

PRIMARY BONE TUMORS OF THE SPINE

A PICTORIAL REVIEW

Miguel Seco

Jorge Brito

Bruno Graça

Belarmino Gonçalves

Luis Curvo-Semedo

Filipe Caseiro-Alves

CLÍNICA UNIVERSITÁRIA DE IMAGIOLOGIA
HOSPITAIS DA UNIVERSIDADE DE COIMBRA



Department of Radiology
Coimbra
PORTUGAL

PURPOSE

- The aim of this presentation is to review the imaging findings of **primary bone tumors of the spine** emphasizing their differential diagnosis, using a multimodality approach (X-Ray, CT, MR).

BENIGN LESIONS OF THE SPINE

OSTEOID OSTEOMA
OSTEOBLASTOMA
GIANT CELL TUMOR
ANEURYSMAL BONE CYST
OSTEOCHONDROMA
ENOSTOSIS
HEMANGIOMA
LANGERHANS CELL HISTIOCYTOSIS

MALIGNANT LESIONS OF THE SPINE

CHORDOMA
CHONDROSARCOMA
EWING SARCOMA
OSTEOSARCOMA
PRIMARY OSSEOUS LYMPHOMA
PLASMACYTOMA

CONTENT ORGANIZATION



- Primary Benign Lesions of the Spine
- Primary Malignant Lesions of the Spine
- Conclusions

OSTEOID OSTEOMA

□ X-Ray

- Round to oval, discrete radiolucent area (nidus).
- Variable surrounding sclerosis; central calcification may be present.
- Complex anatomy of spine often obscures the nidus so that only sclerosis or a dense pedicle is apparent on radiographs.

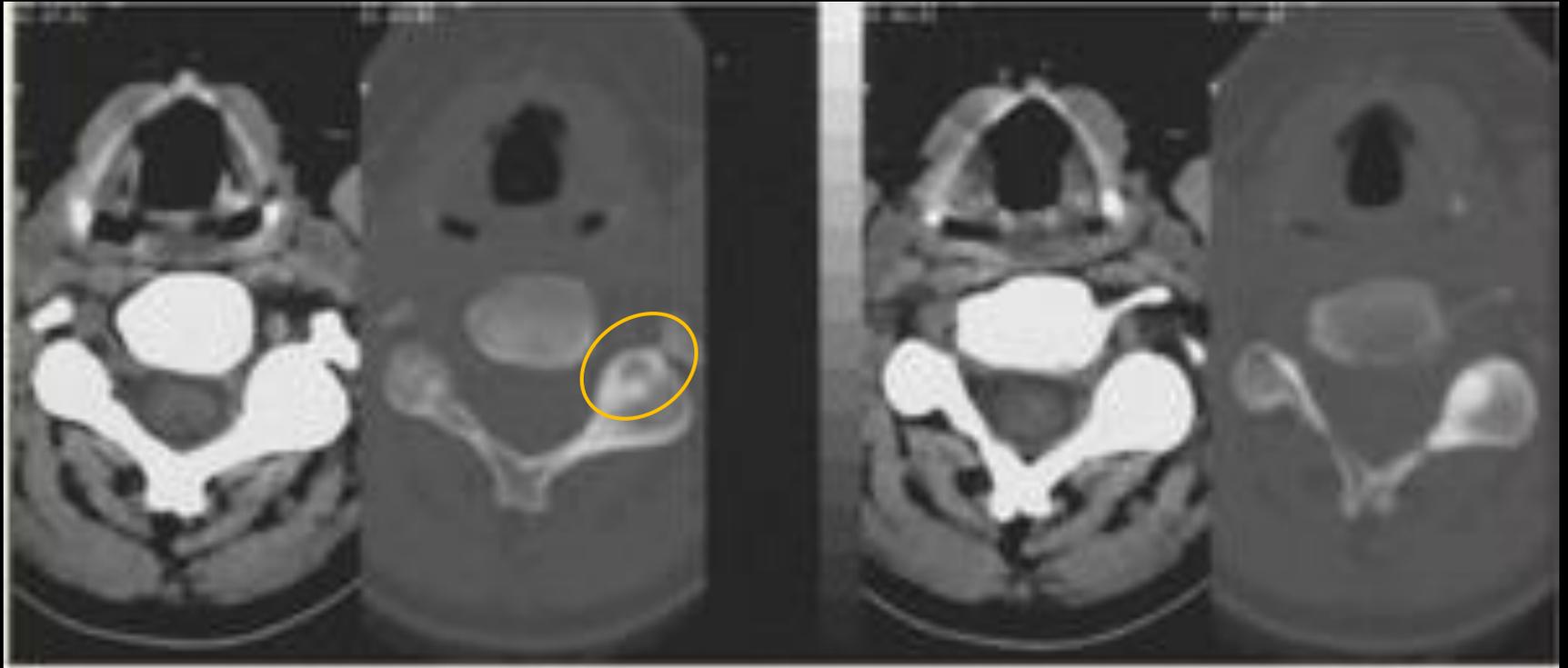
□ CT

- Optimal modality for detecting osteoid osteoma.
- Nidus – well-defined, low-attenuation lesion <2cm, with or without central calcification, surrounded by a variable degree of sclerosis.

□ RM

- Nidus is generally low to intermediate signal intensity on T1 and intermediate to high signal intensity on T2.
- Areas of calcification always have low signal.
- RM can be misleading because the nidus may become obscured by signal changes due to associated surrounding sclerosis, marrow edema and soft-tissue inflammation.

Osteoid osteoma of left articular facet of C4



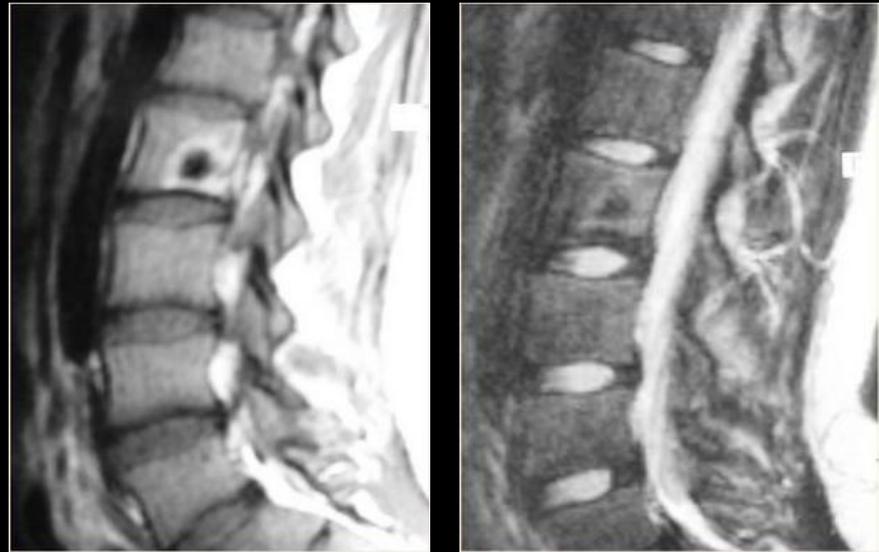
CT – We can see the nidus (left articular facet of C4), a well defined and low attenuation lesion, surrounded by area of sclerosis.

