Aged based variations in sacrum pathology

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Learning objectives

The main aim is illustrate the spectrum of sacrum disorders and show the differences according to subject age.

In addition, to present the different radiologic techniques (radiography, CT and MR) that are available for the study of sacrum pathology and its role in the diagnostic procedure, with emphasis on the key points that may help in this.

Background

Primary sacral involvement can result from a number of lesions affecting both children and adults, but with a different prevalence by patient age group and with distinctive features.

We reviewed of sacral pathology seen in our Site (Hospital Universitario de La Princesa) and in a Children´s Hospital (Hospital Infantil Universitario Niño Jesús) in the last 5 years, including of congenital, tumoral, infectious, inflammatory and metabolic pathology and fractures (Fig. 1 on page 14. Spectrum of sacrum disorders).

In pediatric group, the most common pathology is congenital, whereas in adult group is neoplastic (Fig. 2 on page 15).

Each hospital information service performed a search based on the CIE-9 codes that were or could be related to sacrum pathology.

CONGENITAL PATHOLOGY

Congenital lesions of the sacrum are included in the Fig. 3 on page 15. These disorders are more prevalent in chidren and optimally imaged with MR.

SACRAL AGENESIS

- Sacral agenesis or caudal regression syndrome is a severe and rare form of abnormal sacral development (0,005-0,01%).
- Higher frequency (0.1-0.2%) in children of diabetic mothers.
- It is frequently associated with spinal cord abnormalities (syrinx, tethered cord, lipoma and lipomyelomeningocele).

- Four types:

I: partial unilateral agenesis

II: partial bilateral symmetric agenesis (Fig. 4 on page 16)

III: total sacral agenesis and iliac bones articulate with lumbar spine

IV: total sacral agenesis and iliac bones are fused posteriorly

- CT imaging finding: Absence of the sacrum and coccyx, partial or complete.

- MR imaging finding: Distinct club-shaped configuration of the conus medullaris in total sacral agenesis (Fig. 5 on page 17).

#

DYSRAPHISM, TETHERED CORD AND LIPOMENINGOCELE

- Meningoceles are protrusions of the membrane-lined spinal canal contents through a ventral or dorsal (more common) osseous defect in the vertebral column.

- Anterior meningoceles are asymptomatic or symptomatic masses and may be associated with partial sacral agenesis.

- Posterior meningoceles are classified as myelocoeles, myelomeningoceles or lipomyelomeningoceles, and are frequently associated with a tethered spinal cord (Fig. 6 on page 18).

- CT imaging is used to assess the associated osseous defects.

- The developmental lesions of the sacrum (meningoceles and cord anomalies) are optimally imaged with MR.

MENINGEAL CYST
- Sacral meningeal cysts are common developmental lesions (5%).

- Abnormal dilatations of the meninges within the sacral canal or foramina.

- They can communicate (perineural or Tarlov cyst) or not (sacral meningeal cyst) with the subarachnoid space.

- Usually asymptomatic, although large cysts can manifest as neurologic symptoms.

- CT imaging findings:

  a) Enlarged sacral canal or foramen due to pulsations of the cerebrospinal fluid or raised intraspinal pressure can erode or remodel them.

  b) Thinned cortical margins.

- MR imaging findings: Cyst lesion with the same signal as cerebrospinal fluid in relation to sacral nerve roots (Fig. 7 on page 19).

**NEOPLASTIC PATHOLOGY**

- Neoplastic lesions may involve primarily or secondarily the sacrum, both the bone structure and the sacral canal.

- Metastatic lesions, multiple myeloma and lymphoma are more common than primary malignancy. Although the main aim of this work is to present the primary sacral pathology, we will make a brief reference to these processes because of their frequency.

- Primary benign and malignant tumors of the sacrum are rare lesions (<7% of all intraspinal primary tumors). Among the cases reviewed, the malignant tumors are the most prevalent, with Ewing sarcoma most often in children and metastases in adults (Fig. 8 on page 20).

- Sacral tumor grown slowly so its diagnosis is often delayed. They become symptomatic (low back pain, palpable mass, neurologic deficits), when become large enough to compress adjacent nerves or pelvic organs.

