Metabolic and Inflammatory Diseases of the Spine

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Metabolic Spine Disorders

Disorders of Bone Density

• Osteopenia
  • Condition of low bone mass when bone resorption is greater than bone formation
  • A value for bone mineral density (BMD) more than 1 standard deviation below the young adult mean but less than 2.5 standard deviations

• Osteoporosis (World Health Organization definition)—Osteoporosis is a condition characterized by low bone mass (osteopenia) and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk. It is the most common disease of bone (Table 14–1). It must meet one of the following criteria:
  • A BMD measurement of more than 2.5 standard deviations below the young adult normal mean
  • A previous fragility fracture

Anatomy or Biomechanics of Fragility Fractures

• Most spine pathology caused by osteoporosis affects the vertebral body.
• Vertebral body bone strength is determined by cortical thickness, bone size, trabecular bone density, and microarchitecture.

• The cortical vertebral shell accounts for approximately 10% of vertebral strength in vivo, and the trabecular centrum is the dominant structural component of the vertebral body (Silva et al. 1997).
• Horizontally trabeculae are preferentially lost, leaving the vertically oriented trabecular struts unsupported and substantially weaker (Snyder et al. 1993).

Pathophysiology

• Fracture incidence is directly related to the degree of bone loss.
• Commonly encountered spine problems that relate to osteoporosis are described in the next subsections.

Compression Fractures

• There are 700,000 vertebral compression fractures annually in the U.S.
• Low-energy microfractures within the vertebral body cause a single (anterior) column injury.
• Compression fractures typically involve the midthoracic or thoracolumbar region.
• The vertebral body bears greater loads in these regions, especially with increasing kyphosis.
• The pain symptoms have no correlation with radiographic findings. Although 65% of patients are asymptomatic, the following have been reported:
• Spinal deformity caused by two or more compression fractures significantly affects overall health and the
Table 14-1: Subtypes of Osteoporosis

<table>
<thead>
<tr>
<th>OSTEOPOROSIS SUBTYPES</th>
<th>AGE ONSET</th>
<th>FEMALE/MALE RATIO</th>
<th>CAUSE</th>
<th>CELL TYPE</th>
<th>BONE TYPE AFFECTED</th>
<th>COMMON FRACTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I (postmenopausal)</td>
<td>50-65</td>
<td>6:1</td>
<td>Estrogen deficiency</td>
<td>Osteoclast</td>
<td>Trabecular bone</td>
<td>Vertebreal body radius</td>
</tr>
<tr>
<td>Type II (early)</td>
<td>&gt;70</td>
<td>2:1</td>
<td>Aging</td>
<td>Osteoblast</td>
<td>Cortical bone</td>
<td>Hip, Humerus, Pelvis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Calcium deficiency</td>
<td>Increased PTH</td>
<td></td>
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</tbody>
</table>

- Ability to perform activities of daily living, especially in the elderly.
  - There is a 5% age-adjusted increase in mortality and a 9% loss in predicted forced vital capacity (FVC) for each osteoporotic vertebral compression fracture (Leech et al. 1990).
- Patients with one compression fracture have four times the risk of developing a compression fracture at another level.

**Difficulty with Successful Placement of Spinal Internal Fixation**

- Positive and linear correlation between BMD and pullout strength of pedicle screws
- The use of polymethylmethacrylate (PMMA) during pedicle screw insertion can increase pullout resistance twofold in severely osteoporotic bone (Wittenberg et al. 1993).
- Increased risk of pedicle fracture with screw placement
- Pedicle screw size should not exceed 70% of the outer diameter of the pedicle to avoid fractures in these patients (Hirano et al. 1998).

**Diagnostic Tools**

- Plain radiographs
  - 30% decrease in bone mass before it is detectable on plain radiographic films
- Must assess the amount of compression, angulation, or kyphosis and the stage of healing (acute, subacute, or chronic)
- Dual-energy x-ray absorptiometry (DEXA) scanning
  - Used to assess BMD and to monitor the progress of treatment
- Accurately reflects response to treatment
- Does not provide information about bone turnover rate (formation vs. resorption)
- Laboratory workup
  - For an uncomplicated patient with osteoporosis, a laboratory workup would include a chemistry panel, a complete blood count, and 24-hour urine calcium.
  - The purpose is to check for secondary causes of osteoporosis, which include renal or hepatic failure, anemia, acidosis, hypercalcemia, and abnormalities of calcium or phosphate metabolism.