Osteoid osteoma of vertebral body of L2



CT – Hypodense nidus with central calcification and little reactive sclerosis.

Osteoid osteoma

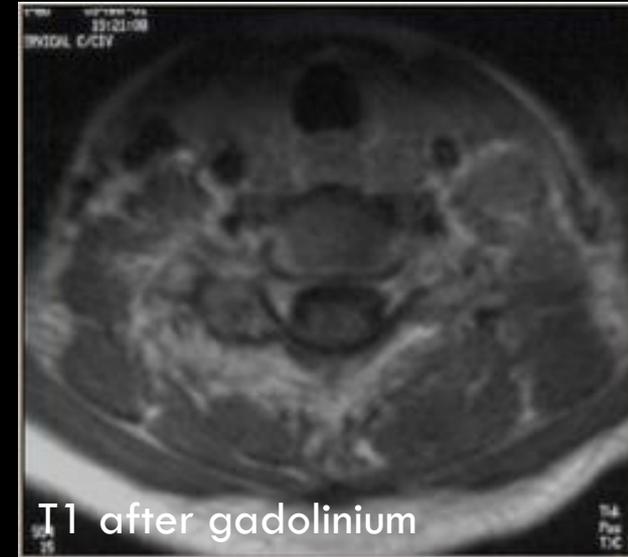


MR (T1 and T2) – Low signal intensity on T1 and T2 images, due to the presence of mineralized osteoid matrix.

OSTEOBLASTOMA

- **Three radiographic patterns:**
 - Central radiolucent area (with or without calcification) and surrounding sclerosis, similar to osteoid osteoma but $> 1,5\text{cm}$.
 - Expansile lesion with multiple small calcifications and a peripheral sclerotic rim – most common appearance of spinal osteoblastomas.
 - Aggressive appearance consisting of osseous expansion, bone destruction, infiltration of surrounding soft tissue and intermixed matrix calcification.
- **CT** - areas of mineralization (50%), expansile bone remodeling and sclerosis or a thin osseous shell about its margins.
- **MR** - generally nonspecific, but optimally depicts the effects of the tumor on the spinal canal and surrounding soft tissues and extensive peritumoral edema has been reported.

Osteoblastoma of right neural arch of C7

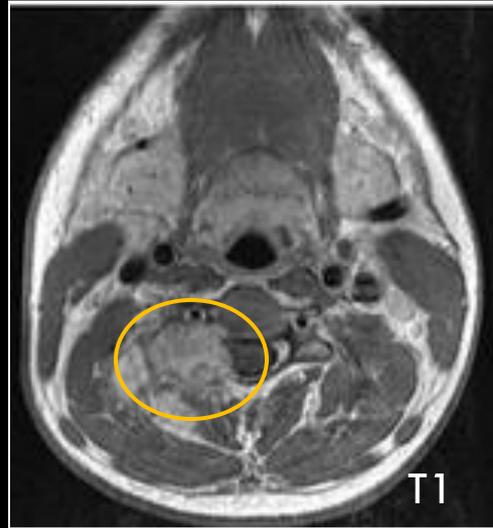
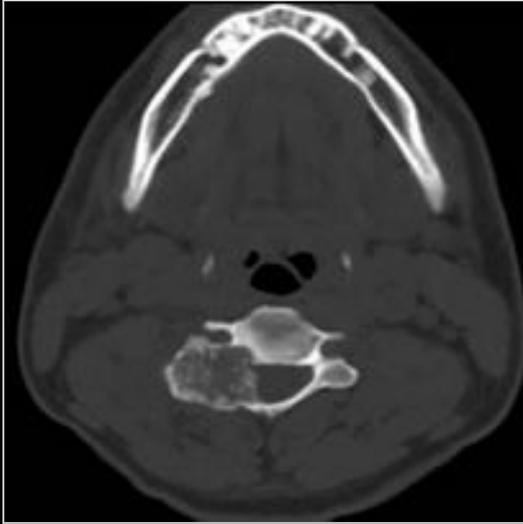


Cervical X-Ray – Thickening and increased density of the right lateral component of C7, with a faintly seen central lytic area.

CT – Low attenuation lesion with 2cm, with calcifications, cortical thinning, but no rupture.

MR – The lesion has the same signal as the adjacent bone and there is a low signal halo in relation with sclerosis. After gadolinium there is some enhancement of the lesion and surrounding soft tissues, suggestive of peritumoral edema.

Osteoblastoma of C4



CT - Expansile lesion of C4 with calcified osteoid matrix in an amorphous pattern ("cloud-like") and little cortical thickening.



MR - The lesion shows high signal and is centered at right lamina and pedicle of C4, extending into the vertebral foramen and adjacent soft tissue. There is marked enhancement pós-gadolinium.

GIANT CELL TUMOR

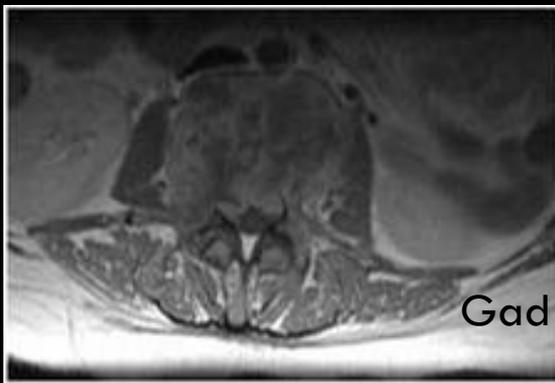
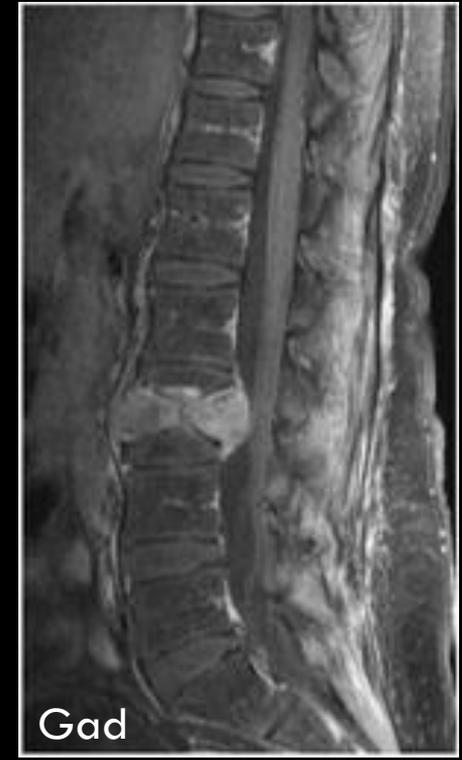
- Spine – usually affects the vertebral body (as opposed to most other spinal tumors).
- **X-Ray** - Expansile lesion, with bone lysis and no evidence of mineralized matrix.
- **CT**
 - Tumor has soft-tissue attenuation with well-defined margins that may show a thin rim of sclerosis.
 - Areas of hemorrhage or necrosis may create heterogeneity (foci of low attenuation)
- **MR.**
 - Heterogeneous signal intensity.
 - Low/intermediate signal on T1.
 - Low/intermediate signal on T2 in 62-96% - **very helpful in differential diagnosis.**
 - Hemorrhage (high signal on T1 and T2) and focal cystic areas (low signal on T1 and high signal on T2) may be present.