**GIANT CELL TUMOR**

- GCT of the spine are rare (3-7% of all GCT), and sacral involvement is the most common site.
- Second most common primary sacral tumor after chordoma.
- 2nd- 4th decades of life.
- Male/ Female: 1 / 2
- Locally aggressive.
- 5-10 % are malignant.
- Plain radiograph: Lytic, expansile and destructive lesion, often eccentrically located and may extend across the sacroiliac joint (Fig. 9 on page 21).
- CT imaging findings:
  a) Soft tissue mass
  b) Thin sclerotic rim
  c) Low attenuation areas (necrosis)
- MR imaging findings:
  a) Intermediate and heterogeneous signal intensity on both T1 and T2
  b) Significant enhancement (very vascular neoplasms)
  c) May contain areas of hemorrhage (fluid-fluid levels) or necrosis

SCHWANNOMAS AND NEUROFIBROMATOSIS

- Schwannomas and neurofibromas are benign, slowly-growing tumours that arise from the myelin sheath of lower lumbar and sacral dorsal sensory nerve roots. In the sacrum, they grow along nerve segments and expand the sacral canal and neural foramina.
- Both present a benign and similar appearance on imaging.
- Sacrum is the most frequent site of schwannoma after the mandible. Giant sacral schwannomas (Fig. 10 on page 22) cause extensive destruction of the sacrum.
- Multiple neurofibromas are characteristic of von Recklinghausen´s neurofibromatosis with potential form malignant transformation (Fig. 11 on page 23).
- CT imaging findings:
a) Circumscribed osteolysis

b) Enlargement of a sacral foramen

c) Fine sclerotic rim

- MR imaging findings:

a) Hypointense on T1

b) Characteristic on T2: high-intensity nodule with zones of low-intensity (islands of collagen)

c) Contrast enhancement

EPENDYMOMA

- Malignant tumors that arise within the central canal of the spinal cord or the filum terminale.

- The intramedullary type occurs most often in the cervical spine, whereas the myxopapillary type occurs exclusively in the conus medullaris and filum terminale (WHO grade I).

- Mean age: 36

- Slight male predominance.

- Vascular soft-tissue masses with areas of hemorrhage and mucinous degeneration.

- It can produce bony destruction but rarely metastasizes.

- CT imaging findings (Fig. 12 on page 24):

a) Neural foramen widening

b) Adjacent bone destruction

- MR imaging findings:

a) High T2 signal

b) Contrast enhancement
OSTEOSARCOMA

- The most common nonlymphoproliferative primary malignant bone tumor but rarely affects the spine (3%).
- Fifth most common primary malignant tumor of the sacrum (4% of sacral tumors).
- Primary (20-30 years old) or secondary to Paget’s disease, osteonecrosis or chronic osteomyelitis (60 years old).
- Male / Female: 1.6 / 1
- CT imaging findings:
  a) Lytic, osteoblastic or mixed lesions.
  b) Osteoid matrix
  c) Periosteal new bone formation ("sunburst" pattern), lifting of the cortex and formation of Codman’s triangle
- RM imaging findings (Fig. 13 on page 25):
  a) Low signal intensity on T1
  b) High signal intensity on T2
  c) Mineralized / osteoid matrix is seen as low signal intensity on all MR pulse sequences.
  d) Contrast enhancement.

EWING SARCOMA

- Only 3-10% of all primary Ewing’s sarcoma are located in the spine (lumbosacral spine is the most common site). Metastasic involvement is more common.
- It is a small round cell sarcoma.
- It is the most common non lymphoproliferative primary malignant tumor of the spine in children.
- Male / Female: 1.5 / 1
- First 3 decades of life
- 30% with lung metastases at diagnosis.
- CT imaging findings:
  a) Lytic, mixed or sclerotic lesions.
  b) Soft-tissue mass usually larger than the bone tumor.
  c) Nonspecific (staging)

- MR imaging findings (Fig. 14 on page 26):
  a) Clearly depicts the intra and extraosseous components of the tumor and paraspinal, extradural and presacral involvement.
  b) Nonspecific (staging)

