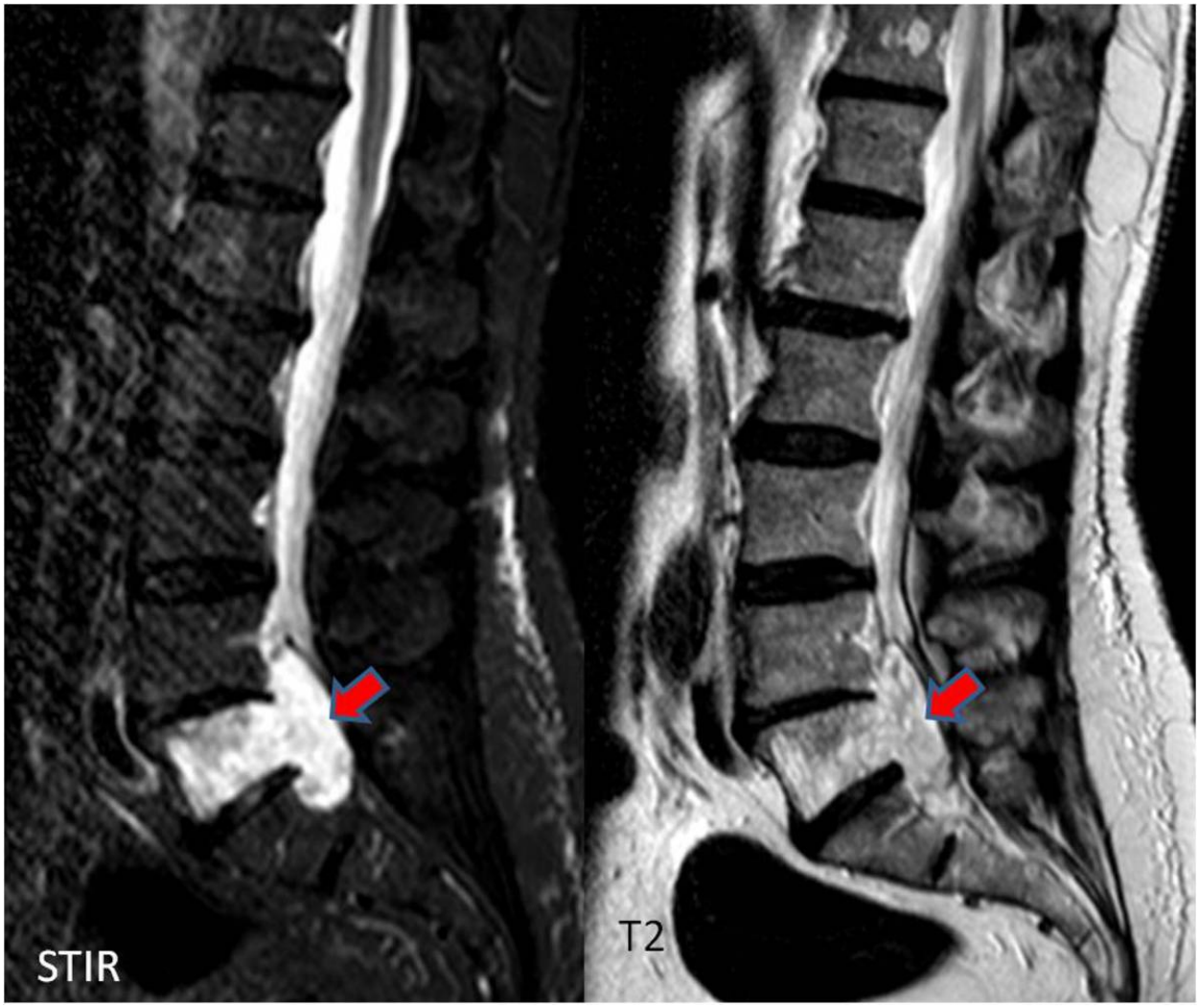

Fig. 14: Chordoma. Expansive lesion originating from L5 with intracanalar extension. There is a slight hyperintense signal on T2WI and strong hypersignal on STIR.
References: - Coimbra/PT

Metastasis

Key facts

- Most common malignancy in bone.
- Must be considered in the differential diagnosis of any bone lesion in a patient > 40 years.
- Location: anywhere in the skeleton (mostly areas that contain red marrow)
- Imaging presentation: Well-defined osteolytic, ill-defined osteolytic and sclerotic bone lesion.
- Majority of osteolytic metastases originate from breast, lung, kidney, colon, melanoma and thyroid.