- Magnetic resonance imaging (MRI) with contrast
- Suspicion of infection, neoplasm, or neural compromise because 15% of compression fractures are caused by secondary osteoporosis

**Nonoperative Care of Compression Fractures**

- Observation because most fractures heal within 6-12 weeks
- Bed rest initially, but avoid prolonged immobilization
- Pro re nata (PRN) pain medication (e.g., Tylenol or mild narcotics)
- Physical therapy to decrease bone loss
- Bracing, which may stabilize the fracture
- However, bracing contributes to bone loss and is poorly tolerated (especially by the elderly).

**Operative Care of Compression Fractures**

**Vertebroplasty**

- Involves the injection of bone cement (PMMA) through the pedicles or directly into the vertebral body fracture to restore structural stability and therefore relieve pain (67%-100%)

**Kyphoplasty**

- Insertion of a bone “tamp” into the vertebral body to create a void to accept the injection of bone cement (PMMA)
- May restore vertebral body height through the use of a bone tamp

**Relative Indications for Vertebroplasty and Kyphoplasty**

- Painful acute or subacute (most effective if the fracture is approximately 6 weeks old) primary or secondary compression fractures nonresponsive to conservative therapy
- Prephylactic augmentation of noncompressed osteopenic levels adjacent to an instrumented fusion in osteoporotic patients
- Anterior column support of an osteoporotic vertebral body following a posterior decompression
Complications of Vertebroplasty and Kyphoplasty
- Short-term complications
  - Cement extravasation
  - Pain and neural injury because of cement contact (thermal burn) with spinal cord or nerve roots
  - Cement emboli
- Long-term complications (not fully evaluated)
  - Local acceleration of bone resorption
  - Foreign-body reaction at the cement-bone interface
  - Increased risk of fracture in treated or adjacent vertebrae through changes in mechanical forces

Disorders of Bone Density
- Increased osteodensity—Increased bone mass caused when bone formation is greater than bone resorption

Osteopetrosis (Albers-Schönberg Disease)
- This rare disease is caused by decreased osteoclastic resorption but normal bone formation.
- The most common form (adult tarda) is autosomal dominant and mild.
- The congenital form is autosomal recessive and the most severe.

Pathophysiology
- Decreased osteoclastic resorption but normal bone formation results in increased bone density and bone marrow obliteration.
- Clinically significant spinal involvement is uncommon; however, case reports of spondylolysis and/or spondylolisthesis secondary to lesions in the lumbar spine have been reported.
- Disordered architecture also makes bones susceptible to fractures.

Diagnostic Tools
- Plain radiographs
- Sclerotic bands underlying endplates result in the hallmark “rugger jersey” appearance of the vertebrae.

Treatment
- Use interferon alpha and nonoperative treatment of fractures.
- Fractures requiring surgical stabilization present unique challenges, and careful preoperative planning is necessary.

Disorders of Bone Mineralization
- Osteomalacia—Inadequate deposition of calcium and phosphorous in bone tissue matrix. The total bone amount is normal; however, newly formed bone is inadequately mineralized.
  - This causes 4%-15% of hip and spinal compression fractures.

Some of the Multiple Etiologies
Intestinal Malabsorption or Malnutrition
- These are secondary to changes seen with aging.
- Immobile malnourished elderly patients without access to sunlight develop vitamin D deficiency.
- Decreased renal and liver function in the elderly lead to decreased vitamin D production (Table 14–2).

Malignancy
- Causes osteomalacia through humorally activated demineralization with hypercalcemia and hypophosphatemic osteomalacia (Goranson et al. 2002)

Renal Osteodystrophy
- Severe renal disease leads to the loss of normal vitamin D production and calcium and phosphorous metabolism.
- This leads to osteomalacia, bony lesions, fracture, and pain.
- Kidneys fail to produce active vitamin D, and this leads to decreased calcium absorption.
- Renal disease causes increased phosphorous resorption and calcium excretion.
- Excess phosphate binds the calcium in serum and leads to extraneous calcification.
- Increase in parathyroid hormone (PTH) secretion—The body produces excess PTH in response to