SYNOVIAL SARCOMA

- 2.5-10% of soft-tissue malignant tumors. The most common malignant soft-tissue sarcoma after rhabdomyosarcoma in children and adolescents. - Majority of patients presenting at 15-40 years of age.
- t(X;18) translocation.
- More frequent in extremities (85%), near large joints, but it can occur anywhere.
- Sharply marginated tumors that may appear to be largely cystic and be misdiagnosed as a hematoma, ganglios cyst, Baker’s cyst or other benign cyst mass.
- Metastasizes to the lung (74-81%), lymph nodes (12-23%) and bone (10-20%).
- CT imaging findings:
  a) Heterogeneous multinodular soft-tissue mass. 30-40 % contain calcifications.
  b) Necrosis and hemorrhage
c) 71 % related to bone: cortical thinning, medullary invasion, extrinsic erosion or periosteal reaction.

d) Heterogeneous enhancement 89-100 %.

- MR imaging findings (Fig. 15 on page 27):

  a) Heterogeneous multiloculated mass with internal septations (bowl of grapes sign).
  b) Well defined margins (53-91%)
  c) Triple signal intensity on T2 in 35-57 %
  d) Fluid-fluid levels from hemorrhage in 10-25 %
  e) Areas of hemorrhage: high signal on T1 and T2
  f) Heterogeneous enhancement 83-100 %.

PLASMACYTOMA AND MULTIPLE MYELOMA

- Multiple myeloma is the second most common primary malignant neoplasm of the sacrum (Fig. 16 on page 28).

- Malignant monoclonal proliferation of plasma cells of the bone marrow.

- # 50 years old

- Male / Female: 2 / 1.

- Plasmacytoma is a solitary form, in younger patients and eventually progresses to multiple myeloma (Fig. 17 on page 29).

- CT imaging findings: Large and expanded lytic lesion

- MR imaging findings: Nonspecific, with low-to-intermediate signal intensity on T1- and high signal intensity on T2-weighted images.

METASTASES

- 25 times more common than primary bone tumors.
- Most commonly affecting the axial skeleton (bone marrow).

- # 40 years

- Hematogenous or contiguous spread.

- Single or multiple. The presence of multiple lesions in the sacrum and the rest of the spine suggests the diagnosis of metastases or multiple myeloma, which must be confirmed by other clinical, laboratory and scintigraphic findings.

- The cartilage resists invasion (joints, discs).

- CT imaging findings:

  a) Usually osteolytic lesions (Fig. 18 on page 30)

  b) Sclerotic lesions: breast, prostate (Fig. 19 on page 31)

- MR imaging findings:

  a) Hypointense on T1

  b) Hyperintense on T2

  c) Contrast enhancement.

  d) Sclerotic: Hypointense on all pulse sequences

- Derived from lung, breast, kidney, prostate (Fig. 20 on page 32), head and neck, gastrointestinal or skin (melanoma) cancers. Neuroblastoma in children.

- Contiguous spread from advanced pelvic neoplasms to the sacrum may be seen with rectal (Fig. 21 on page 33), uterine, prostate and bladder carcinoma.

**INFECTIOUS PATHOLOGY**

(Fig. 22 on page 34)

**OSTEOMYELITIS**

- Routes of infection:
a) Contiguous spread from adjacent infection (more often)

b) Hematogenous:

- Antegrade flow (nutrient arterioles) or IV injections in drug abusers.
- Retrograde flow via the Batson plexus from the bladder, intestines or genitourinary tract.

c) Direct inoculation (surgery or trauma).

- Infecting organism:

  a) Pyogenic infection: *Staphylococcus aureus* (55-90%), *Streptococcus*, *Pneumococcus*, *Enterococcus*, *Escherichia coli*, *Salmonella*, *Pseudomonas aeruginosa* and *Klebsiella*.

  b) Granulomatous infection: *Mycobacterium tuberculosis*, *Brucella*, fungi and parasites (hydatid disease).