Giant cell tumor of sacrum



X-Ray, CT and MR (with and without FS) – Lytic and expansile lesion of sacrum. There is cortical rupture and associated soft tissue mass. This mass has low signal on T1 and heterogeneous enhancement after gadolinium administration.

Giant cell tumor of L3

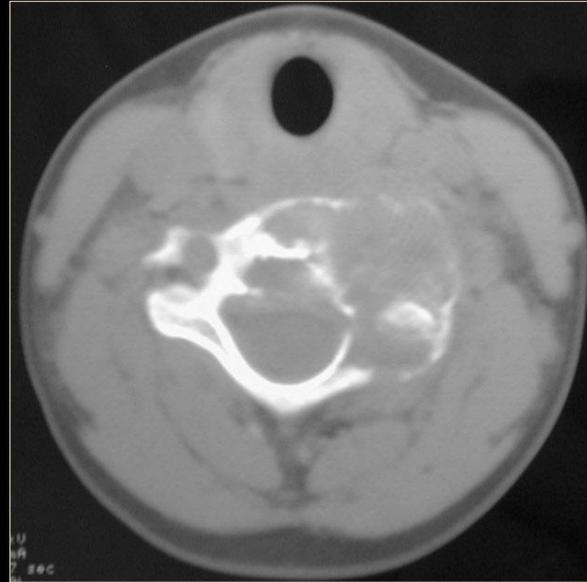


MRI - This GCT of L3 affects mainly the vertebral body, pedicles and laminae with sparing of the spinous process. There is compression of the dural sac and there is extension to the right intervertebral foramen of L2-L3 and L3-L4. The lesion has low signal on T1; intermediate sign on T2 and heterogeneous enhancement after gadolinium on T1.

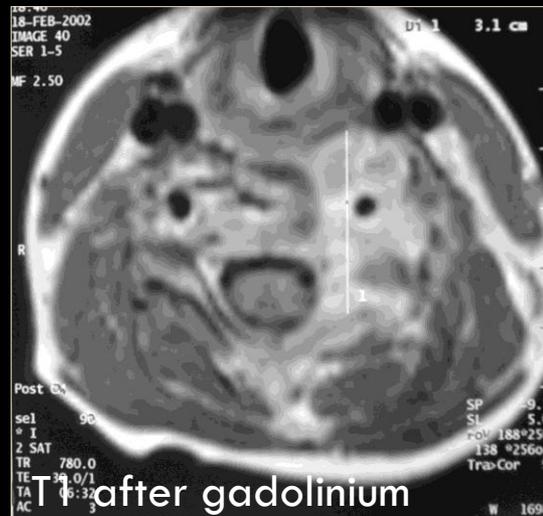
ANEURYSMAL BONE CYST

- **Radiographs** show marked expansile remodeling of bone centered in the posterior elements.
- May also extend into adjacent vertebral bodies, intervertebral disks, posterior ribs and paravertebral soft tissues – similar to GCT.
- **CT and MR** appearance suggests the cystic nature of lesion and often show fluid-fluid levels indicative of hemorrhage with sedimentation (MR is the most sensitive).
- Fluid-fluid levels are suggestive but are not pathognomonic.
- Often present a soft-tissue attenuation or low signal intensity rim on TC and MR (all pulse sequences), that corresponds to an intact, thickened periosteal membrane.

Aneurysmal Bone Cyst of cervical spine



X-Ray, CT and MR – Lytic and expansile lesion of the left neural arch and vertebral body of C4, with “ballooned” bony contour. There is marked cortical thinning, but there is no cortical rupture, no periosteal reaction and no soft tissue masses. Intermediate sign on T1, marked high sign on T2. There is peripheral and internal septa enhancement after intravenous administration of gadolinium.



T1 after gadolinium



T2

OSTEOCHONDROMA

- The pathologic and radiologic hallmarks of osteochondroma is continuity of the lesion with the marrow and cortex of the underlying bone.
- **Thin-section CT** is the radiologic examination of choice for detecting the osseous characteristics of the exostosis and the pathognomonic marrow and cortical continuity of the lesion to the underlying bone.
- **MR** reveals yellow marrow centrally (high signal on T1 and intermediate signal on T2) with a low signal cortex.
- The hyaline cartilage cap is often small and thin.
- Spinal osteochondromas with marked thickening ($> 1\text{cm}$) of the cartilage cap should be viewed with suspicion of malignant transformation to chondrossarcoma.

Osteochondroma of cervical spine



Cervical spine X-Ray – Volumous exostosis with the classic cauliflower appearance.

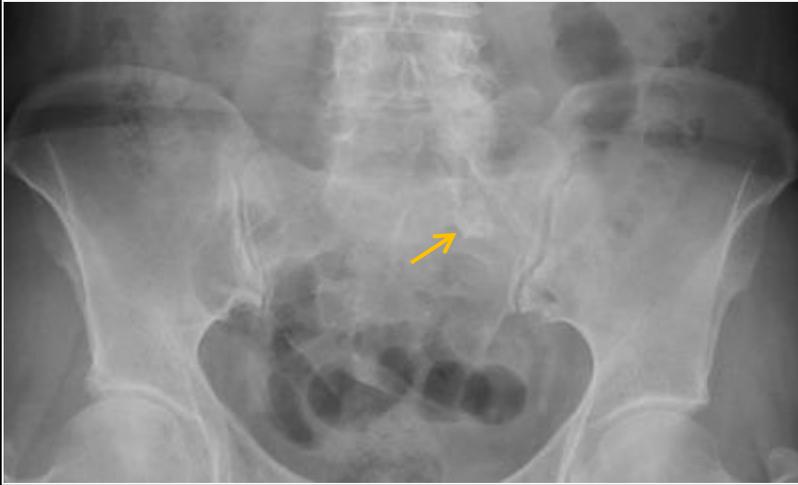


CT – We can see that the lesion has marrow and cortical continuity to the underlying bone, a finding that is pathognomonic.