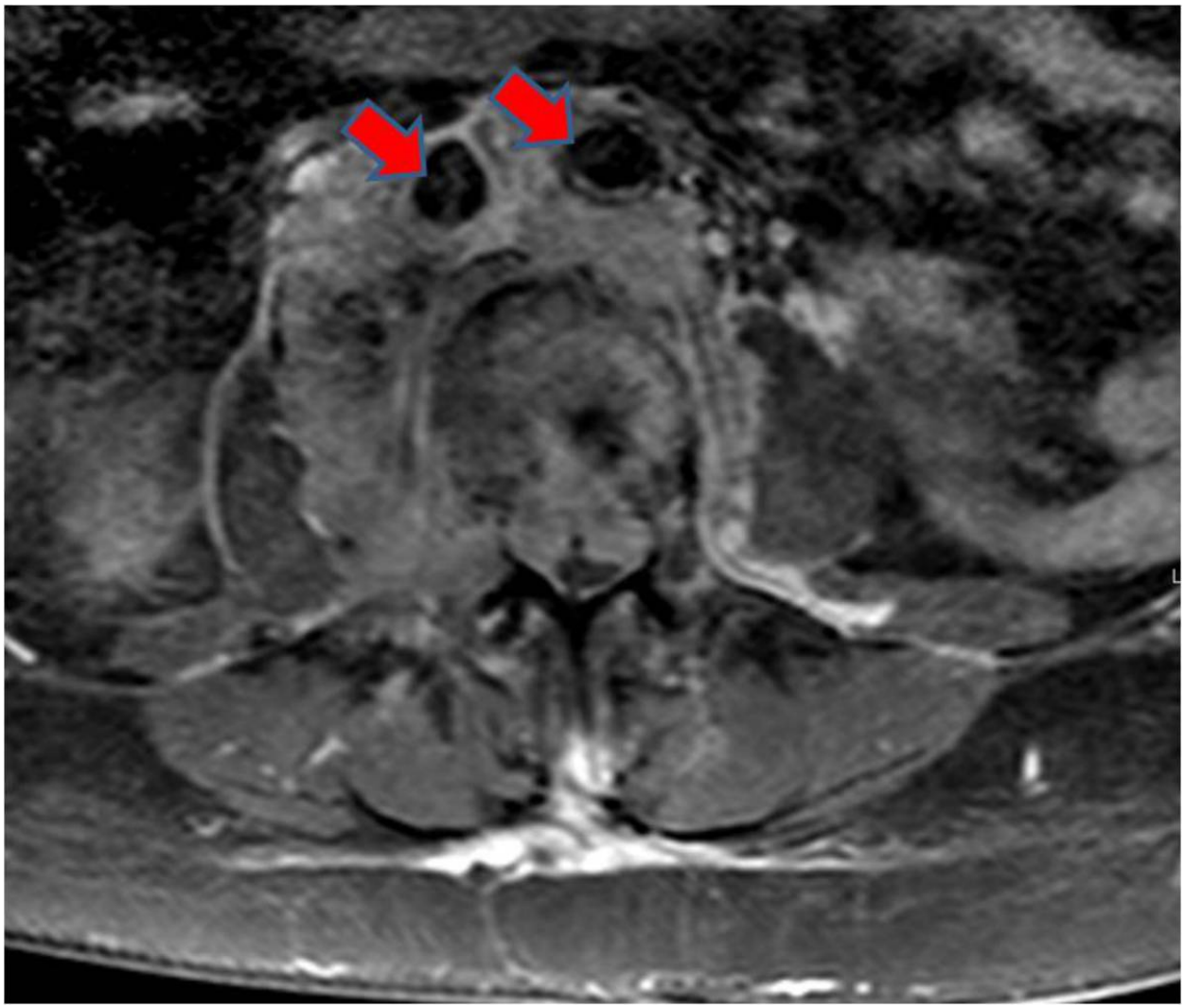

Fig. 15: T1WI_SPIR_Gd axial. Spinal metastatic breast carcinoma that causes entrapment of the abdominal aorta and inferior vena cava.
References: - Coimbra/PT