- CT imaging findings (Fig. 23 on page 35):

  a) Ill defined and poorly marginated lytic lesion of the sacrum

  b) Medullary low-attenuation areas or trabecular coarsening

  c) Cortical erosion and periosteal reaction

  d) Extensive overlying soft-tissue inflammatory change

  e) Fluid collections (presacral space, adjacent articulation, eg)

  f) Involvement of adjacent disc space or sacroiliac joint

  g) An extramedullary fat-fluid level is a rare but specific sign (cortical breach)

  h) Sclerotic foci or osseus sequestra in chronic infection

  i) More reliably ito determine cortical destruction and gas.

- MR imaging findings (Fig. 24 on page 36):

  a) Low signal intensity on T1-weighted
b) High signal intensity on T2-weighted images.

c) Disk space: fluid-like signal intensity on T1 and T2 images.

d) Enhancement: diffuse (bone marrow, disk) or rim-like (paravertebral and epidural soft-tissue lesions)

e) Better definition of epidural extension of the inflammatory process and f) compression of the spinal cord.

g) The intervertebral disk may be spared in tuberculosis and in Aspergillus infections.

h) More reliably to determine the viability of sequestered bone.

HYDATID DISEASE

- Intercontinental zoonosis

- Produced by the larva of the tapeworm Echinococcus granulosus or multilocularis

- Humans are infected by direct contact with an infected dog or by ingestion of contaminated food.

- Bone involvement is seen in only 1 to 2.5% of cases of hydatidosis (50% in the spine)

- When the bone is affected, multiple slow-growing vesicles proliferate along the medullary canal, replacing trabecular bone, but not forming encapsulated cysts as occurs in other organs. With time, the parasite may destroy the cortical bone and protrude into adjacent soft tissue.

- CT imaging findings:

  a) Well-defined expansile osteolytic lesion with coarse trabeculae (Honeycomb appearance) and cortical thinning.

  b) Multivesicular cyst in soft tissues

  c) Calcified soft tissue mass

- MR imaging findings (Fig. 25 on page 37):

  a) Superior to demonstrate neural involvement.
b) Hypointense on T1 and hyperintense on T2-weighted images (cyst nature)

**TRAUMATIC PATHOLOGY**

**FRACTURES**

A) Traumatic fractures (n=22) Fig. 26 on page 38

- **Zone 1**: Lateral to the sacral foramina. Rare neurological deficits

- **Zone 2**: Involve one or more of the foramina. Unfrequent neurologic deficits, unilateral lumbar or sacral radiculopathy

- **Zone 3**: Involve the central sacral canal with or without involvement of the other two zones. Frequent bilateral neurological damage, "cauda equina syndrome" (Fig. 27 on page 39).

B) Stress fractures (n=6)

- Types:

  1. Insufficiency fractures (98%): Normal stress is applied to abnormal bone (Fig. 28 on page 40).

  2. Fatigue fracture (2%): Normal bone is exposed to repeated abnormal stress.

- CT imaging findings: Sclerotic band or discrete fracture lines.

- MR imaging findings: Bone marrow edema with or without discrete vertical fracture lines.

**OTHERS**

**PAGET**

(Fig. 29 on page 41)
- Older age: 10% # 80 years old.
- Male / Female: 2/1
- Monostotic o polyostotic
- Stages of disease activity: lytic, lytic-sclerotic and sclerotic or blastic.
- 75% located in pelvis
- Elevated levels of serum alkaline phosphatase.
- Malignant transformation into an osteosarcoma or, much less frequently, a chondrosarcoma or fibrosarcoma<1%.

- CT imaging findings:
  
a) Cortical thickening
b) Enlargement of the bone
c) Depending on stage:
   - Lytic areas
   - Blastic areas
   - Mixed pattern

- MR imaging findings:
  
a) Lytic stage: Hypointense on T1 and hyperintense on T2
b) Blastic stage: Hypointense on both T1 and T2

Images for this section:
Fig. 1: Department of Radiology, Hospital Universitario La Princesa.