<table>
<thead>
<tr>
<th>TYPE OF OSTEOMALACIA</th>
<th>TREATMENT</th>
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<tbody>
<tr>
<td>All patients</td>
<td>Calcium 1500 mg/day</td>
</tr>
<tr>
<td>Vitamin D deficiency</td>
<td>Vitamin D, 50,000 IU 3-5 times per week, then 1000-2000 IU/day when stable serum levels</td>
</tr>
<tr>
<td>Intestinal malabsorption</td>
<td>25-hydroxyvitamin D, 20-100 mg/day</td>
</tr>
<tr>
<td>Phenylketonuria</td>
<td>25-hydroxyvitamin D, 20-100 mg/day</td>
</tr>
<tr>
<td>Type I vitamin D-dependent rickets (production)</td>
<td>1,25-hydroxyvitamin D, 2-3 µg/day</td>
</tr>
<tr>
<td>Type II vitamin D-dependent rickets (receptor)</td>
<td>1,25-hydroxyvitamin D, 25 µg/day</td>
</tr>
<tr>
<td>X-linked hypophosphatemic rickets</td>
<td>1,25-hydroxyvitamin D, 2-3 µg/day</td>
</tr>
<tr>
<td>Renal osteodystrophy</td>
<td>1,25-hydroxyvitamin D, 1-2 µg/day</td>
</tr>
<tr>
<td>Restriction in phosphate</td>
<td></td>
</tr>
<tr>
<td>Parathyroidectomy if PTH levels uncontrollable</td>
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</tbody>
</table>
A review article detailing the metabolic bone sequel of malignant disease. The article describes the natural history of malignant disease and the mechanism causing osteomalacia.


This article reviews the literature providing information about the pathomechanics by which Paget's disease alters the spinal structures. It describes spinal entities such as pagetic spinal arthritis, spinal stenosis, and other pathologies. It also assesses the best treatment options and available drugs for treating this disease.


The structural changes that occur in the pedicles of severely osteoporotic patients were analyzed using quantitative CT scanning. The effects of these structural changes on the risk of pedicle fracture during screw insertion were then assessed. Of the seven fractures that occurred, all were in patients with a DEXA value of less than 0.7 g/cm² and with screw diameters greater than 70% of the outer diameter of the pedicle. The authors conclude that to avoid fractures in osteoporotic patients, the screw diameter should not exceed 70% of the outer diameter.


Koval K et al. (2002) Orthopaedic knowledge update 7. AAOS.


Eleven patients with chronic renal failure and destructive spondylodiscopathy of the cervical spine were evaluated to determine the results of surgical and nonsurgical treatment. The authors conclude that cervical fusion is an effective method of treating patients with chronic renal failure and destructive spondylodiscopathy. Patients with laminectomy alone had no improvement in pain or neurologic function, one of three patients with anterior fusions had some improvement, and both patients with posterior fusions improved.


In this study, 74 women referred for osteoporosis testing underwent pulmonary function testing. After controlling for age, there was a significant decrease in FVC when hyperkinesia increases. Regression equations revealed that with each thoracic compression fracture there was a decrease in FVC of 9.4%.


A basic science study demonstrating that disks in patients with diabetes have proteoglycans with lower buoyant density and substantially underutilized glycosaminoglycans, which—with the specific neurologic damage in these patients—might lead to increased susceptibility to disk prolapse.


The authors compared the amounts of compressive forces that the cortical shell and the trabecular centroid endure when lumbar vertebral bodies are loaded. They found that the shell accounts for only 10% of vertebral strength in vivo and that the trabecular centroid is the dominant component of the vertebral body in regards to strength.


A three-dimensional stereological analysis of trabecular bone was performed on lumbar vertebral bodies extracted from cadavers between the ages of 27 and 81. The authors found that the number and thickness of trabecular decreased linearly with density when age increased. They also found that the number of vertically oriented trabecular changed with density at twice the rate of that seen in the transverse (horizontal) trabecular.


A clinical study demonstrating that OPLL in patients with vitamin D-resistant rickets is different from degenerative OPLL and may not be reversible with medical management, leading to surgical treatment of spinal pathology.


A case report demonstrating the association between X-linked hypophosphatemia and exocrine ossification of the ligamentum flavum. This patient had progressive paraplegia, which was unresponsive to medical management and required surgical intervention. Electromyography testing and clinical motor strength were regained after surgical laminectomy.


A human study demonstrating that MRI documented disk degeneration and back pain is associated with certain polymorphisms of the vitamin D receptor.