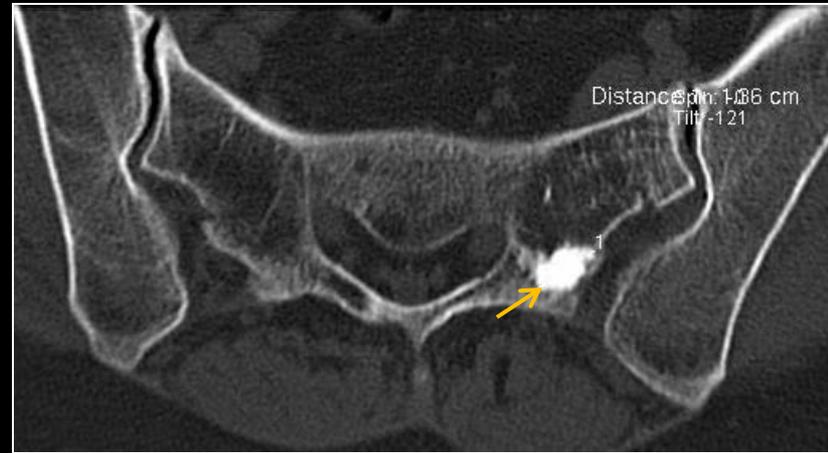
ENOSTOSIS

- **X-Ray and CT findings**
 - Circular or oblong, osteoblastic lesion.
 - Irregular, spiculated margin – “thorny radiations” or “brush border”.
 - Surrounding trabecular bone is normal with an abrupt transition to the lesion.
- **RM**
 - low signal intensity, regardless of the pulse sequence used.
 - spiculated margins may also be apparent.
 - Signal intensity of the surrounding marrow is normal.
- The distinction between enostosis and osteoblastic metastatic disease can be particularly troublesome if lesion enlargement has occurred.
- Consider vertebral biopsy if the lesion increases in diameter by more than 25% within 6 months or 50% within 1 year.

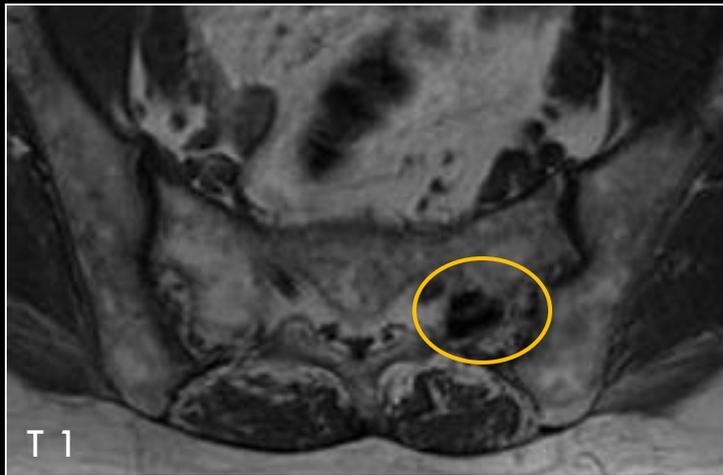
Enostosis



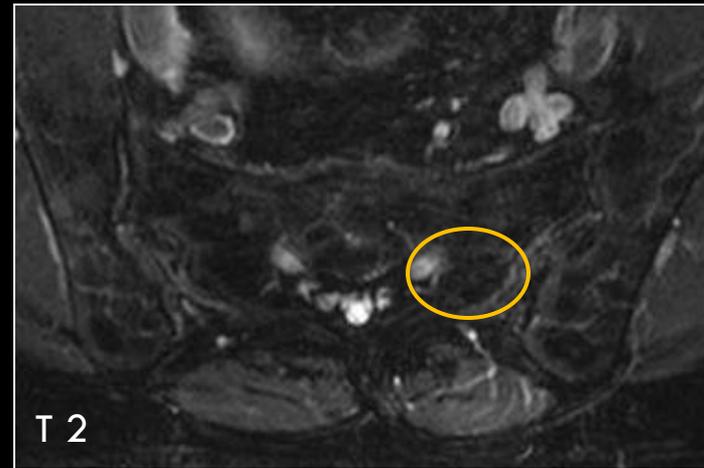
X – Ray – Sclerotic focus (arrow) located at left wing of sacrum.



CT – Densely sclerotic lesion (1,4 cm) with an irregular spiculated border just beneath the posterior cortex of the sacrum's left wing.



T 1



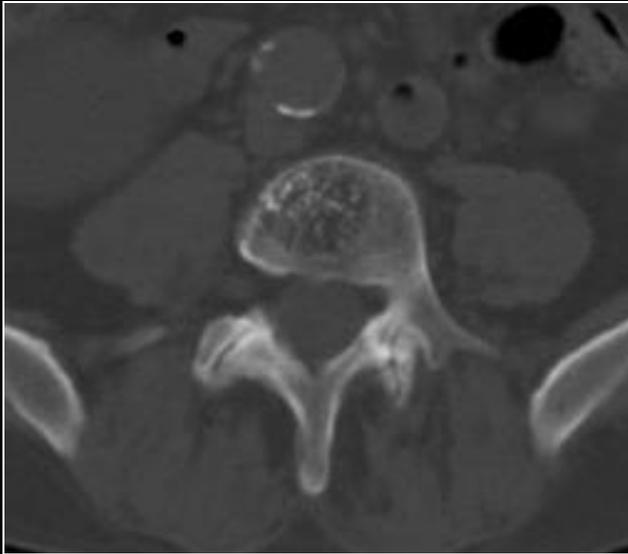
T 2

MR – The lesion is low signal on both T1 and T2. After gadolinium there was no lesion enhancement.

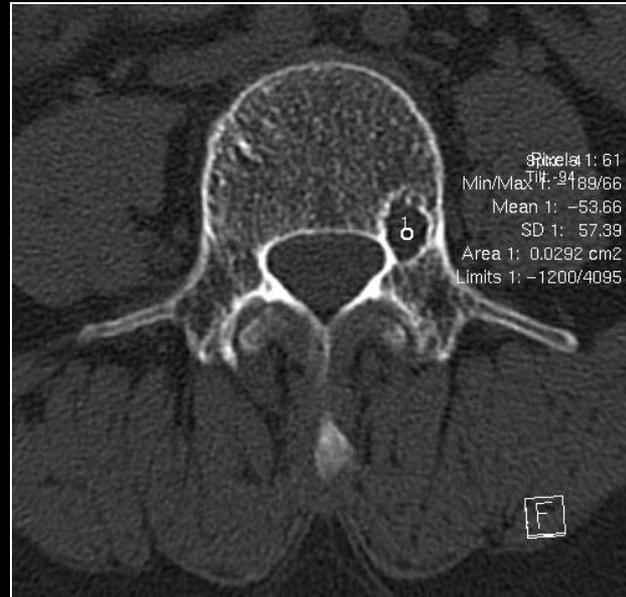
HEMANGIOMA

- **At radiography**, vertebral hemangiomas classically have a coarse, vertical, trabecular pattern with osseous reinforcement (trabecular thickening) adjacent to the vascular channels that have caused bone resorption.
- **At CT**, hemangiomas are of low attenuation and contain coarse punctuate and striated areas of sclerosis – “polka-dot” appearance.
- **At MR**, areas of trabecular thickening have low signal intensity
 - ▣ T1 – the signal intensity varies from low to high, depending on the degree of adipose tissue present.
 - ▣ T2 – usually show areas of very high intensity corresponding to the vascular components.
- Less than 1% behave aggressively and lead to compression fractures or soft tissue masses that may cause spinal cord compression.