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<th>Category</th>
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<th>Adults (n=97)</th>
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<td>n=29 (Paget)</td>
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Figure 2. Sacrum disorders identified in our hospitals

Fig. 2: Department of Radiology, Hospital Universitario La Princesa.
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<thead>
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<th>CHILDREN (n=25)</th>
<th>ADULTS (n=5)</th>
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<td>Dysraphism and spondylolysis (1)</td>
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<td>Partial sacrum agenesis (4)</td>
<td>Giant bone island (enostoses) (1)</td>
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<td>Filum terminale lipoma and tethered cord (4)</td>
<td>Meningeal cyst (3)</td>
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<td>Meningocele and sacrum agenesis (2)</td>
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<td>Lipomielomeningocele/</td>
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<td>Myelomeningocele and tethered cord (5)</td>
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<td>Spondylolisthesis L5-S1 (3)</td>
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<td>Filum terminale lipoma and dysraphism (3)</td>
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<td>Intraspinal arachnoide cyst (1)</td>
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<td>Dysraphism and tethered cord (1)</td>
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<td>Diastamatomyelia and filum terminale lipoma (1)</td>
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**Fig. 3:** Department of Radiology, Hospital Universitario La Princesa.
Figure 4. 5 year-old male. Pelvis X-ray (A) shows a complete sacral agenesis. 12 year-old male. MR of another patient with partial sacral agenesis. Previous surgery for anterior sacrum meningocoele and dermal sinus. Axial (B) and sagittal T1 (C) and T2 (D) weighted images show complete S1 and partial S2 vertebral bodies with absence of the rest of the sacral bone. Tethered cord that ends at L3 level. Terminal ventricle (fifth ventricle) from D11 to L1 is also observed (D).

Fig. 4: Department of Radiology, Hospital Pediátrico Niño Jesús.
Figure 5: 4 year-old male. Pelvis X-ray (AP: A and lateral: B): Normal lumbar spine and abnormal S1 vertebrae with agenesis of the rest of the sacrum. RM: Sagittal T2 (C) and T1 (D) weighted images show a medullar cone positioned at the level of D12. The thecal sac ends at L5 level. Coronal T1 (E) shows a butterfly S1 vertebral body that articulates with the iliac bones and agenesis of the rest of the sacrum and coccyx.

Fig. 5: Department of Radiology, Hospital Pediátrico Niño Jesús.
Figure 6. 12 year-old female. Lumbar MR: Sagittal T1 (A) and T2 (B) weighted images. Axial STIR (C) and T1 (D) weighted images. Tethered cord of posterior location at S1 level (A and B) where lack of fusion of posterior sacral elements (D) and lipomeningocele are observed (A, B and C).

Fig. 6: Department of Radiology, Hospital Pediátrico Niño Jesús.
Figure 7. 77 year-old male.
Sagittal reconstruction (A) CT shows an enlarged first left sacral foramen, with sclerotic margins, by a low attenuation cystic-like lesion. A similar and smaller lesion is observed caudally. Sagittal (A-C) and axial (D-E) MR show enlarged sacral foramina by multiple and bilateral cystic lesions that are hypointense on T1 (B, D) and hyperintense on T2 (C, E) weighted images.

Fig. 7: Department of Radiology, Hospital Universitario La Princesa.
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<td>. Giant cell tumor (1)</td>
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<td>. Benign</td>
<td>. Schwannoma (1)</td>
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<td>. Ependymoma (1)</td>
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*Fig. 8: Department of Radiology, Hospital Universitario La Princesa.*
Fig. 9: Department of Radiology, Hospital Pediátrico Niño Jesús.
Figure 10. 22 year-old male. Pelvis CT (A and B, bone and soft-tissue window): Lytic lesion with a slight sclerotic rim, rupture of the cortical and expansile component that affects the body and left sacral wing. Important soft tissue mass (arrow).

Pelvis MR: Bone destruction of the body and left sacral wing by a large exophytic soft tissue mass that invades the epidural space. The soft tissue displays a heterogeneous pattern, isointense on T2-weighted images (C), hyperintense with areas inside of low signal on T2-weighted images (D) and enhancement after administration of contrast (D). The lesion invades and enlarges the left sacral foramina affecting their roots.