The effect screw diameter and different screw insertion techniques on axial pullout force and transverse bending stiffness were compared using a biomechanical model. The axial pullout force of Schanz screws was significantly increased, with a 1-mm increase in screw diameter, but there was no significant increase in transverse bending stiffness. Augmenting pedicle screws with PMMA in the lumbar spine increased both the axial pullout force (approximately twofold) and the transverse bending stiffness.
Miscellaneous Inflammatory Disorders Affecting The Spine

Calcium Pyrophosphate Dihydrate Deposition Disease

- The common disorder is characterized by calcium pyrophosphate dihydrate deposition disease (CPPD) crystal deposition within soft tissues.
- The incidence of CPPD increases in hyperparathyroidism, hemochromatosis, hemosiderosis, hypogammaglobulinemia, and hypophosphatemia.
- Spinal involvement is common (secondary to knee involvement) but mostly asymptomatic.
- There is a male/female ratio of 1:1 with a typical onset after 50 years of age.

Pathophysiology

- CPPD crystal deposition in hyaline cartilage, fibrocartilage, and periarticular tissues leads to the chondrodyscinosis, the hallmark of the disease. Deposition can lead to secondary arthritis with prominent calcifications, cysts, and erosions, but the clinical significance of this can vary (Box 14–2)
  - Mostly asymptomatic
  - Pain and symptoms similar to those seen in osteoarthritis and RA
  - Compression of neural structures when depositions are located within the spinal canal.
  - Cervical myelopathy rare but reported
  - Spinal stenosis

Diagnostic Tools

- Laboratory test
- Mildly elevated erythrocyte sedimentation rate
- Synovial aspiration demonstrating pyrophosphate crystals (gold standard to establish the diagnosis); crystals are rhomboid shaped and positively birefringent
- Plain radiographs
- MRI
- Indicated if neural compression suspected

<table>
<thead>
<tr>
<th>Radiographic Features Distinguishing CPPD from Degenerative Joint Disease</th>
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<tbody>
<tr>
<td>Prominent calcification</td>
</tr>
<tr>
<td>Involvement of unusual joints and compartments</td>
</tr>
<tr>
<td>Presence of extensive sclerosis, cysts, fragmentation, and osseous debris</td>
</tr>
<tr>
<td>Variable osteophyte formation</td>
</tr>
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</table>

Treatment

- Nonoperative treatment
- NSAIDs
- Operative treatment
- Surgical decompression is indicated in patients with myelopathic symptoms, symptomatic spinal stenosis, or both nonresponsive to conservative treatment.

References


A case report of a patient with clinical AS by examination and history with osteoracalia diagnosed through pseudofractures on radiography.


A clinical study demonstrating that vitamin D deficiency is a major cause of lower back pain in area of the world where decreased intake is endemic. Screening for vitamin D deficiency and treatment with supplements is recommended in these areas. Measurement of serum 25-OH cholecalciferol is sensitive and specific for detection of vitamin D deficiency and hence for presumed osteoracalia in patients with chronic low back pain.


Text distributed by the AAOS that contains core information on all aspects of spinal care.


A case report of a young adult with progressive kyphosis of the thoracic spine managed surgically, demonstrating that unrecognized endogenous production of glucocorticoids in Cushing's disease should be considered in young adult patients with progressive osteoporotic spinal deformities.

Psoriatic Arthritis
- 7% of patients with psoriasis
- Arthritis precedes skin lesions in 15% of cases
- 20% HLA-B27 positive
- Spine involved in 20% patients
- Shares many musculoskeletal features with Reiter's syndrome
- Nonmarginal asymmetric syndesmophytes (large and bulky) (Fig. 14-5)
- Sacroiliitis is unilateral and asymmetric
- Can involve small joints (e.g., proliferative erosions, soft tissue swelling, periostitis, and ankylosis)
- Arthritis deformans (severe involvement of hands and feet)

Reiter Syndrome
- Triad of urethritis, uveitis, and arthritis
- 90% patients HLA-B27 positive
- Spine involved in 30%-40% patients
- Microbes implicated include Shigella, Salmonella, Yersinia, and Campylobacter
- Disability occurs in 25% (mostly because of calcaneal involvement)
- Unilateral asymmetric sacroiliitis
- Nonmarginal asymmetric syndesmophytes

Figure 14-5: An anteroposterior plain radiograph of the thoracolumbar spine demonstrating a nonmarginal syndesmophyte characteristic of psoriatic arthritis and Reiter's syndrome.

