요통의 영상학적 진단

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김 학 진

Radiologic Evaluation of Low Back Pain

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MECHANISMS OF SPINAL PAIN

1. FUNCTONAL ANATOMY

Functional Unit
2 adjacent vertebral bodies
1 intervertebral disc
Anterior segment of the functional unit
Supporting, weight-bearing, shock-absorbing, flexible structure
Posterior segment of the functional unit
Non-weight-bearing structure
Containing & protecting the neural structures
Direct moving portion of the unit by paired joints

1) Anterior weight-bearing portion of the functional unit
2 adjacent vertebrae
Cartilagenous end plates (epiphysis);
Growth center of the vertebra ossification (age 15-20), fusion with body
Intervertebral disc
Hydrodynamic elastic structure
Acting as a shock-absorbing mechanism
Central nucleus pulposus; matrix & fibers
Peripheral annulus fibrosus

*Function of the disc
Mechanical; by the structure & function of the annular fiber
Chemical & hydrodynamical; by the dynamics of the matrix

*Longitudinal ligament;
Reinforcing & protecting the intervertebral disc
Anterior & posterior ones
Adhering to the vertebral body cortex by Sharpey fibers
Narrow at the lower lumbar region (1/2 in width)

2) Posterior portion of the functional unit (neural arch)

Posterolateral aspect of the vertebral bodies
Pedicles
Facet joints
Laminae
Transverse processes
Spinous process

*Facet joints;
Lie in a vertical sagittal plane
-allow flexion & extension
restrict lateral flexion & rotation

*Rotation of the functional unit
Provided by Annulus fibrosus; 40~50%
Posterior articulations; facets, their capsules, ligaments

3) Muscles of the functional unit

Erector spinae muscle
Origin; T11,T12
L1-L5
Sacral spine
Sacrum
Sacroliac ligament
Medial aspect of the iliac crest

Insertion; 3 columns
Iliocostal-angle of the rib cage
Longissimus-transverse process, scalp
Spinalis-posterior spine

-Extensors causing the spine to return to the erect position after bending
-Fascial sheath; proprioceptive, nociceptive site of stimuli

*Thoracolumbar fascia;
A major role in spine function

Transverse spinae muscle; under erector spinae muscle
Semispinalis
Mulitifidus
Rotatores

Other small muscles
Interspinalis
Intertransversarii

4) Ligaments of the functional unit

Interspinous ligament

Intertransversus ligament

5) Nerves of the functional unit

Major nerve within the functional unit;

Posterior primary division (Dorsal compartment)

Anterior primary division (Ventral compartment)

Recurrent nerve of von Luschka (recurrent meningeal nerve)

*Anterior primary division; supplied by fibers of the sinuvertebral N

Dural cuff around each spinal nerve

Anterior aspect of the dural sac

Posterior longitudinal lig.

Posterior aspect of the annuli fibrosa

*Posterior primary division;

Division - cutaneous branch

muscular branch (back muscles)

articular branch (to the facet joint)

*Recurrent meningeal nerve

Sensory nerve enters the gray mater of the spinal cord

Fibers from the sympathetic ganglia;

Posterior longitudinal ligament

Anterior longitudinal ligament

Dural sac of the nerve roots

Very outer layer of the intervertebral disc

*Sensory nerve in the lumbar fascia, ligg., capsules of the facet joints, muscles; potential sites of nociception

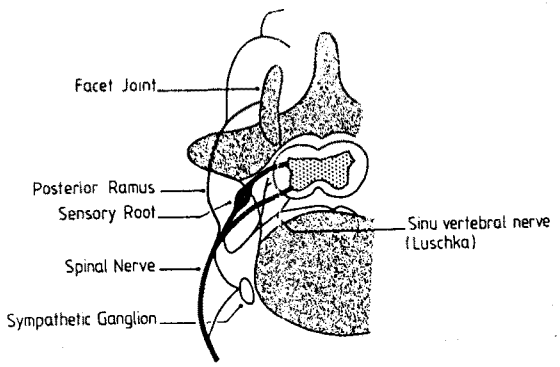

Fig. 1. Sensory Innervation of the Lumbar Spine.