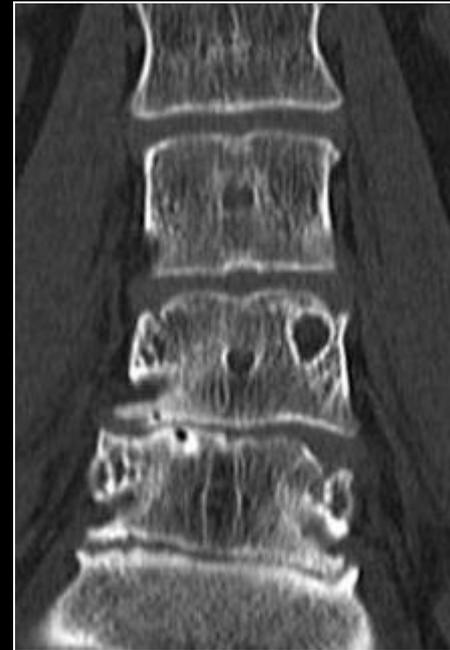
Hemangiomas of lumbar spine



CT – This is the classic CT appearance of hemangioma. Lesion of low attenuation that contains coarse punctate and striated areas of sclerosis, originating the “polka-dot sign”.



CT – Low attenuation lesion (ROI of minus 53 HU) in the left upper region of L4, with some extension into the ipsilateral pedicle, sclerotic margins and no cortical rupture. This was a hemangioma with a predominantly fat matrix.



Hemangioma of dorsal spine



T1



T2



T1 after gadolinium

MR – High signal on T1 and T2, with lesion enhancement after gadolinium.

LANGERHANS CELL HISTIOCYTOSIS

- Early lesions appear lytic followed by uniform collapse of the vertebral body.
- Extreme vertebral collapse produces de wafer or “coin-on-edge” appearance know as vertebra plana.
- The intervertebral disk spaces are preserved or appear slightly widened.
- Associated paraspinal mass may represent soft-tissue edema and hemorrhage related to the vertebral collapse or soft-tissue extension of LCH.
- CT and MR are useful in outlining the extension of the lesion if surgery is considered.

Langerhans cell histiocytosis



Lumbar spine X-Ray - Extreme vertebral collapse of L2, the so called vertebra plana appearance.



CT – Lytic lesion of the left side of the neural arch and vertebral body, without sclerosis and without soft tissue masses.

Chordoma

□ Radiology:

- The most frequent radiographic appearance is a destructive lesion of a vertebral body centered in the midline, with a large, associated soft-tissue mass.
- Osseous expansion is frequent.
- Evidence of **intratumoral calcification** is seen in 50-70% of sacrococcygeal lesions on radiographs and in as many as 90% on CT.
- There may be intervertebral disk involvement, with narrowing, which is unusual for most spinal tumors and simulates infection.

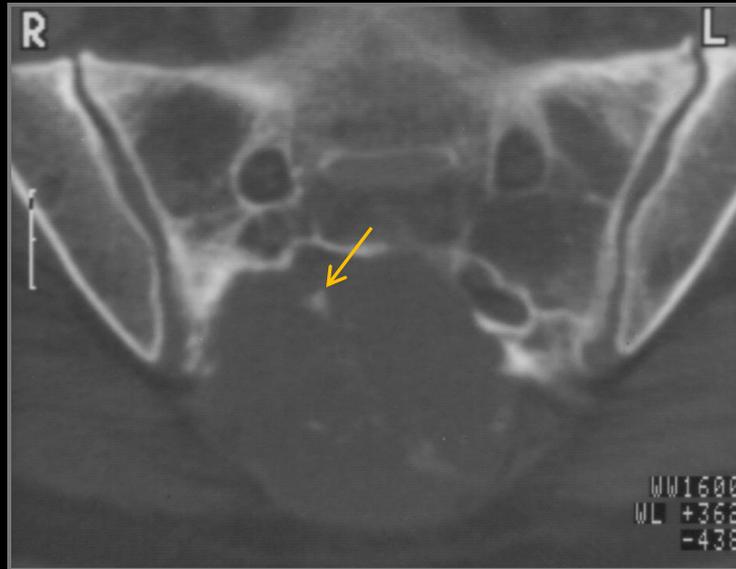
□ CT:

- Coronal oblique CT of sacrococcygeal lesions is the optimal method for detecting intervertebral foramen and sacroiliac joint involvement.
- > 50% of cases with soft-tissue mass of low attenuation, which reflects the myxoid-type tissue present pathologically.

□ MR:

- low to intermediate signal intensity on T1 and very high signal intensity on T2.

Chordomas

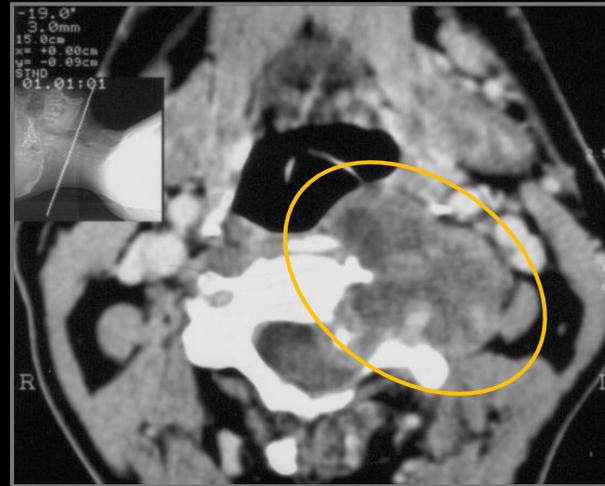
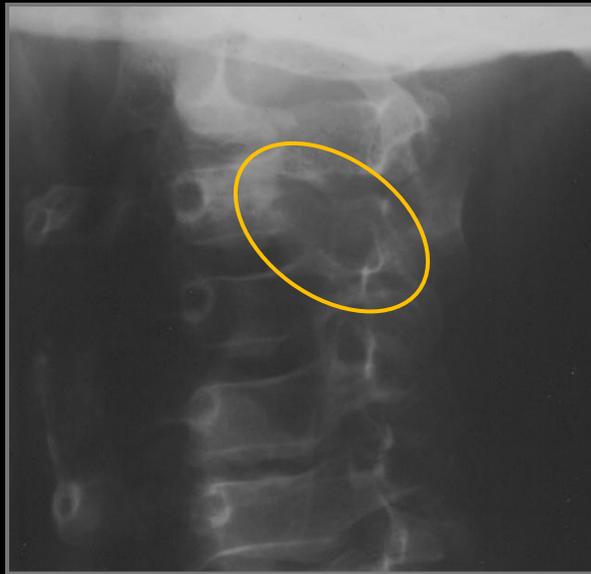


X-Ray and CT – Chordoma appearing in the midline of sacrococcygeal region as a expansile lytic lesion that spares the upper portion of sacrum. At CT the soft-tissue mass has low density due to the myxoid-type tissue. There are intra-tumoral calcifications (arrow) that usually represent destroyed bone sequestrum (and not matrix calcification).