Inflammatory Bowel Disease
- Shares many musculoskeletal features with AS
- HLA-B27 positive in 5% of cases
- Spondyloarthropathy more prevalent in Crohn's disease than in ulcerative colitis
- Spine involved in 5% of patients (of those, 50%-75% are HLA-B27 positive)
- Spinal involvement usually independent of bowel disease
- Marginal (starting at the endplates) symmetric syndesmophytes
- Sacroiliitis is bilateral and symmetric
- Peripheral arthritis following disease exacerbations
OSTEOPHYTES

MARGINAL SYNDESMOPHYTES

NONMARGINAL SYNDESMOPHYTES

Figure 14-3: A lateral plain radiograph of the thoracic spine demonstrating a bamboo spine and marginal syndesmophytes as a result of AS.

Figure 14-4: An anteroposterior radiograph of the pelvis and sacroiliac joints demonstrating the typical erosions and the sclerosis of sacroiliac joints frequently seen in patients with AS.

- Bone scan can be "hot" because of the disease itself.
- There is a high incidence of neurological compromise if fractures are missed.
- Always maintain a high index of suspicion for spinal fracture!

Physical Examination
- Stooped posture
- Rigid kyphotic spine
- Most effective measure of the spinal deformity—Chin-brow to vertical angle
- Compensatory hip flexion contractures common

Nonoperative Treatment
- Radiation therapy
- Rarely used and predisposes to malignancy
- NSAIDs
- Control pain and stiffness but do not alter the course of the disease
- Phenylbutazone and indomethacin most effective
- Steroids
- Useful for local control but systemically have no proven value
- Disease-modifying agents—Sulfasalazine, cyclophosphamide, and methotrexate may be helpful
- Exercise

Operative Treatment

Indications for Surgery
- Flexion deformity associated with pain and neurologic compromise
- Loss of horizontal gaze
- Stabilize spine fractures (flexion deformity is probably a late consequence of fractures)
Table 14-4: Predictors of Neurologic Recovery and Ranawat Classification*

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SYMPTOMS</th>
<th>PROGNOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Pain but no neurologic deficit</td>
<td>Better postoperative outcomes</td>
</tr>
<tr>
<td>II</td>
<td>Subjective weakness</td>
<td>Less recovery and increased mortality after surgery</td>
</tr>
<tr>
<td>IIA</td>
<td>Ambulatory with weakness and pathologic reflexes</td>
<td>Less recovery and increased mortality after surgery</td>
</tr>
<tr>
<td>IIB</td>
<td>Nonambulatory with weakness and pathologic reflexes</td>
<td>Less recovery and increased mortality after surgery</td>
</tr>
</tbody>
</table>

* Pts with patients with Spinal Canal Diameter (SCD) > 14mm had complete recovery postoperatively
SCD < 14mm had recovery of one Rankawat class
Early decompression in pts with neurologic deficits are associated with improved outcomes.

Seronegative Spondyloarthropathies

- Human leukocyte antigen (HLA) B27 associated with the development of spondyloarthropathies and including the following:
  - AS
  - Reactive arthritis associated with inflammatory bowel disease
  - Psoriatic arthritis
  - Reiter’s syndrome

Ankylosing Spondylitis

- Chronic inflammatory disease affecting the axial skeleton
- Prevalence is 1 in 1,000
- Onset 15-50 years of age

Box 14-1: Surgical Pearls in Treating Rheumatoid Arthritis

- Avoid if possible anterior instrumentation in RA patients with osteoporosis.
- Consider preoperative traction to realign the spine prior to fusion in patients with a multilevel disease.
- Be aware of ending a fusion at an unstable or isometric segment because this increases the risk of failure.
- Extend fusion levels if there is any uncertainty about the spine stability at the ends of a surgical construct.
- Do not ignore the occiput and the C1-C2 junction if they are significantly involved with disease, fuse them.
- Before fusing just the cephceoaxial junction, rule out subaxial instability.
- Perform a close follow-up to assess for junctional breakdown above and below the fusion level.
- If a severe deformity exists, consider anterior and posterior stabilization.
- For example, consider an anterior strut graft with posterior segmental instrumentation.