*Difficulty in identifying an anatomical pain source;
Overlaping of both innervation & pain pattern in each level

FACET JOINT PAIN

1) Nociceptor fiber; located in the joint capsule
connecting, via its medial branch, to the dorsal ramus of each spinal nerve

2) The facet syndrome; 1933, Ghormely
Sxs of backache similar to those of arthritic joint pain
Correctable defect in low back pain
Pathogenesis; Boas
Shortening of the spinal column
-overriding of the facet joint each other
-contact of the nonarticular surfaces of the joint
-inflammatory reaction in the capsule & periarticular tissue
Lateral obliquity of the pelvis
-lateral flexion of the lumbar spine
-stress on the facet joint
Spondylolisthesis with a fracture at the dorsal arch
-dissociation of the facet joints

**Irritation caused by facet joint subluxation
-resulting in
pain
reduction in movement
& reflex spasm of the erector spinae muscles

**Chronic inflammation
-osteophyte formation & degenerative changes
-stenosis of the intervertebral foramen
-root pain

3) Diagnosis

1) Clinical findings;
Symptomes
Deep & aching pain
Radiate diffusely following a sclerotome or myotome
-lower lumbar area (main)
buttock, thigh, feet, groin, & lower abdomen

Increasing pain by sitting or standing in one position
Stiffness on rising from bed in the morning with relief with movement
Flexion-less painful
Acute pain on hyperextension or sudden movement

Signs

Tenderness over the paraspinal muscles on the affected side
Focal pain on deep palpation over the affected joint
Reduced SLR
Negative sciatic stretch test
Sensory or motor changes (referred phenomena)

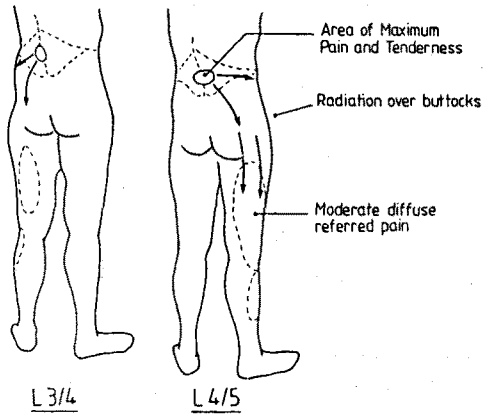

Fig. 2. Referred pain patterns in the facet syndrome.

Radiologic findings

Arthritic changes in the facet joint
-Sclerosis of the articular surface
Narrowing of the joint space
Osteophyte formation
Subarticular cystic change
-usually absent in the acutely irritated joint

DDx

Lumbar disc compression
-consistent neurologic signs
positive sciatic stretching

Lumbar stenosis
-pain & muscle spasm on exercise
relief by rest & flexion of the spine

Ankylosing spondylitis
-increased ESR
positive human leucocyte antigen, B27 antibody
increased radioactive isotope uptake in the sacroiliac joint

MYOFASCIAL PAIN SYNDROMES

Large muscles, extensive fasciae & ligaments: vulnerable to this type of pain

Pathophysiology

Faulty posture; excessive strains on the myofascial structures
Lack of proper exercise after injury or back operation
Persistent stress; pain & spasm of the muscles
-nociceptor stimulation
muscle ischemia
fiber damage
*The ligamentum flavum; Aneural, and insensitive
*The erector spinae muscles: Highly innervated by nociceptors
*Ligamentous pain: by the articular branches (somatic & sympathetic) of the posterior primary division
*The anterior longitudinal lig; by the recurrent meningeal nerve
*The posterior longitudinal lig; by somatic & sympathetic sensory verves

Clinical findings

Pain; initially diffuse, changing to sharp, stabbing on movement
Tender areas (trigger points); paravertebral muscles, gluteus over the greater trochanter
Stiff back
Increased lumbar & cervical lordosis
Unable to sit for any length of time
Severe localized pain on spinal movement

MECHANICAL BACK PAIN

General

Neoplasm
Primary
Secondary
Infection
Inflammation
Metabolic
Osteoporosis
Osteomalacia

Local

Trauma
Spondylolisthesis
Instability syndrome

RADIOLOGIC ASSESSMENT OF THE LOWER BACK PAIN

The choice of investigation;
depend on the type of pain from 2 main sources

1. Mechanical derangement of the motor segment
   - Irritation of nerve ending in the outer annulus, lig, or posterior facet joints
   - Sclerodermal refered pain
2. Irritation or compression of the nerve roots
   - partial or complete dermatomal pain
3. Superficial localized central pain & tenderness; 3rd, minor
   - Originate from the spinous process & superficial lig.