Fig. 10: Department of Radiology, Hospital Universitario La Princesa.
Figure 11. 25 year-old male, LUMBOSACRAL MR: Multiple neurofibromas in lumbar spinal roots and the sacral plexus with enlarged foramina and anterior extension into the pelvis where large soft tissue masses corresponding to enlarged nerve roots are identified (arrows). Some of them also invade the epidural space. Neurofibromas are hypointense on axial T1 (A and D), hyperintense and heterogeneous on axial T2 (B and E) and show heterogeneous enhancement after contrast administration (C and F).

Fig. 11: Department of Radiology, Hospital Universitario La Princesa.
**Figure 12.28 year-old male.** Relapsed ependymoma. Mass in the sacral canal that invades and erodes the sacrum and introduces and expands the sacral foramina. It is hypointense on T1 weighted MR (A and C), hyperintense on T2 (B) and enhances after contrast administration (D). Note the postoperative sacral laminectomy and fatty replacement of L4, L5 and sacrum bone marrow secondary to radiotherapy.

**Fig. 12:** Department of Radiology, Hospital Universitario La Princesa.
Fig. 13: Department of Radiology, Hospital Universitario La Princesa.

Figure 13. 36 year-old male. CT MIP reconstruction (A) shows an infiltrative and lytic lesion in the right ilium and sacral wing with a large associated soft tissue mass with osteoid matrix. Cortical disruption together with intense sunlight periosteal reaction are observed (arrow).

MR: On coronal T1-weighted sequences (B) the mass is hypointense with small areas of increased signal consistent with bleeding. On inversion-recovery sequences (C) the mass is hyperintense, with areas of increased signal corresponding to areas of necrosis. On postcontrast T1-weighted sequences (D) a marked enhancement of the mass is observed.
**NEOPLASTIC**

**EWING SARCOMA**

**Fig. 14:** Department of Radiology, Hospital Pediátrico Niño Jesús.
Fig. 15: Department of Radiology, Hospital Pediátrico Niño Jesús.
Fig. 16: Department of Radiology, Hospital Universitario La Princesa.
**Figure 17**: 46 year-old male. Pelvis X-ray (A) shows diffuse alteration in bone density with multiple lytic images. Pelvis CT: (B) Multiple intramedullary lytic bone lesions in all visible bones without expanding or affecting the cortical. There is a soft tissue mass (arrow) in sacrum with intraspinal extension. Sacrum MR: The bone marrow of lumbar vertebrae and the sacrum is replaced by a patchy pattern alternating hypointense and hyperintense signal areas on MR all sequences (C and E: T1, G: T2 and D: STIR) that enhances after gadolinium administration (F). In the lower region of S1 and S2 there is a mass that is isointense to muscle on T1 weighted images (C and E), hyperintense on T2-weighted images (G) and enhances after gadolinium administration (F) with spinal canal and sacral foramina invasion.

**Fig. 17**: Department of Radiology, Hospital Universitario La Princesa.
**NEOPLASTIC**

**OSTEOLYTIC METASTASES**

*Figure 18. Breast metastases: 57 year-old female.* Pelvis X-ray (A) shows multiple lytic lesions in both iliac bones. On axial bone window pelvis CT (B and C) multiple lytic lesions are observed in both iliac and sacrum bones.

*Thyroid metastases: 66 year-old female.* Pelvis enhanced CT: bone (D) and soft tissue window (E) show lytic lesions in right iliac and sacral wing with associated soft-tissue mass (arrows).

**Fig. 18:** Department of Radiology, Hospital Universitario La Princesa.
Fig. 19: Department of Radiology, Hospital Universitario La Princesa.
**Figure 20. 71 year-old male. Pelvis CT (A and B):** Lytic sacral lesions with soft tissue mass in the caudal region (arrow) **Lumbosacral MR:** On T2-weighted images (C) the bone marrow which is affected by metastases has increased signal identifying the involvement of multiple vertebral bodies (L1, L2, L4 and L5) and sacrum and coccyx where there is also soft tissue mass. On T1 weighted images (D) the affected bone and soft tissue mass appear hypointense and enhance after intravenous contrast administration (E).

