

## Imaging Findings of Sacral Tumors<sup>1</sup>

Seung Ho Kim, M.D., Sung Hwan Hong, M.D., Ja-Young Choi, M.D.,  
Sung Hye Koh, M.D., Hye Won Chung, M.D., Jung-Ah Choi, M.D., Heung Sik Kang, M.D.

The various pathologic conditions detected at CT and MRI and subsumed by the term "sacral tumor" include primary bone tumors, sacral canal tumors and metastases. Among these, metastases are much more common than primary bone tumors, of which chordoma is the most common. Although the imaging findings of sacral tumors are nonspecific, a patient's age and sex, and specific findings such as calcification or fluid-fluid levels, can help radiologists in their differential diagnosis. We describe the imaging findings of primary sacral tumors, emphasizing the MRI findings.

**Index words :** Sacrum, neoplasms  
Neoplasms  
Magnetic resonance (MR)

Sacral tumors include primary bone tumors, sacral canal tumors and, most commonly, metastases. The most common primary malignant bone tumor is chordoma, and the second most common is giant cell tumor. The presence of multiple lesions involving the sacrum and other bones suggests metastasis or multiple myeloma. Although the imaging findings of sacral tumors are nonspecific, a patient's age and sex, and specific findings such as calcification or fluid-fluid levels, can help radiologists determine the differential diagnosis. The imaging findings may overlap, however, in which case the final diagnosis can be determined by biopsy. We illustrate the imaging findings of primary sacral tumors, emphasizing the MRI findings.

### Benign Bone Tumors

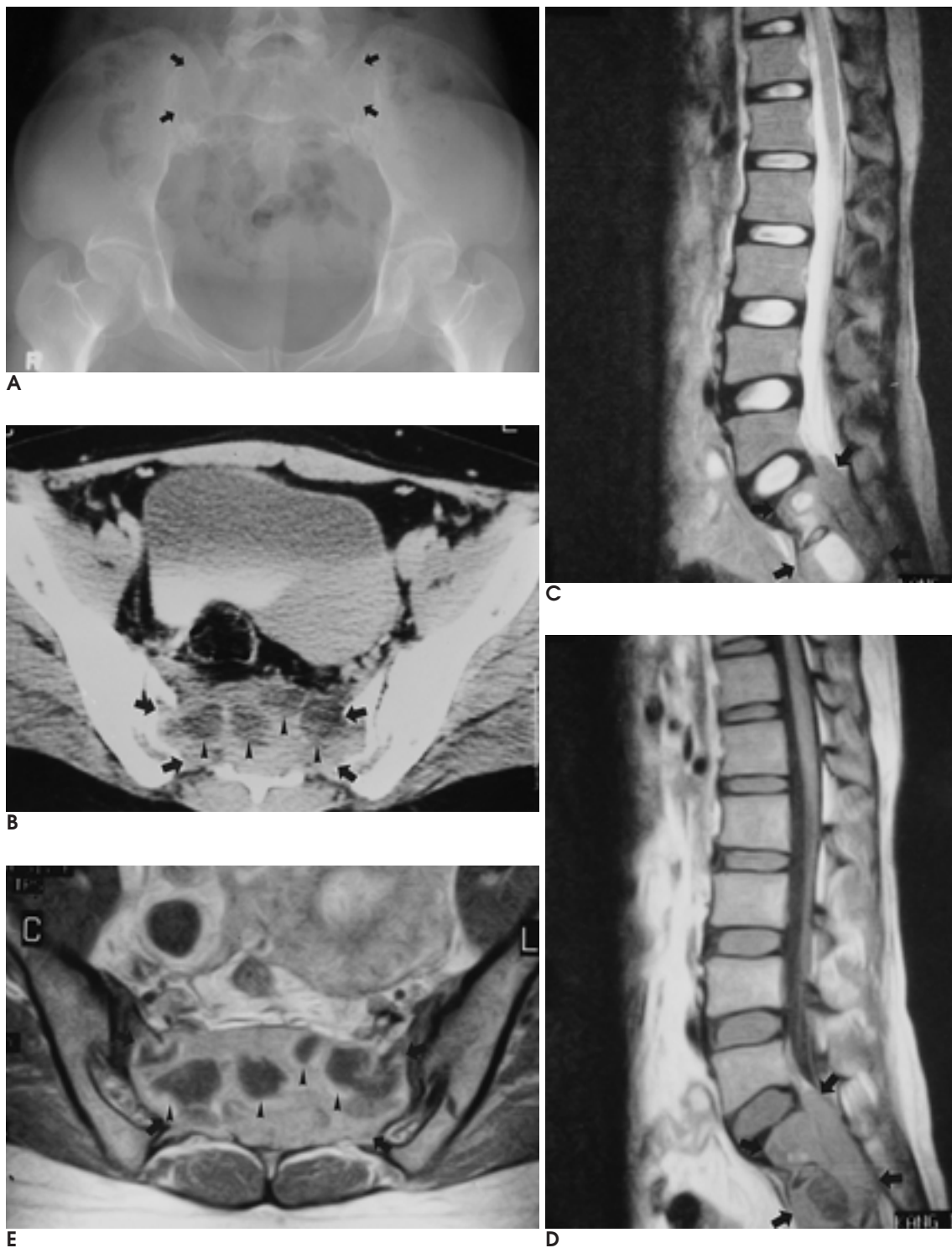
#### *Giant Cell Tumor*

Giant cell tumor is the second most common primary sacral tumor. Its peak incidence is during the 2nd-4th decades of life, and there is female predominance (1-4). Sacral giant cell tumors are frequently eccentric and originate in anterior spinal elements. They are generally found in a subchondral location in both long and flat bones, and this may lead to transarticular spread (3, 5). Typically, the tumor is a purely lytic lesion without marginal sclerosis or tumor matrix calcification. Due to the presence of necrosis and hemorrhage, heterogeneous intermediate signal intensity is seen at both T1- and T2-weighted MR imaging (3) (Fig. 1).