1) Conventional Radiology

Appropriate for all 3 types of pain
Provides a guide to the anatomical status
Low specificity

***Disc Degeneration**

Loss of hight of the anterior disc space
Osteophyte formation
Normal in mild or moderate degeneration

***Abnormal alignment of posterior joint & osteoarthritis**

Hypertrophy of the articular processes
Sclerosis of bone
Alteration of position of the joint surface

***Spondylolysis**

Defect at the pars interarticularis
More commonly ass. with pain

***Deveopmental stenosis**

Below 15mm of the AP diameter of the canal on lat. view

2) Dynamic Radiology

*Plain dynamic view; flexion, extension, both lateral bending
Abnormal; horizontal sheer or excessive intervertebral tilt

Hypermobility; in the early stage of disc damage
Marked narrowing of the disc space; reduced mobility
Assessment of postsurgical pain
*Myelographic dynamic view;
Lateral bending; condition of the nerve root sheath

3) Myelography

*Myelographic false-negatives
Posterior or posterolateral HNP at L5/S1
Lateral herniation
*False-positives;
Annular bulging being interpreted as a prolapse
*Myelographic CT
Ix;
Arachnoiditis
Small extruded sequestered fragments
Conjoint root

4) CT

Advantages;
Superior soft tissue contrast resolution
Direct imaging of the multiple imaging planes
Multiple imaging sequences

5) MRI

Advantages;
Superior soft tissue contrast resolution
Direct imaging of the multiple imaging planes
Multiple imaging sequences

6) Invasive Studies

Discography
Facet arthrography

CT OF THE SPINE

1. INDICATIONS

Disc disease
Spinal stenosis
Tumors & Tumor like conditions

Infection
Inflammation
Congenital abnormality
Post-traumatic"
Postoperative"

2. LIMITATIONS

Limitation of the reconstruction
Inability to evaluate lesion of the cord & dura without intrathecal contrast agent
Metal artifact

3. Normal & variants of Normal

1) Pseudoherniation of the Disc

*L5-S1, frequently
*Causes;
Nonpararrel scan to the disc plane
Spondylolisthesis
Scoliosis

2) Conjoined Nerve Roots

*Congenital anomaly-2 nerve roots entering common dural sheath
*Similar to disc herniation or mass lesion
*L5 & S1, TMC
*CT; Lower density to the disc material
Slightly wider ipsilateral lateral recess

3) Cystic Nerve Root Sleeve Dilatation & Tarlov's Cyst

*Enlargement of the SAS, encircling nerve root
*Proximal portion of the dorsal root ganglion
-Tarlov's cyst (perineural cyst); dilatation at the dorsal root ganglion
*Cystic mass at the neural foramen
*DDx;
Lateral or extruded disc herniation
Neurofibroma

4) Normal Vascular Structures

*Basivertebral vein; midbody level의 posterior에서 보이며 retrovertebral venous plexus로 drain된다. 이들 venous plexus는 vertical로 나 있는 anterior internal vertebral veins과 만남. Bony septum이 있으며 osteophyte로 오인 않도록.
*Cervical, thoracic, upper lumbar spine에서는 scant epidural fat때문에 venous plexus나 epidural vein이 잘 안보인다.

*Radicular (intervertebral, pedicular) veins; anterior internal vetebral vein과 ascending lumbar vein을 연결시켜 준다. Internal canal을 따라 주행하다가 neural foramen을 빠져 나간다. More horizontal하며 nerve root보다 *thin.
*The groove of the basivertebral vein; U or V shape

5) Butterfly Vertebra

*Persistent notochodal tissue로 인해 lateral halves of the body가 fusion되지 않은 것. Disc tissue cleft로 disc material이 빠져 들어가면서 vertebral surface의 center가 depression된다.

6) Limbus Vertebra

*Dsic tissue가 anterior로 herniate될 때 나타난다. 즉, cartilaginous end plate와 bony vertebral rim의 junction에 있는 trabeculae를 뚫고 herniation됨으로 생김.

7) Schmorl's node & Cupid's Bow deformity

4. DISORDERS OF THE LUMBAR DISC

1) Bulging Annulus Fibrosus

*Biochemical, biomechanical factors;
Nucleus pulposus의 팽창된 형태(turgidity)가 없어지고 disc space height가 감소
Annulus fibrosus는 fissuring, hyalin degeneration, increased Pigmentation일어남.
Annulus는 elasticity를 잃고 vertebral body margin을 넘어서서 bulging된다.
*Sx; back pain있을 수 있으나 radiculopathy는 보통 없다.
*CT/F;

A generalized, symmetric extension of the disc beyond the vertebral margins
No focal protrusion of the disc margin
Convex posterior margin at the bulging annulus (or concave)
Gas within the disc
Calcification of the outer fibers of the annulus fibrosus