**Fig. 20:** Department of Radiology, Hospital Universitario La Princesa.
Figure 21. 87 year-old male. Pelvis X-ray (A) shows an area of low density in right sacral wing secondary to lytic metastases with a fracture line (arrow). Sacrum MR: A signal alteration that involves almost completely the sacrum is observed; hyperintense on coronal STIR (B) and axial T₂ (E) e hypointense on coronal T₁ weighted images (D). Enhancement is observed after contrast administration (C and F: coronal T₁ and axial fat-saturated T₁ weighted image, respectively). A fracture line corresponding to pathologic fracture is observed on the right sacral wing (arrows in C and D).

Fig. 21: Department of Radiology, Hospital Universitario La Princesa.
Figure 22. Sacrum infectious pathology identified

**Fig. 22:** Department of Radiology, Hospital Universitario La Princesa.
Figure 23. 60 year-old male. **Axial sacrum CT bone (A) and soft-tissue (D) window.** Medullary low attenuation in right iliac and sacral wing with cortical rupture and pathologic fracture of right iliac bone. Enlargement of adjacent soft-tissue. **Sacrum MR:** Signal intensity alteration is seen in right iliac and sacral wing bone marrow and adjacent soft-tissues, hypointense on T1 (B) e hyperintense on T2 weighted images (STIR - C). Diffuse enhancement in the areas of altered signal and some with peripheral enhancement in the affected bones and in adjacent muscles after contrast administration is seen (E and F) in relation to bone and muscle abscesses (arrows).

**Fig. 23:** Department of Radiology, Hospital Universitario La Princesa.
Fig. 24: Department of Radiology, Hospital Pediátrico Niño Jesús.
Fig. 25: Department of Radiology, Hospital Universitario La Princesa.

Figure 25: 58 year-old male.
Lumbosacral MR: Signs of transpedicular fixation. Extensive collection extending from the spinal canal epidural space to the subcutaneous tissue of the lower back, contacting the dermis. Like any fluid collection it is hypointense on T1 (A and D) and hyperintense on T2-weighted images (B and E). Multiple round images of low signal on all sequences that could correspond to membranes of daughter vesicles can be identified inside the collection. Rim-enhancement is seen after IV contrast administration (C).
Fig. 26: Department of Radiology, Hospital Universitario La Princesa.
Figure 27. Axial bone window pelvis CT:
48 year-old male. Left wing sacrum fracture type 1 (A and D) lateral to sacral foramina (arrows). Another fracture is observed in the left iliac bone (short arrow).
24 year-old female. Bilateral type 2 sacrum fracture through sacral foramina (arrows in B and E).
48 year-old male. Sclerotic bands corresponding to healed type 1 and type 3 sacrum fractures (short arrows indicating type 3 fracture in C and F).

Fig. 27: Department of Radiology, Hospital Universitario La Princesa.
Fig. 28. 79 year-old male. Case 1. Sacrum bone window axial (A-B) and coronal (C) CT: Fracture line (arrows) surrounded by sclerotic bands in the right sacral wing.

82 year-old male. Case 2. Coronal and axial T1 (D-E) and STIR (F-G) images: Bilateral linear images with lack of signal surrounded by areas of low intensity signal on T1 and high signal on T2 in both sacral wings, corresponding to fracture lines with peripheral edema.

**Fig. 28:** Department of Radiology, Hospital Universitario La Princesa.
**Figure 29.** 78 year-old male. Pelvis X-ray (A): Diffuse and symmetric density increase in the sacrum. Axial pelvis CT (B): Cortical thickening of the sacrum and sacral foramina together with diffuse increased attenuation of the bone marrow and alternating areas of lower density. These findings support as the first possibility the existence of mixed phase monostotic Paget's disease. Pelvis CT (C and D) of another patient with similar findings. Note that the iliac bones are spared.

**Fig. 29:** Department of Radiology, Hospital Universitario La Princesa.
We reviewed plain radiography, CT and RM of more than 160 cases of sacral involvement, but finally only included primary involvement of the sacrum.

We have selected and showed the most representative cases of each disease group and summarize the main CT and MR signs.

**Conclusion**

In pediatric group the more common sacral pathology is congenital, whereas in adult group is neoplastic.

CT and MR are the most important imaging techniques in identifying, localizing and characterizing lesions of the sacrum.

**References**


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