#### *Aneurysmal Bone Cyst*

Aneurysmal bone cysts are expansile lesions with multiloculated blood-filled sacs. Their incidence peaks during the second decade of life, and there is slight female predominance (4). They may result from trauma or coexist with other bone lesions, both benign and ma-

<sup>1</sup>Department of Radiology, Seoul National University College of Medicine  
Received July 16, 2003; Accepted September 29, 2003  
Address reprint requests to: Heung Sik Kang, M.D., Department of Radiology, Seoul National University Bundang Hospital, 300 Gumidong, Bundanggu, Kyunggi-do Sungnam-si 463-707, Korea.  
Tel. 82-31-787-7609 Fax. 82-31-787-4011  
E-mail: kanghs@radcom.snu.ac.kr



**Fig. 1.** A 31-year-old woman with sacral giant cell tumor.  
**A.** Anteroposterior radiograph shows ill-defined subtle osteolytic lesion in the upper sacrum (arrows).  
**B.** Contrast-enhanced CT scan shows multiple cystic components (arrowheads) within the mass (arrows).  
**C.** Sagittal T2-weighted MR image shows intermediate signal intensity mass (arrows) with multiple internal cystic components. It extends into the sacral canal.  
**D.** Sagittal T1-weighted MR image shows intermediate signal intensity mass (arrows).  
**E.** Contrast-enhanced axial T1-weighted MR image shows moderate enhancement of the mass (arrows). Multiple cystic components (arrowheads) correspond to necrosis.

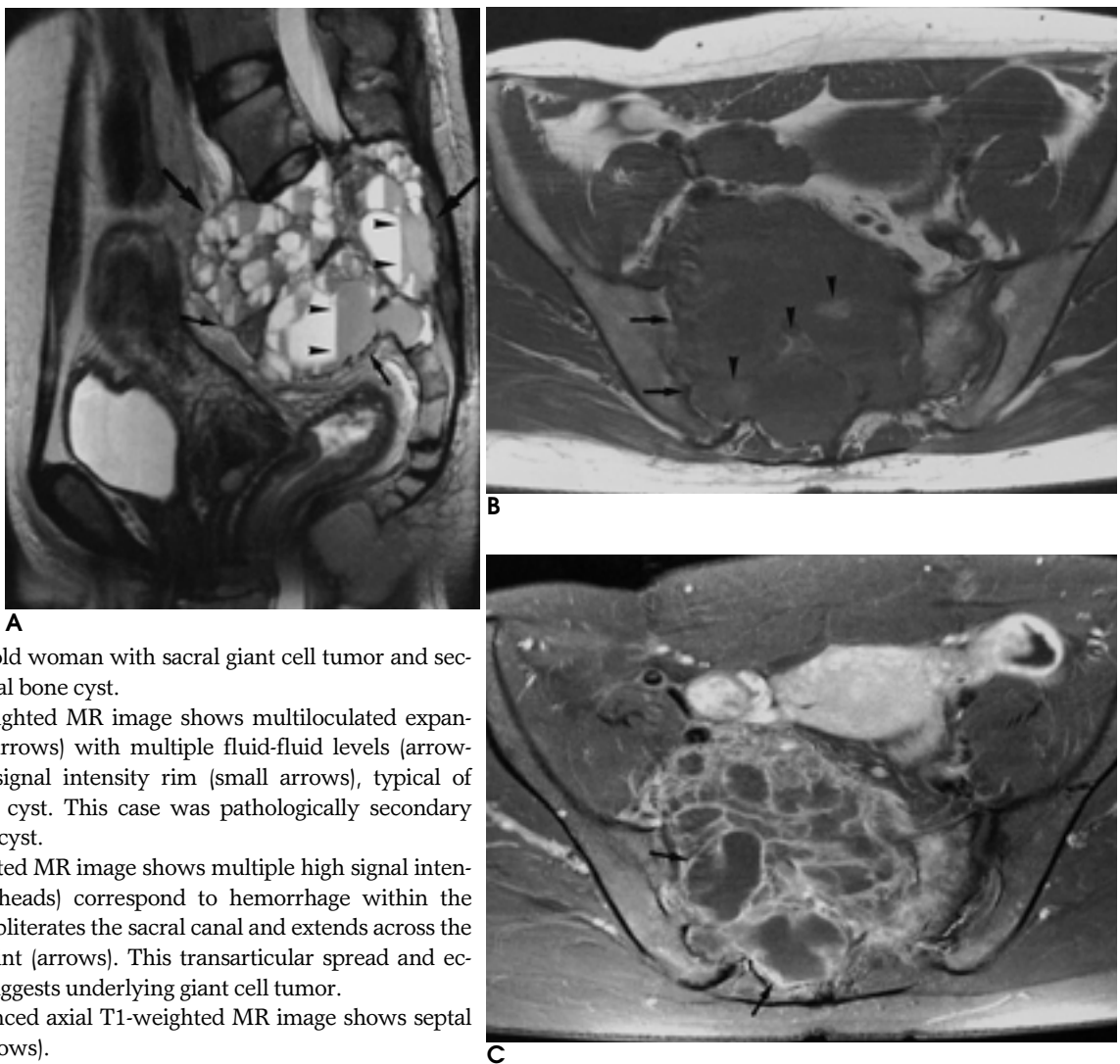
lignant (3, 6), though a sacral location is relatively rare (6). The presence of fluid-fluid levels is diagnostically useful but is not pathognomonic, since fluid-fluid levels have also been reported in giant cell tumors, telangiectatic osteosarcomas, osteblastomas, and chondroblastomas (1, 7). The most common radiographic appearance is an osteolytic expansile lesion surrounded by a thin bony shell (2) (Fig. 2).