2) Disc Herniation

*Herniation; Protrusion of all or part of the nucleus pulposus due to tearing of the annulus fibrosus

A. Posterolateral Disc Herniation

*TMC type of disc herniation (60~85%)
*Nerve root compression radiculopathy
*CT/F;
Focal alteration of disc margin due to protrusion of disc

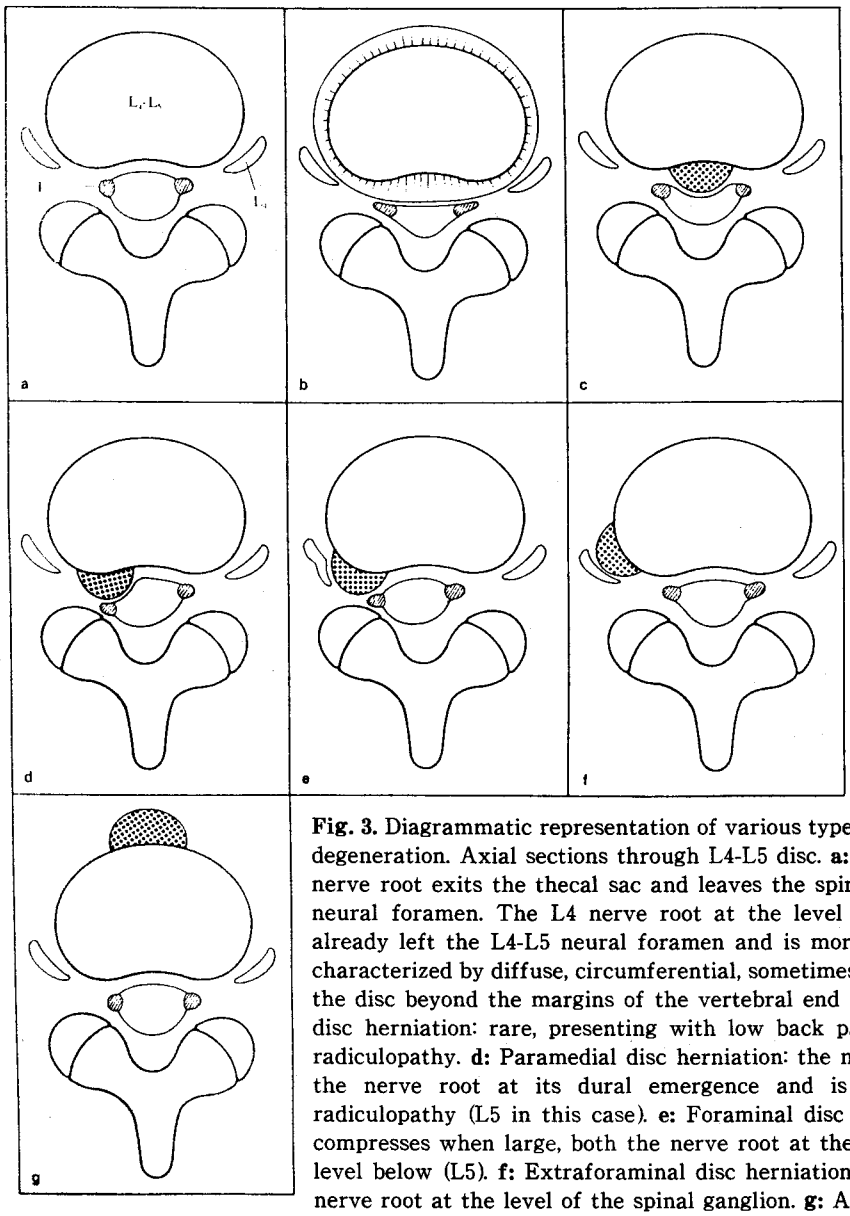

Fig. 3. Diagrammatic representation of various types of disc herniation and disc degeneration. Axial sections through L4-L5 disc. **a:** Normal appearance: the L5 nerve root exits the thecal sac and leaves the spinal canal through the L5-S1 neural foramen. The L4 nerve root at the level of the spinal ganglion has already left the L4-L5 neural foramen and is more lateral. **b:** Bulging disc is characterized by diffuse, circumferential, sometimes asymmetrical, extension of the disc beyond the margins of the vertebral end plates. **c:** Midline or central disc herniation: rare, presenting with low back pain, bilateral or alternation radiculopathy. **d:** Paramedial disc herniation: the most frequent. it compresses the nerve root at its dural emergence and is responsible for unilateral radiculopathy (L5 in this case). **e:** Foraminal disc herniation: less frequent. it compresses when large, both the nerve root at the same level (L4) and at the level below (L5). **f:** Extraforaminal disc herniation: rare, it compresses the L4 nerve root at the level of the spinal ganglion. **g:** Anterior disc herniation: very rare, it compresses or ruptures the anterior longitudinal ligament. Far from the nerve roots, it usually pressents with low back pain.