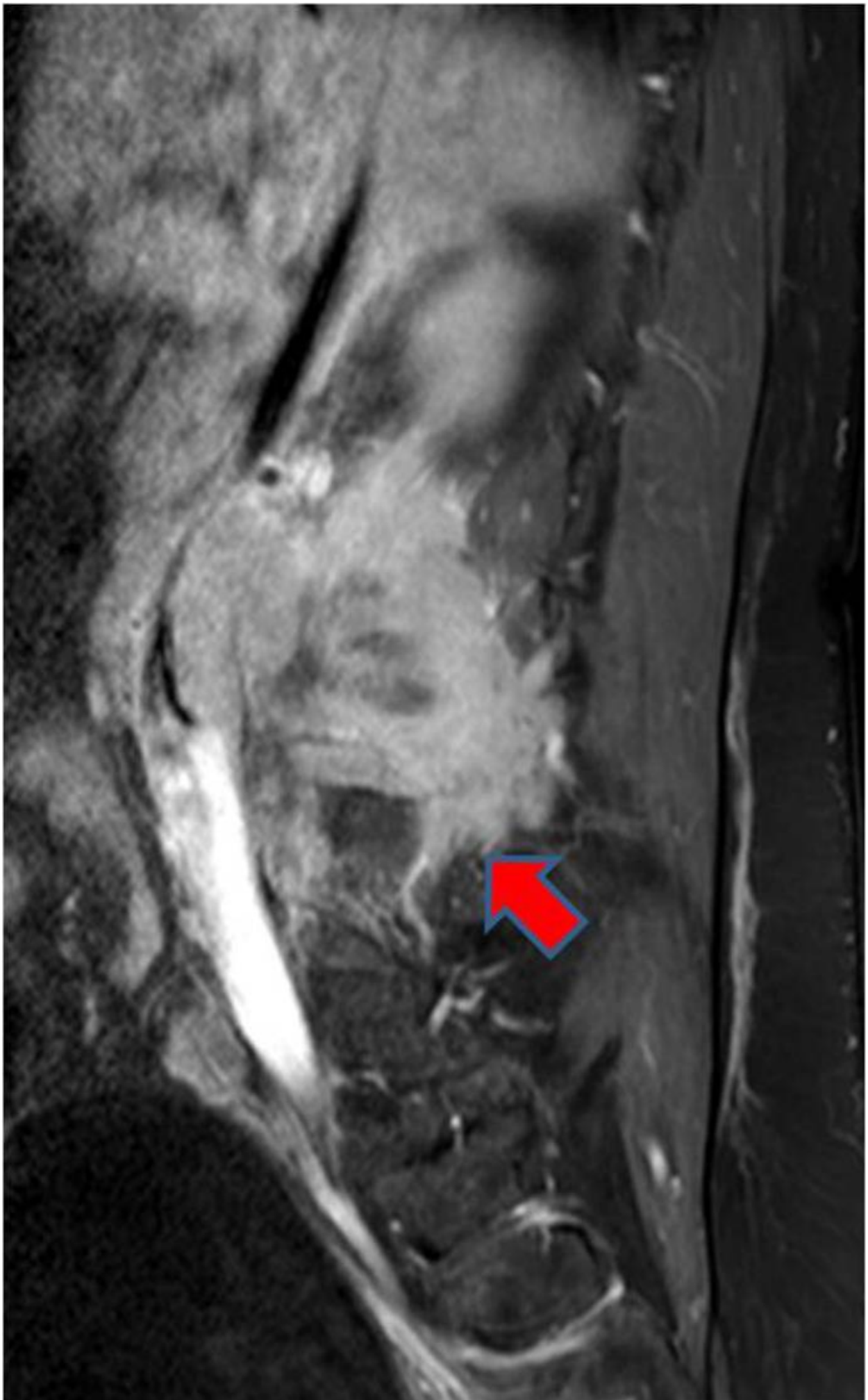

Fig. 16: T1WI_SPIR_Gd sagittal. Spinal metastatic breast carcinoma which is centered on L3 and involves the entire L2 vertebra.
References: - Coimbra/PT

Conclusion

MRI is an essential aid in the diagnosis of bone neoplasia, allowing for basic anatomical review and characterization of tumor type for diagnosis, therapy, monitoring and pre-operative planning.

Every patient with a possible malignant bone lesion should undergo both plain radiographs and MRI, before invasive procedures are performed. A team approach to tumor imaging and treatment is optimal.

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