### Benign Sacral Canal Tumors

#### *Schwannoma and Neurofibroma*

Sacral schwannomas are rare; schwannomas tend, instead, to grow along nerve segments and expand the sacral canal and neural foramen. Schwannomas and neurofibromas that occur in this location arise from the lower lumbar and sacral dorsal sensory nerve roots.

Reports have stated that the target sign seen at T2-weighted MR imaging, comprising a central area of low-to-intermediate signal intensity surrounded by a peripheral ring of high signal intensity, is almost pathognomonic of neurofibroma. This finding corresponds pathologically to fibrous tissue (with high collagen content) centrally and more myxoid tissue peripherally, and is a feature of schwannomas and malignant peripheral nerve sheath tumors, as well as neurofibromas (8). On the basis of imaging findings only, it is often difficult to differentiate schwannoma from isolated neurofibroma within the sacrum (Fig. 3, 4), but the presence of multiple nerve sheath tumors suggests a diagnosis of neurofibromatosis. In such cases, malignant transformation may occur (3).



**Fig. 2.** A 41-year-old woman with sacral giant cell tumor and secondary aneurysmal bone cyst.

**A.** Sagittal T2-weighted MR image shows multiloculated expansile mass (thick arrows) with multiple fluid-fluid levels (arrowheads) and low signal intensity rim (small arrows), typical of aneurysmal bone cyst. This case was pathologically secondary aneurysmal bone cyst.

**B.** Axial T1-weighted MR image shows multiple high signal intensity areas (arrowheads) correspond to hemorrhage within the mass. The mass obliterates the sacral canal and extends across the right sacroiliac joint (arrows). This transarticular spread and eccentric location suggests underlying giant cell tumor.

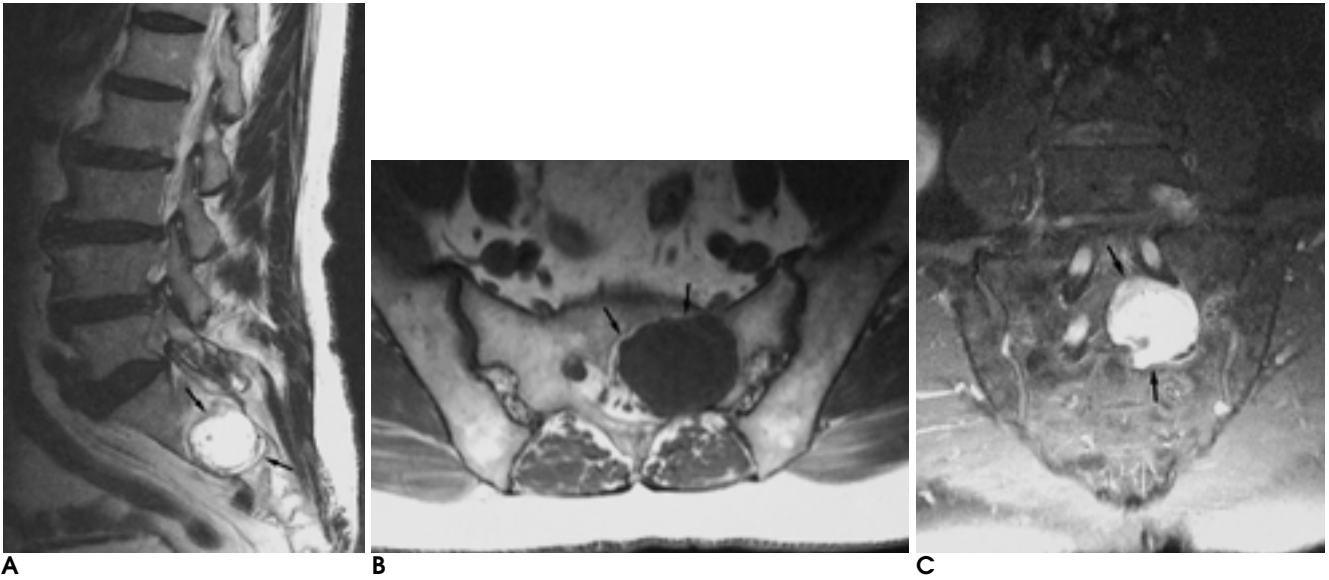
**C.** Contrast-enhanced axial T1-weighted MR image shows septal enhancement (arrows).

## Malignant Bone Tumors

### Chordoma

Chordoma is the most common primary malignant

sacral tumor, accounting for 2–4% of all primary malignant bone tumors. A chordoma arises from intraosseous notochordal remnants, and so almost always occurs in a midline or paramedian location (1–4). Nearly 50% of all chordomas originate in the sacrococcygeal region,