Displacement or compression of nerve root
Displacement or compression of thecal sac
Displacement or obliteration of epidural fat
Calcification or gas occasionally within disc herniation
*Hard disc; calcified disc herniation or osteophyte formation

B. Central Disc Herniation

*5~35% of HNP
*CT/F;
Midline focal protrusion of the disc
Compression of the thecal sac sparing individual nerve roots
*Pain;
due to sensory innervation of the
Meninges, Post. longitudinal lig & outer layers of the annulus fibrosus
*Radiculopathy; usually abscent

C. Lateral Disc Herniation

*5% of HNP
*Myelographic study; WNL
*CT/F;
Focal protrusion of the disc within or lateral to the neural foramen
Absence of dural deformity
*DDx;
Schwannoma
Soft tissue involvement
By lymphoma
Metastatic ds
infection
cystic nerve root sleeve dilatation
conjoined nerve root sheath anomaly

D. Extruded Disc

*Extruded disc; Protruded nucleus pulposus through a tear in the annulus fibrosus and extending through or around the posterior longitdinal ligaman

5. SPINAL STENOSIS

***Etiologic classification of spinal stenosis**
Congenital-Developmental
Idiopathic
Achondroplasia
Morquio's ds
Acquired
Degenerative
Spondylolisthetic
Iatrogenic (postsurgical fibrosis, fusion, postchemonucleolysis)

Post-traumatic
Paget's ds
Acromegaly & gigantism
Steroid induced epidural lipomatosis
Fluorosis
OPLL & OLF
Combined

***Anatomical classification of spinal stenosis**

Central
Impingement on cauda equina or spinal cord
Lateral
Impingement on nerve root
Lateral recess stenosis (subarticular)
Neural foraminal stenosis (intervertebral canal)

1) Congenital-Developmental Central Spinal Stenosis

*Typical uniform throughout several or all lumbar segments
*Thick pedicles & laminae
*Short pedicles
*Decreased AP diameter (absolute stenosis<10mm, relative st 10~12mm)
*Decreased interpedicular distance (in achondroplasia, progressively)

2) Degenerative Central Stenosis

*Osseous or soft tissue encroachment on the central spinal canal
*Typically segmental
*Level; disc & facet joints
*Hypertrophy & osteophytes from articular processes of facets
*Decreased transverse diameter of the central canal
*Decreased AP diameter-in only 20%
*Thickening of ligamentum flavum
*Generalized bulging of annulus fibrosus
*Posterior vertebral body osteophytes
*Decreased cross-sectional area of thecal sac
*Obliteration of the epidural fat

CI/F of spinal stenosis

Back pain
Sciatica
Claudication
Pain

3) Combined Central Canal stenosis

*Congenital + Acquired

4) Lateral Recess Stenosis

*Boundaries of the lateral recess
Ant; posterolateral margin of vertebral body & disc
Post; Superior articular process
Lat; Pedicle
*Measurement of lateral recess in axial plane
Over 5mm = normal
Over 4mm = borderline
<3mm = stenotic
*Causes
Medial hypertrophy of the superior articular process
Vertebral body osteophytes
Subluxation of the facet joints
*Trefoil shape of the canal;
Not represent stenosis, but predispose to acquired lateral recess stenosis
*CI/F; similar to central stenosis

5) Stenosis of the Neural Foramen

*Boundaries of the neural foramen (intervertebral canal)
Sup; pedicle of vertebra above
Inf; pedicle of vertebra below
Ant; posterior aspect of vertebral bodies & disc
Post; pars interarticularis & apex of sup. articular process of inf. vertebral body
*Causes of stenosis
Osseous stenosis
Lateral disc herniation
Postoperative fibrosis
Spondylolisthesis
Tumor

6. LIGAMENTOUS OSSIFICATION

1) OPLL

*TMC site; cervical spine
*CI/F; Numbness of the hands
Weakness of the legs
Spastic gait
Pain in the neck & arms