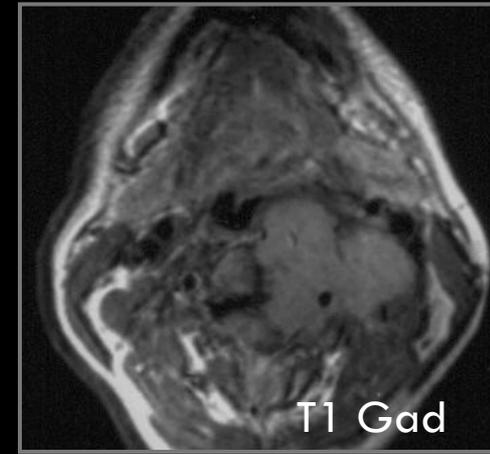
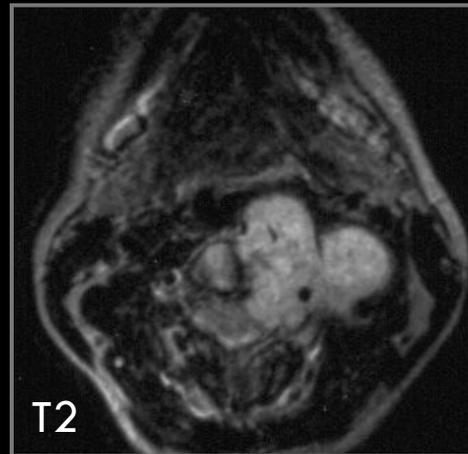
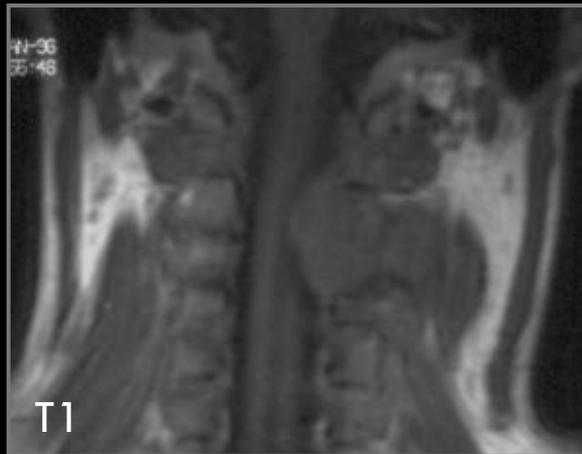


X-Ray and CT – In lumbar spine the lesion usually arises from the transition between the anterior 2/3 with the posterior 1/3 of the vertebral body (place of remnants of notochord). Usually, lumbar chordoma, as seen in this case, has a mixed pattern of lysis and sclerosis. There is a soft tissue mass with calcifications, intervertebral disk involvement with narrowing (can simulate infection!) and partial vertebral body collapse.

Cervical Chordoma



X-Ray, CT – Osteolytic lesion, with a big and lobulated soft-tissue mass, that goes through an enlarged neural foramina extending to epidural and paravertebral space.

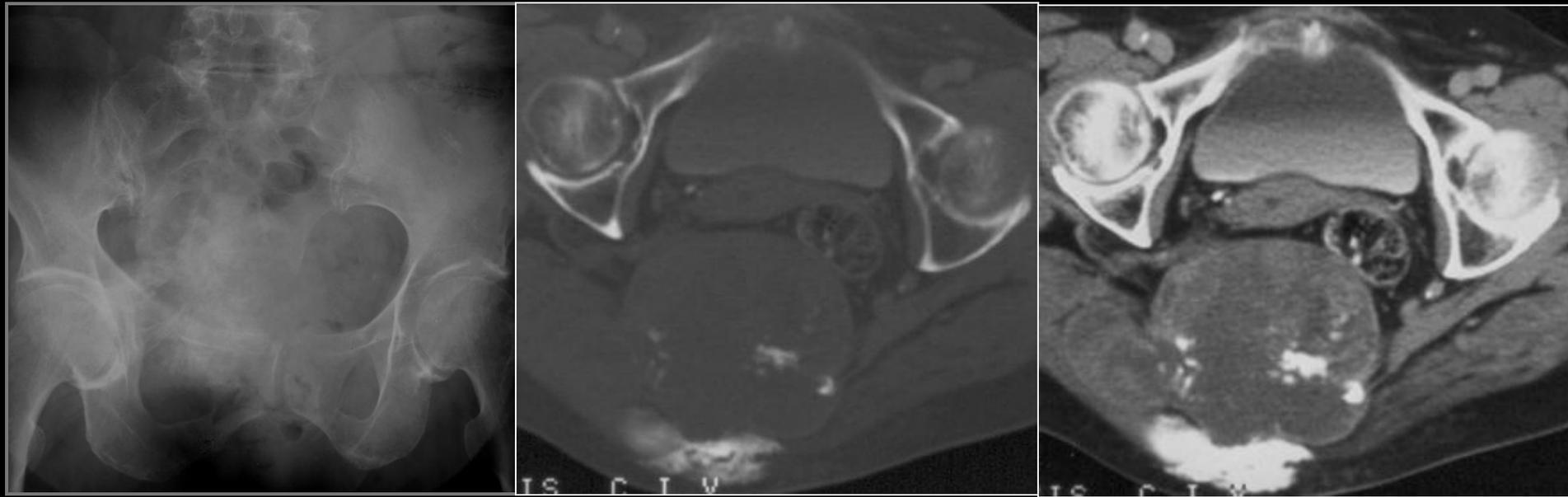


MR - There is low signal on T1, very high signal on T2 (myxoid content) with a weak but heterogeneous enhancement after gadolinium.

Chondrosarcoma

- Radiography typically reveals bone destruction.
- Cortical destruction invariably present.
- Characteristic **chondroid matrix mineralization** (rings and arcs) is apparent on radiographs in 70% of patients, but is better delineated by CT.
- Extension into the surrounding soft tissues is common (best seen by CT/RM), with mineralization usually apparent in the soft-tissue component.
- When arising from osteochondroma is seen as thickening at the peripheral cartilaginous cap.
- **CT** – the attenuation of the nonmineralized portion of the lesion is often lower than muscle (high water content of hyaline cartilage).
- **MR** – low to intermediate signal intensity on T1 and very high signal on T2.

Sacrum Chondrosarcoma

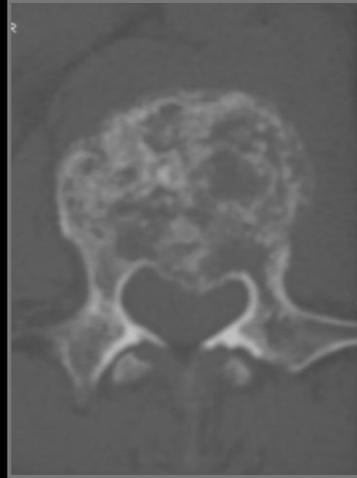


X-Ray and CT – There is an osteolytic lesion associated with a voluminous soft-tissue mass, which has several mineralized areas (resulting not only from chondroid matrix mineralization but also due to bone sequestra that result from destruction of the previous osteochondroma). The low attenuation seen at CT in the nonmineralized portion of the mass is typical, and reflects the high water content of hyaline cartilage.