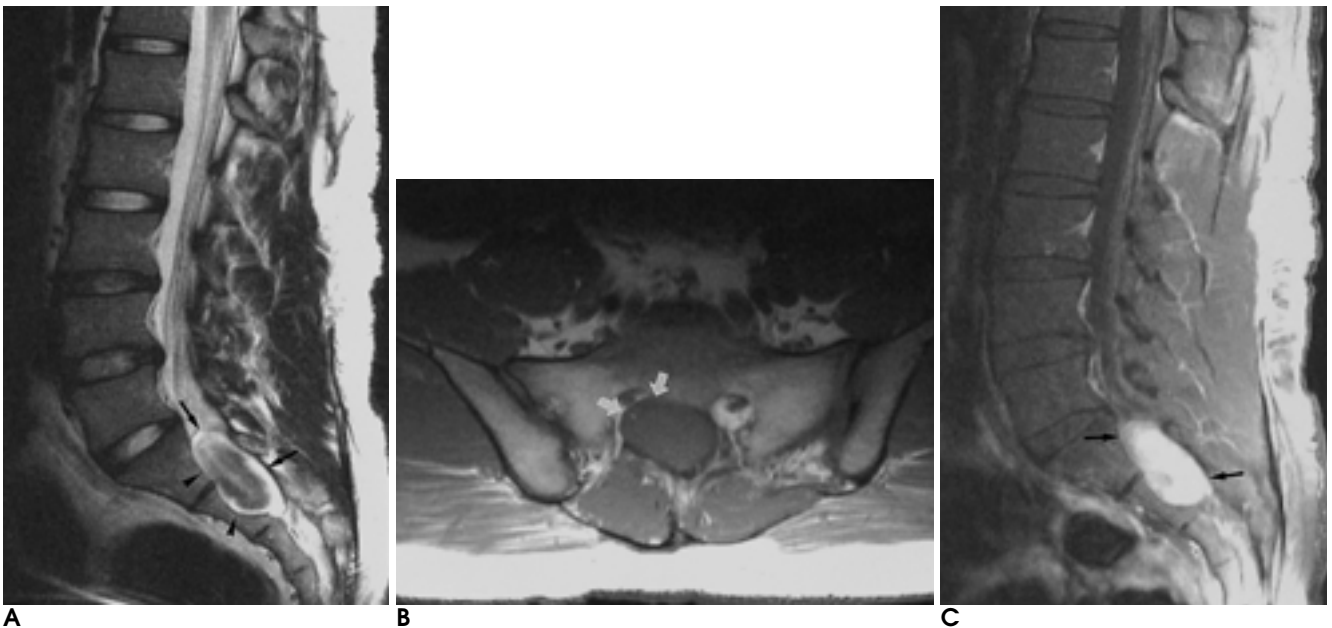


**Fig. 3.** A 71-year-old man with schwannoma.

**A.** Sagittal T2-weighted MR image shows high signal intensity mass (arrows) in the sacral canal.

**B.** Axial T1-weighted MR image shows a low signal intensity mass just distal to the left sacral foramen. There is erosion (arrows) of the sacral vertebral body.