Urinary or intestinal Sxs
ASx
*Segmental-behind each vertebral body
Continuous-involving multiple vertebrae without interruption
Mixed-segmental & continuous
Localized-limited to the intervertebral disc level (the least frequent type)
*CT/F;
An ovoid or oblong shape
Attached or unattached to the body

2) OLF

*Site; Lower thoracic spine, TMC (T9~T10,T10~T11)

7. FACET JOINTS

*L-3/4; more sagittal
L-4/5; intermediate
L-5/S-1; more coronal
*Osteoarthritis;
Joint space narrowing
Osteophytes of articular process
Hypertrophy of articular process
Subchondral sclerosis
Subchondral erosion & cyst
Vacuum phenomenon; 20% of Pt of back pain
*Subluxation; degenerative spondylolisthesis
*Synovial cyst; degenerative change of the synovial membrane-lined facet joint

8. SPONDYLOLYSIS & SPONDYLOSISTHESIS

1) Spondylolysis

*Abreak (or defect) in the pars interarticularis
*Callus or granulation tissue; 20%, adjacent to the pars defect
*Fragmentation of the lamina; 15%
*Unilateral spondylolysis;
less common
may be ass. with contralateral neural arch sclerosis & hypertrophy

2) Spondylolisthesis

A. Isthmic Spondylolisthesis
*Defect at the pars interarticularis
*L-5/S-1, TMC
*Pseudoherniation; posterior to the L5 body
*HNP-rare, asymmetric compression of the epidural fat, thecal sac or nerve root

TMC- at the next superior disc level

*Stenosis of the intervertebral canal (neural foraminal stenosis); 25%

*Central & lateral recess stenoses; less often

B. Degenerative Spondylolisthesis

*No defect at the pars interarticularis

*L-4/5, TMC

*Subluxation of the facet joints

Posterior displacement of the sup articular process of lower vertebra

*Osteoarthritis change of the facet joints

*Degenerative change; neural foraminal or central stenosis

HNP-TMC at the level of slippage

C. Retrospondylolisthesis

*Posterior slippage of one vertebra on the adjacnet caudad vertebra

*TMC at the L-2/3, L-3/4.

*2~3mm slipping

*Degenerative origin

9. OSSEOUS TUMORS & TUMOR LIKE CONDITIONS

1) Metastasis

*TMC tumor of the spine

*From breast, prostate & lung in adult

From neuroblastoma in the infant & child

Direct extension from paravertebral tumor

*Rl scan; highly sensitive, but nonspecific

Plain film; not sensitive

*DT/F;

Single or multiple destructive osteolytic change of the body, pedicles

No sclerotic rim or calcification within the matrix

Osteosclerotic mets; typical of prostatic ca. lymphoma & breast Ca (occasional)

2) Myeloma

*Rl; insensitive to the detection of myeloma

27% of proven myeloma-normal in Rl

*CT/F;

Multiple small osteolytic foci

TMC at the body (red marrow)

Pedicle-infrequently involved early

*Osteosclerotic myeloma

rarely in untreated Pt or following RTx

may ass. with the POEMS synd

Polyneuropathy, Organomegaly, Endocrinopathy, M-protein & Skin change

3) Other Primary Osseous Lesions of the Spine & Sacrum

Chondrosarcoma
Osteosarcoma
Ewing's sarcoma
Giant cell tumor
Chondroma
Osteoblastoma
Osteoid osteoma
Aneurysmal bone cyst
Hemangioma
Osteochondroma
Paget's disease

10. INTRASPINAL TUMORS

1) Epidural Tumors

Common

Dermoid, teratoma, epidermoid
Epidural metastasis
Meningioma
Neurogenic tumor
Vertebral neoplasm with intraspinal extension (sarcoma, myeloma, chordoma, hemangioma, giant cell tumor, aneurysmal bone cyst, osteoblastoma, osteochondroma)

Uncommon

Arachnoid cyst
Lipoma

2) Intradural-Extramedullary Tumors

Common

Meningioma
Metastasis
Neurofibroma

Uncommon

Arachnoid cyst
Dermoid, teratoma
Ependymoma of conus medullaris

3) Intramedullary Tumors

Common

Ependymoma

Astrocytoma
Ganglioglioma
Hemangioblastoma
Primary melanoma

Uncommon

Dermoid, teratoma
Lipoma
Lymphoma
Metastasis

4) Tumors of the Cauda Equina, Conus Medullaris, & Filum Terminale

Ependymoma
Neurofibroma

11. OSTEOMYELITIS

Conventional radiography
Rl bone scanning; sensitive & nonspecific
CT
MRI