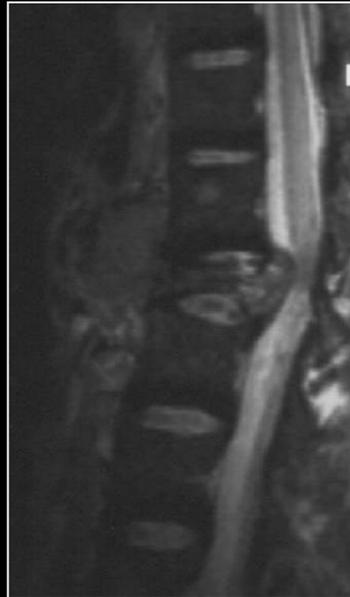
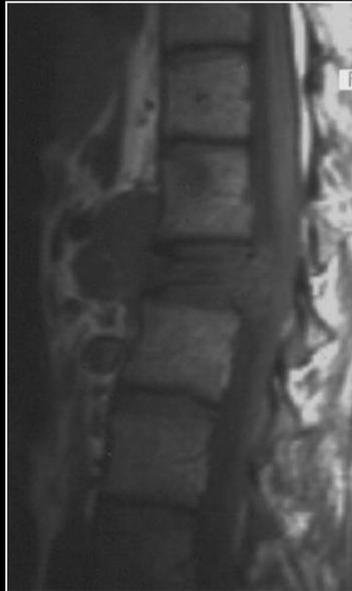
Ewing Sarcoma

- The most common nonlymphoproliferative primary malignant tumors of the spine in children.
- Most common location is the sacrococcygeal region, followed by the lumbar and thoracic segments.
- Typically centered in the vertebral body.
- Radiographs may reveal permeative bone lysis, osseous expansion or sclerosis.
- Paraspinal soft-tissue masses are often a prominent feature.
- MR – intermediate signal intensity on T1 and intermediate to high signal intensity on T2.

Dorsal Ewing Sarcoma



X-Ray and CT – This case has a mixed pattern (lytic and sclerotic), more often seen after treatment. The lesion is centered in the vertebral body – a typical location for Ewing Sarcoma. There is a prevertebral soft-tissue mass, also a prominent feature of these lesions.

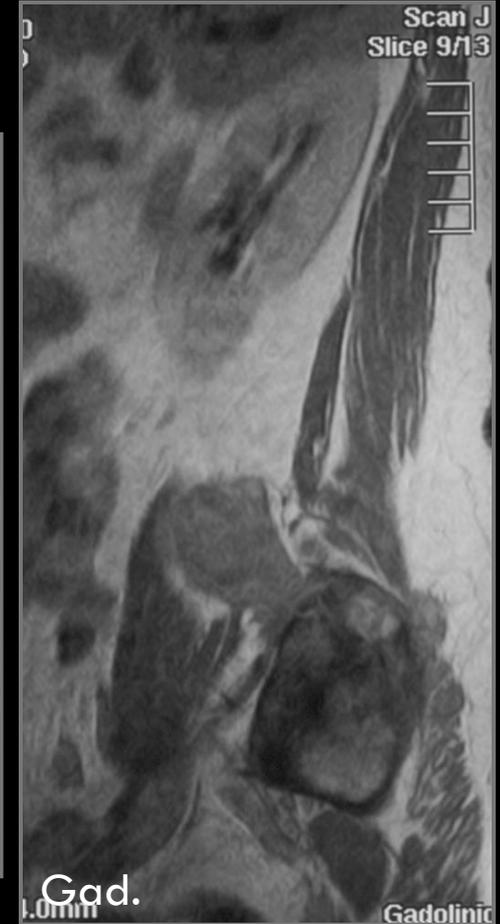


The **MR** appearance is nonspecific – intermediate signal intensity on T1 and intermediate to high signal intensity on T2.

Lombar Ewing Sarcoma



T1



MR – The associated soft-tissue mass is the prominent feature of this tumor. The MR findings are nonspecific, with low/intermediate signal on T1, and a weak homogeneous enhancement after gadolinium.

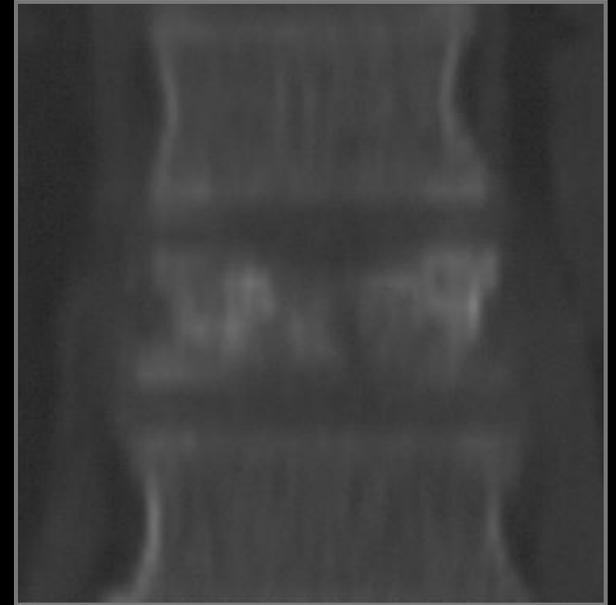
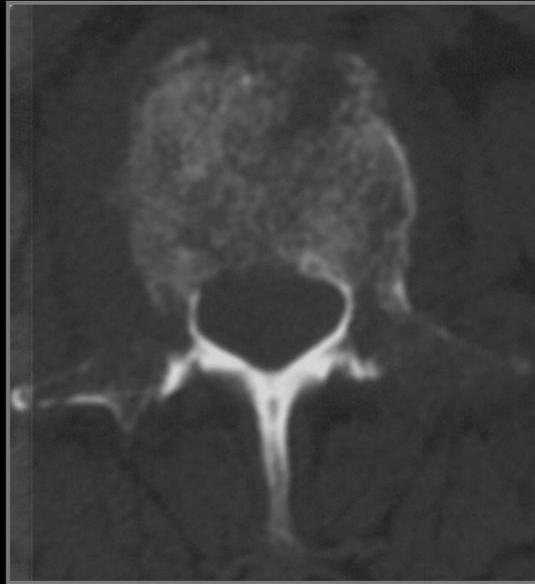
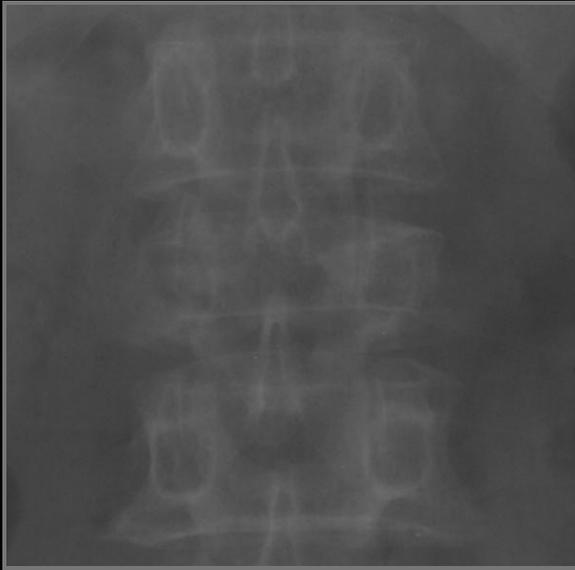
Osteosarcoma