**C.** Contrast-enhanced fat-suppressed coronal T1-weighted MR image shows heterogeneous enhancement (arrows).

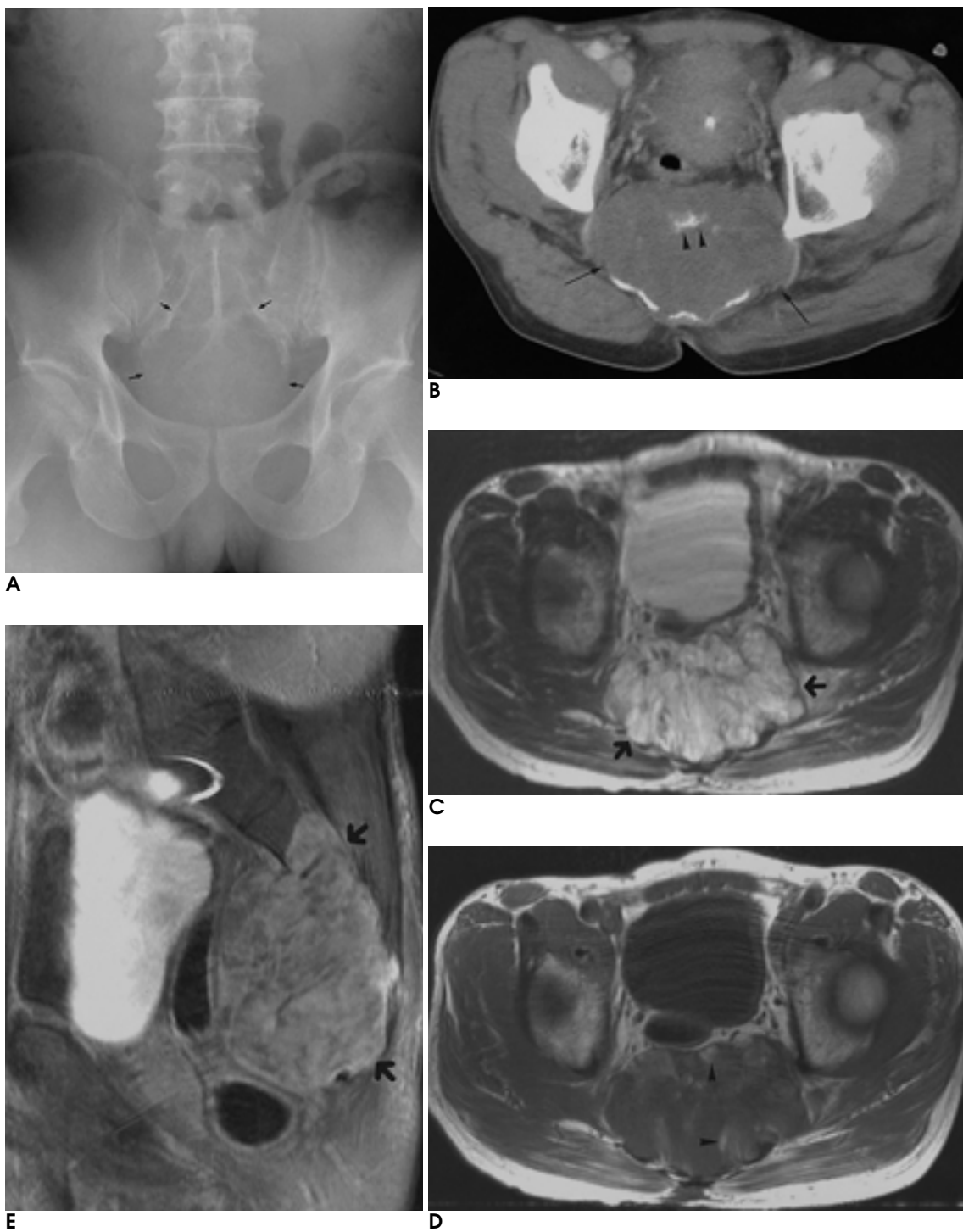


**Fig. 4.** A 22-year-old man with sacral nerve neurofibroma.

**A.** Sagittal T2-weighted MR image shows peripheral high signal intensity mass (arrows) in the sacral canal. There is slight erosion (arrowheads) of the sacral vertebral body. This image shows typical target sign.

**B.** Axial T1-weighted MR image shows iso signal intensity mass extending into the right sacral foramen (arrows).

**C.** Contrast-enhanced sagittal T1-weighted MR image shows heterogeneous enhancement (arrows).



**Fig. 5.** A 61-year-old man with sacral chordoma.

**A.** Anteroposterior radiograph shows large expansile osteolytic lesion (arrows).

**B.** CT scan shows destructive mass (arrows) with soft tissue density containing calcification (arrowheads).

**C.** Axial T2-weighted MR image shows heterogeneous high signal intensity mass (arrows) centered in the midline. This findings correlate with the intratumoral accumulation of mucin.

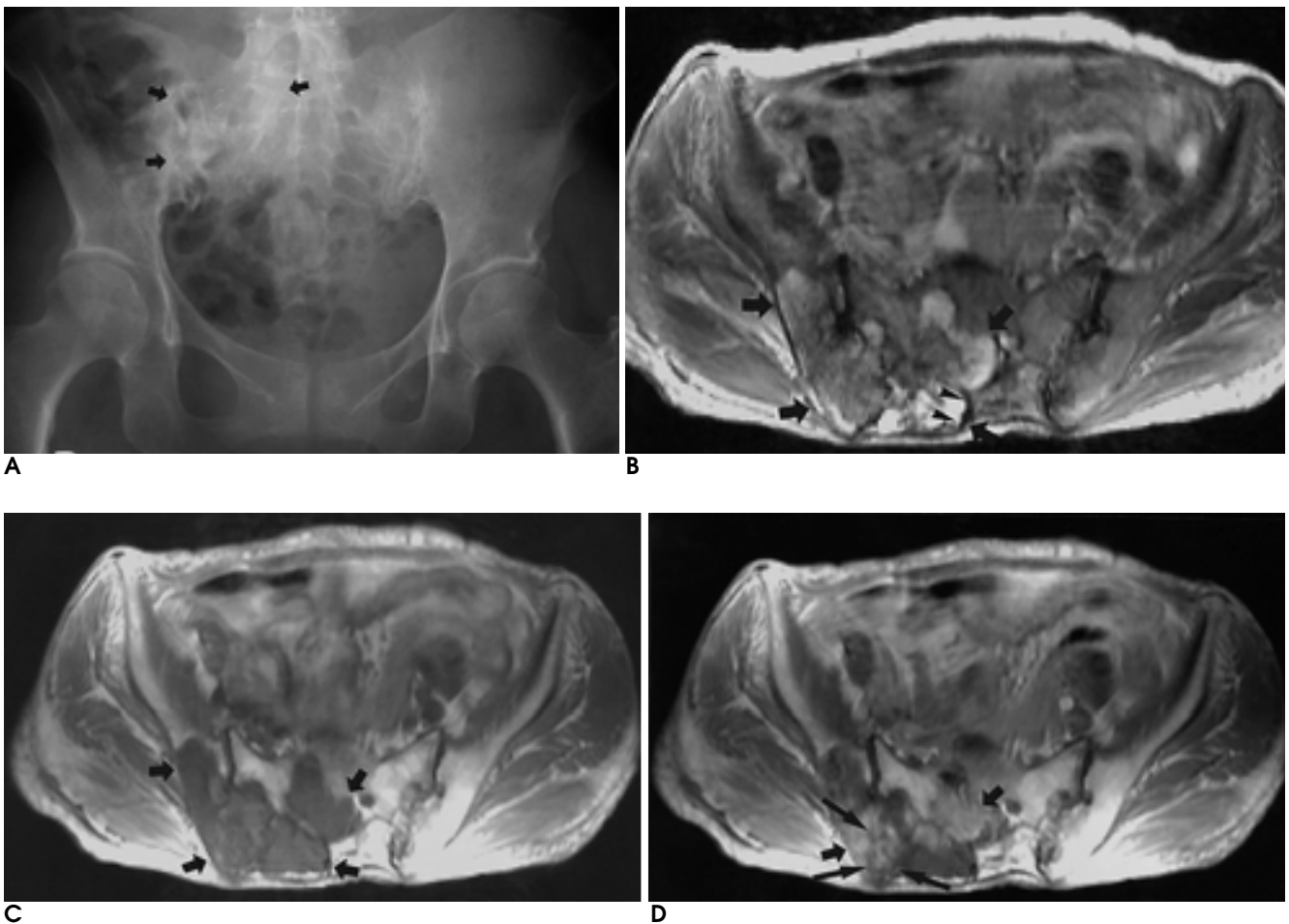
**D.** Axial T1-weighted MR image shows slightly low signal intensity mass with focal high signal intensities (arrowheads) resulting from hemorrhage.

**E.** Contrast-enhanced sagittal T1-weighted MR image shows moderate enhancement (arrows).

and a further 35% in the sphenoccipital region. The remaining 15% occur in the spine above the sacrum. Men are affected twice as frequently as women, and patients' mean age is 50 years (2). Typical chordomas contain clear cells with intracytoplasmic vacuoles and abundant mucin; in atypical chordomas, the mucinous matrix is replaced by chondroid or osteoid elements. CT images of sacral chordomas depict large lytic lesions centered in the midline, and calcification is present in 30–70% of patients. Typical chordomas are isointense or slightly hypointense on T1-weighted images, and hyperintense on T2-weighted images. At both CT and MR, enhancement of their soft tissue components, which varies, is often moderate (2, 3) (Fig. 5).

### Chondrosarcoma

Chondrosarcomas account for 7–12% of malignant primary tumors of the spine, where about 10% of all chondrosarcomas are found (2, 4). The thoracic spine is the most common site and sacral involvement is unusual. Patients' mean age is 45 years. Histologically, chondrosarcomas are composed of lobules of hyaline cartilage separated by fibrovascular septations. Radiographs and CT images reveal large destructive lesions with characteristic chondroid matrix mineralization. Calcifications are typically rounded or curvilinear and are also visible in the soft tissue component of the lesions. On MR images, they are manifested as areas of signal void. Enhanced MR imaging typically demon-



**Fig. 6.** A 59-year-old woman with chondrosarcoma.

**A.** Anteroposterior radiograph shows irregular sclerotic lesion (arrows) in the sacrum and the right iliac bone, extending across the right sacroiliac joint. It corresponds to matrix mineralization of tumor.

**B.** Axial T2-weighted MR image shows heterogeneous high signal intensity mass (arrows) with multilobulated contour and soft tissue involvement. Its center is in the right sacrum and extends into the right iliac bone. Curvilinear signal void (arrowheads) corresponds to calcification.

**C.** Axial T1-weighted MR image shows slightly low signal intensity mass (arrows). It extends into the right sacral neural foramen.

**D.** Contrast-enhanced axial T1-weighted MR image shows peripheral patchy enhancement (arrows) and ring-like septal enhancement (long arrows).

strates peripheral and septal enhancement corresponding to vascular septations between cartilaginous lobules (2) (Fig. 6).