- In most cases, the vertebral body is primarily involved, albeit eccentrically, but secondary extension into the posterior elements is also common.
- May be a secondary lesion: Radiation (5-20 year latent period); associated with Paget disease.
- Radiology:
 - **Radiographs** usually reveal densely mineralized matrix, and an ivory vertebral body may be recognized
 - Loss of vertebral height and sparing of the adjacent disk are common
 - Purely lytic lesions is rare
 - **CT and MR** – useful for evaluating lesion extent and the soft-tissue involvement
 - Lesions with large amounts of matrix mineralization may remain low signal intensity on all MR images

Primary osseous lymphoma

- Uncommon presentation of lymphoma, and must be distinguished from secondary osseous involvement by extraosseous primary disease.
- The lesion is lytic, most frequently moth-eaten or permeative, but it can appear to be of mixed density because of reactive bone formation and prominent endosteal thickening.
- The lesion can enlarge rapidly, giving rise to two features seen on radiography, CT or MRI that can be suggestive of dx:
 - Very large soft tissue mass without extensive cortical destruction.
 - Bone sequestra can be seen.
- MR is needed for staging because radiographs do not show the true size and extent of lesion.

Lumbar Primary Osseous Lymphoma



X-Ray and CT – This lesion is difficult to characterize on X-Ray. However CT demonstrates well the typical permeative pattern seen in primary bone lymphoma.

Dorsal Primary Osseous Lymphoma

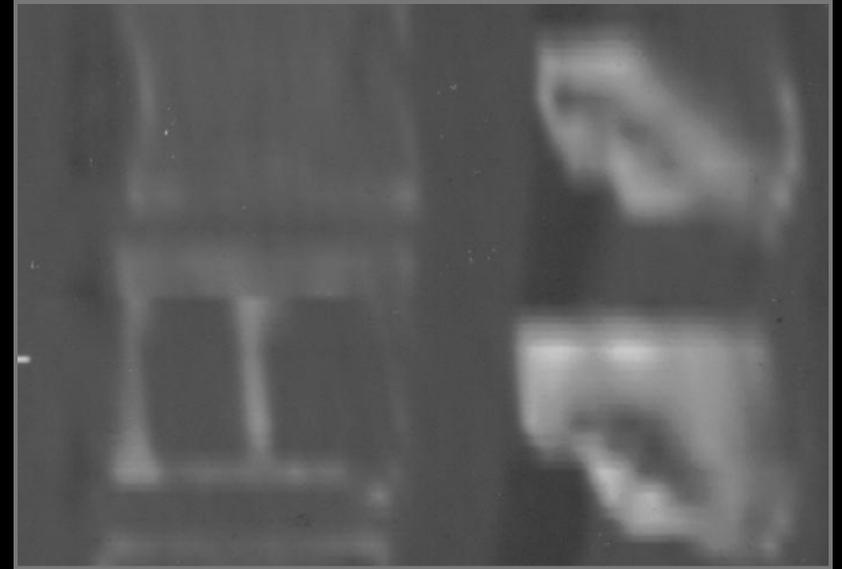
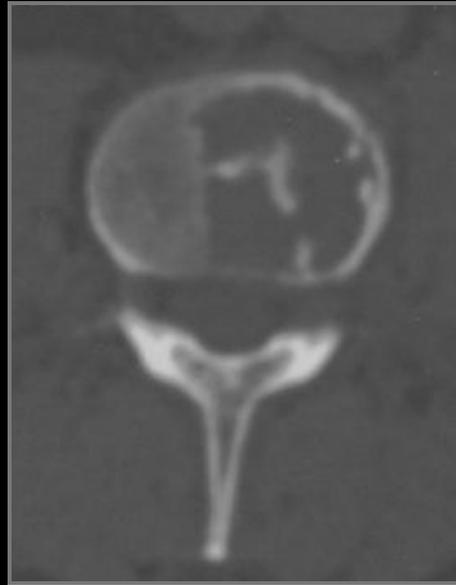


CT – The pattern of this lesion is mainly osteolytic, with partial vertebral body collapse. In this case there isn't an associated soft-tissue mass (frequently seen with this kind of tumors).

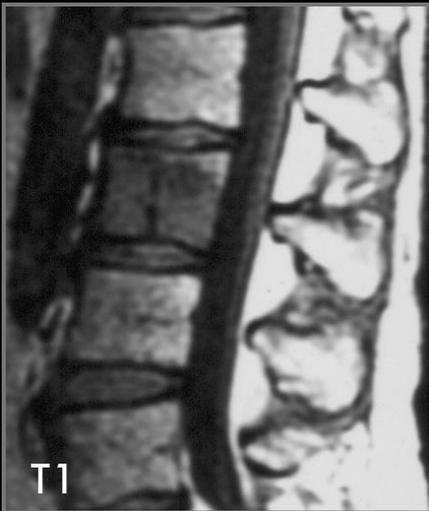
Plasmacytoma

- Neoplastic proliferation of plasma cells. **The solitary form** of this type of proliferation is called **plasmacytoma** (as opposed to multiple myeloma).
- Usually patients with > 40 years.
- Radiology:
 - ▣ Vertebral bodies are a frequent location because they are rich in hematopoietic marrow.
 - ▣ Lytic expansile geographic lesion, with a relatively narrow zone of transition without sclerotic margins.
 - ▣ No matrix calcification is present.
 - ▣ MR – **“mini-brain” appearance.**

Lombar Plasmacytoma



X-Ray and CT – Osteolytic lesion affecting a lumbar vertebral body, with relative preservation of cortical bone – “empty vertebra appearance”. We can see several lytic areas, separated by vertical bone bridges, with preservation of vertebral body height.



MR - The lesion has low signal on T1 and high signal on T2, with enhancement after gadolinium.

Lumbar Plasmacytoma



X-Ray and CT – Purely lytic lesion with associated soft-tissue mass.

Interventional Radiology - Biopsy guided by CT



Interventional Radiology – CT guided biopsy is instrumental for obtaining tissue for histologic analysis. Biopsy can be made in the bone lesion or in the often associated soft-tissue mass, at any level of the spine.

SUMMARY

- The identification of a solitary spinal bony lesion challenges the differential diagnosis, and imaging is instrumental for clinical decision making.
- Radiological findings quite often are sufficiently specific to address the correct diagnosis.
- The combination of cross-sectional modalities (CT/MR) assist X-ray techniques in the differential diagnosis and convey staging information including foraminal or spinal extension of the process.