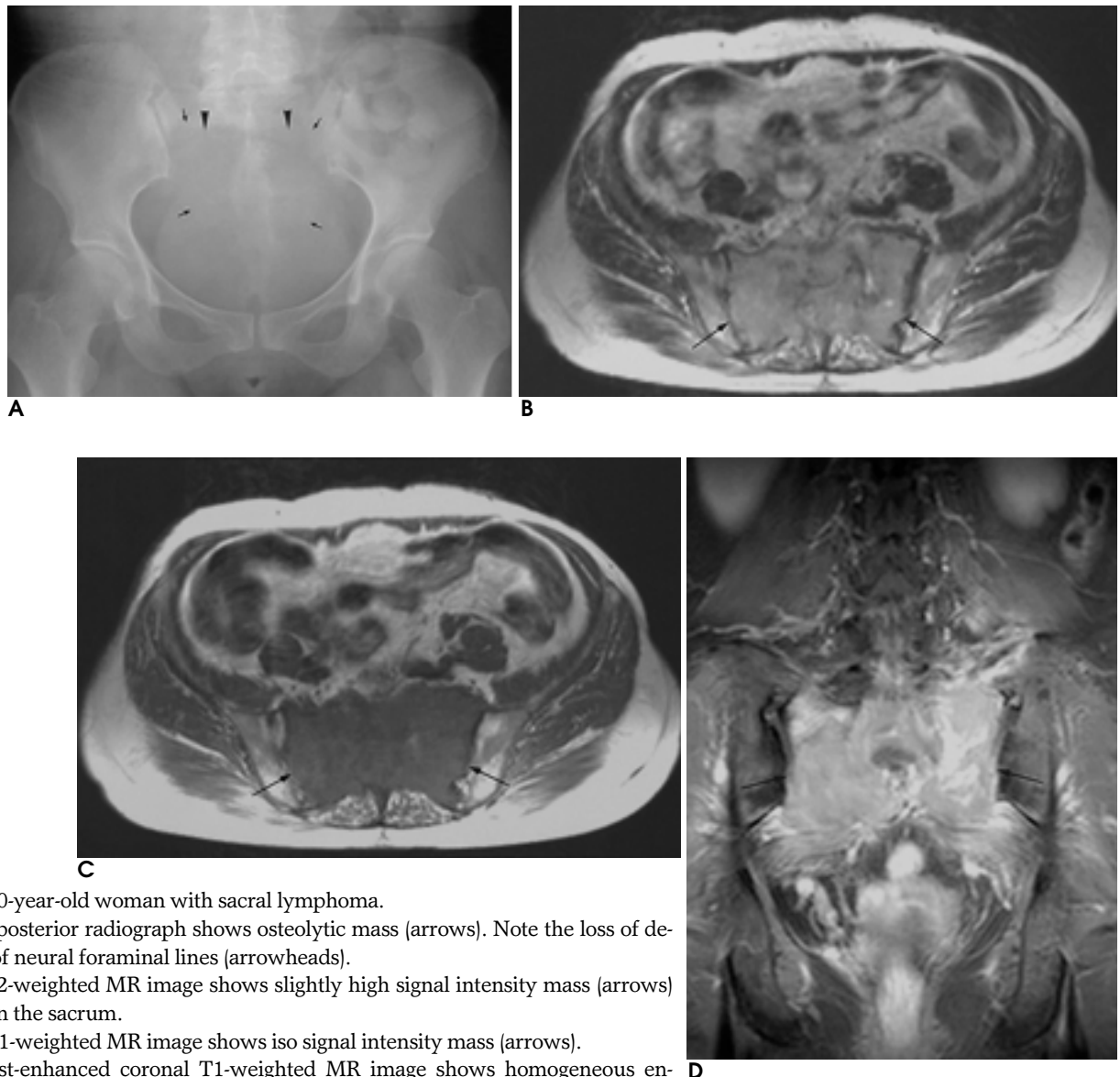
### Lymphoma

Primary bone lymphoma is a rare round-cell tumor, but is the third most common malignant primary neoplasm of the sacrum, with a prevalence of 8% (9). Its incidence peaks during the second and third decades of life, with a male-female ratio of 2:1. Aggressive bone destruction is a usual feature (Fig. 7). Because the tumor tends to extend to soft tissue while leaving underlying osseous structures intact, osteolytic lesions are not always visible at radiography. At times, the appearance of a soft tissue mass can be the only clue to extensive un-

derlying bone involvement (1, 9).

### Multiple Myeloma

Multiple myeloma arises due to the neoplastic clonal expansion of plasma cells, and is the second most common malignant primary neoplasm of the sacrum (9). The incidence of myelomas peaks in the sixth and seventh decades of life; the tumor is more common in men than women, with a ratio of almost 2:1. Typically, multiple round lytic lesions with nonsclerotic margins occur, though in some patients (12-25%) there is diffuse demineralization (1). Multiple lesions are depicted as hypointense to healthy marrow at T1-weighted imaging, and hyperintense at T2-weighted imaging (2) (Fig. 8).



**Fig. 7.** A 60-year-old woman with sacral lymphoma.  
**A.** Anteroposterior radiograph shows osteolytic mass (arrows). Note the loss of delineation of neural foraminae (arrowheads).  
**B.** Axial T2-weighted MR image shows slightly high signal intensity mass (arrows) centered in the sacrum.  
**C.** Axial T1-weighted MR image shows iso signal intensity mass (arrows).  
**D.** Contrast-enhanced coronal T1-weighted MR image shows homogeneous enhancement (arrows).



**Fig. 8.** A 61-year-old man with multiple myeloma.

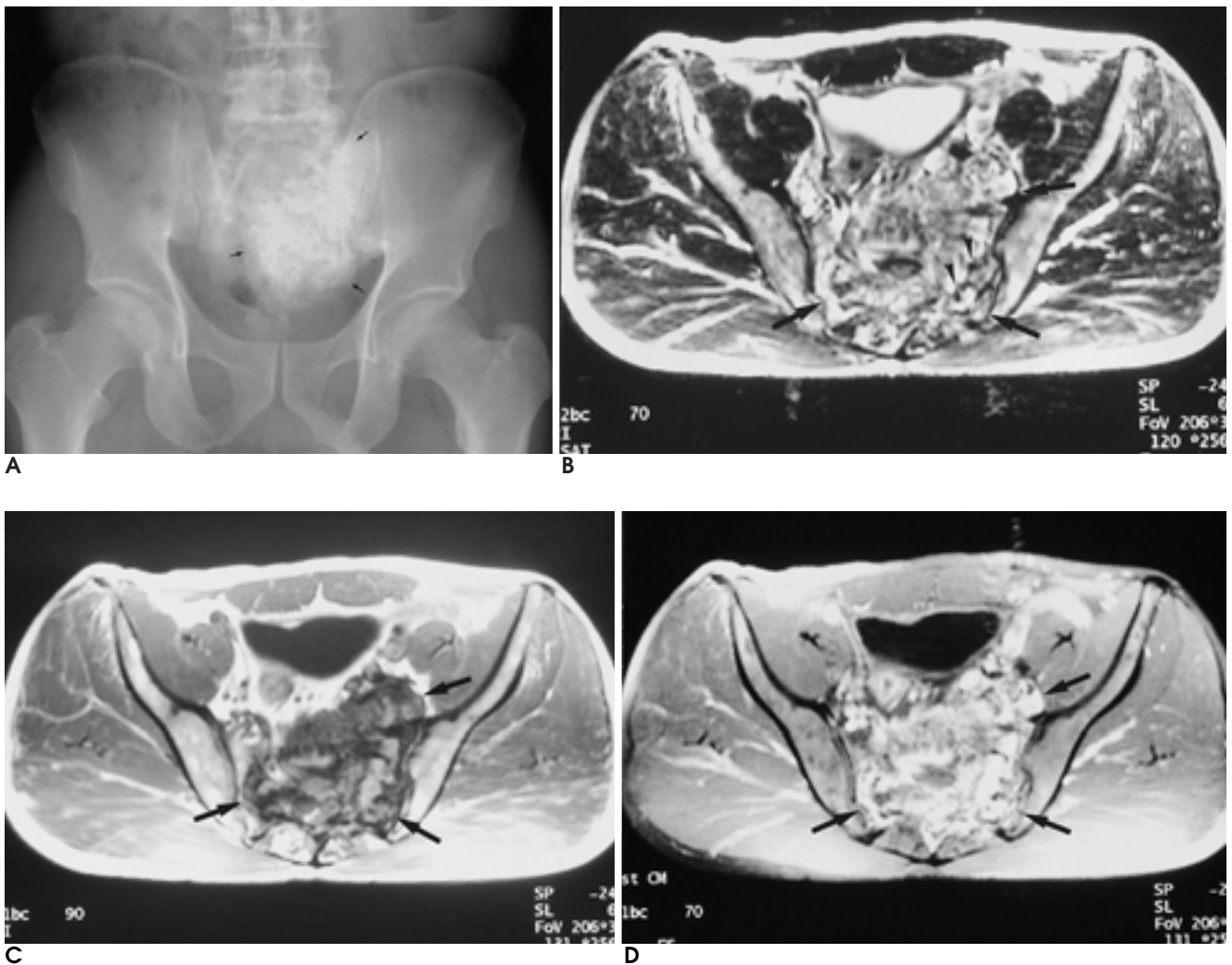
**A.** Anteroposterior radiograph shows multiple lytic lesions (arrows) with nonsclerotic margin in the sacrum and the left pubic bone.

**B.** Sagittal T2-weighted MR image shows lesion (arrows) slightly hyperintense to healthy marrow.

**C.** Sagittal T1-weighted MR image shows iso-intense mass (arrows). Diffuse abnormal signal intensity is also seen in whole lumbar spines. It may be diffuse infiltration of multiple myeloma or red marrow reversion or mixed pattern.

**D.** Contrast-enhanced coronal T1-weighted MR image shows mild enhancement (arrows) with obliteration of the sacral neural foramen.





**Fig. 9.** A 46-year-old man with sacral osteosarcoma.

**A.** Anteroposterior radiograph shows ill-defined mass (arrows) with osseous matrix.

**B.** Axial T2-weighted MR image shows slightly hyperintense heterogeneous mass (arrows) extending into the pelvic cavity. Multiple signal void structures (arrowheads) correspond to bone formation.

**C.** Axial T1-weighted MR image shows low signal intensity mass (arrows).

**D.** Contrast-enhanced axial T1-weighted MR image shows well enhancement (arrows).

### Osteosarcoma

Osteosarcoma is the most common nonlymphoproliferative primary malignant bone tumor, but rarely affects the spine. Less than 3% of all osteosarcomas are found there, and the tumor account for 5% of all primary malignant spinal tumors (10). The lumbosacral region is the most common site. Radiographs and CT images depict a purely lytic, mixed, or predominantly osteoblastic lesion; CT helps identify both matrix mineralization and extension into paravertebral and extradural soft tissues. The MR imaging of nonmineralized areas is non-specific; lesions show low to intermediate signal intensity at T1-weighted imaging, and high signal intensity at T2-weighted imaging (Fig. 9). Areas of bone formation

may show a signal void at all pulse sequences (2).

### References

1. Disler DG, Miklic D. Imaging findings in tumors of the sacrum. *AJR Am J Roentgenol* 1999;173:1699-1706
2. Llauger J, Palmer J, Amores S, Bague S, Camins A. Primary tumors of the sacrum: diagnostic imaging. *AJR Am J Roentgenol* 2000;174:417-424
3. Diel J, Ortiz O, Losada RA, Price DB, Hayt MW, Katz DS. The sacrum: pathologic spectrum, multimodality imaging, and subspecialty approach. *Radiographics* 2001;21:83-104
4. Murphey MD, Andrews CL, Flemming DJ, Temple HT, Smith WS, Smirniotopoulos JG. From the archives of the AFIP. Primary tumors of the spine: radiologic-pathologic correlation. *Radiographics* 1996;16:1131-1158
5. Dahlin DC. Caldwell lecture. Giant cell tumor of bone: highlights

of 407 cases. *AJR Am J Roentgenol* 1985;144:955-960

6. Capanna R, Van Horn JR, Biagini B, Ruggieri P. Aneurysmal bone cyst of the sacrum. *Skeletal Radiology* 1989;18:109-113

7. Tsai JC, Dalinka MK, Fallon MD, Zlatkin MB, Kressel HY. Fluid-fluid level: a nonspecific finding in tumors of bone and soft tissue. *Radiology* 1990;175:779-782

8. Murphey MD, Smith WS, Smith SE, Kransdorf MJ, Temple HT. From the archives of the AFIP. Imaging of musculoskeletal neuro-

genic tumors: radiologic-pathologic correlation. *Radiographics* 1999;19:1253-1280

9. Unni KK. *Dahlin's bone tumors: general aspects and data on 11,087 cases*, 5th edition. Philadelphia: Lippincott-Raven, 1996

10. Green R, Saifuddin A, Cannon S. Pictorial review: imaging of primary osteosarcoma of the spine. *Clinical Radiology* 1996;51:325-329

## 천골 종양들의 방사선학적 소견<sup>1</sup>

<sup>1</sup>서울대학교 의과대학 방사선과학교실

김승호 · 홍성환 · 최자영 · 고성혜 · 정혜원 · 최정아 · 강홍식

천골 종양들은 전산화 단층 촬영과 자기 공명 영상에서 다양한 모습을 보인다. 천골 종양들은 원발성 골 종양과 천골 신경관종양 그리고 전이암들로 구성된다. 이중 전이암들이 가장 흔하다. 척삭종은 가장 흔한 악성 원발성 골 종양이다. 비록 천골 종양들이 비특이적이고 서로 겹치는 방사선학적 소견을 나타내지만, 석회화나 액체-액체 층 등과 같은 특이한 소견들은 환자의 나이와 성별과 더불어 감별 진단하는데 도움이 될 수 있다. 따라서 이 임상 화보에서는 원발성 천골 종양들의 방사선학적 소견들을 자기 공명 영상에 중점을 두어 기술하고자 한다.