- Male = female; however, males have a more severe disease expression
- Mostly Caucasian (HLA-B27)
- Propensity toward spinal fractures (rigidity and osteoporosis)
- Development of spinal deformity (related to microfractures)
- Usually presenting symptoms of low back pain and morning stiffness
- When spine autofuses, most symptoms resolve
- Requires the most attention of the seronegative spondyloarthropathies because of the risk of worsening spinal cord or nerve injury from delayed diagnosis of spinal fractures and instability

Anatomy and Pathophysicsiology

- HLA-B27 in 88%-96% patients with AS
- Earliest changes are in SI joints followed with cephalad spinal progression
- Pannus formation common
- Initial cartilage destruction and bony erosions
- After a reparative phase, fibrous and bony ankylosis
- Enthesitis at tendon and ligament bony insertions
- In the spine, enthesitis at the insertion of the annulus fibrosus
- Osification of the annulus producing syndesmophytes and eventually a “bamboo spine”
- Nonkeletal manifestations
- Acrotic insufficiency, cardiac conduction defects, uveitis, uremia, and pulmonary fibrosis (cause of death in 10% patients)
- Spontaneous atlantoaxial subluxation can result from bony erosions

Diagnostic Tools

Plain Radiography

- Squaring the corners of vertebral bodies
- Marginal symmetric syndesmophytes (Fig. 14-2)
- Syndesmophytes—Vertical paravertebral ossification
- Osteophytes—More horizontal ossifications
- Bamboo spine (Fig. 14-3)
- Saccoutitis (Fig. 14-4)
- Bilateral and symmetric
- Sequence erosions, sclerosis, and aurofusin
- CT—Test of choice for SI joint involvement
- Arthropathy of large joints resembles RA

Occult Fractures

- Such fractures can occur with minimal trauma or minor motor vehicle collision.
- Plain radiographs can be misleading and hard to interpret.
- CT can be hard to interpret because of the difficulty in obtaining true axial cuts.
- MRI is a more reliable test for occult fractures and hematoma evaluation.
• Neurologic symptoms caused by direct compression of the cervical mediullary junction or ischemia from compression of the neural vasculature
• Migration evaluated by measuring Chamberlain’s line, Wackenheim’s line, and the Ranawat measurement

Subaxial instability
• Least common and found in 20% of patients
• Occurs as a direct result of facet, ligament, and disk destruction
• May be seen at multiple levels causing a stepladder deformity frequently associated with kyphosis
• Spinal canal diameter (SCD) is the best prognostic factor for assessing subaxial instability.

Diagnostic Tools

Physical Examination
• Gait, equilibrium, cervical range of motion, and motor and sensory testing
• Pathologic reflexes
• Hoffman reflex—Upper motor neuron sign produced by applying a sudden hyperextension to the distal phalanx of the third finger, eliciting flexion of the metacarpal phalangeal and interphalangeal joints of the thumb and second finger.
• Babinski sign, hyperreflexia, and clonus
• Patients with more severe disease in the peripheral skeleton (hands) usually develop worse disease involving the cervical spine.

Plain Radiographs

Assessing Stability
• SCD is measured from the posterior vertebral body to the spinolaminar line.
• Cord compression occurs when SCD is less than 14 mm on the neutral lateral plain radiograph.
• Posterior space available for the cord at the atlantodens junction is the most reliable indicator for risk of neurologic deterioration.
• Posterior space available for the cord is measured from the posterior dens to the anterior aspect of posterior atlas arch.
• Atlantodental interval
  • Normally <3 mm (adults) and <5 mm (children)
  • Normal posterior atlantodental interval is >14 mm
• Tip of odontoid should be inline with basion

Flexion or Extension Radiographs
• Such radiographs are used to assess for dynamic instability.
• Red flags for instability are subaxial vertebral translation more than 3.5 mm or an 11-degree angulation between adjacent vertebrae.
• These radiographs should be used as a preoperative screen in all rheumatoid patients to avoid complications that may occur during intubation.
• Such radiographs are helpful in assessing fusion levels if surgery is indicated.

Magnetic Resonance Imaging
• MRI has the advantage of being able to visualize spinal cord compression because of bone and soft tissue pannus.
• Two thirds of patients with RA have a soft tissue pannus of more than 3 mm not visualized on plain radiographs. This further reduces the SCD.
• Flexion or extension MRI is useful in evaluating dynamic instability.
• MRI is indicated if an SCD of less than 14 mm or an instability is seen on radiographs.

Laboratory Tests
• The Rhesus factor is negative in 15% of patients.
• C-reactive protein is frequently elevated (three times the normal amount) in patients with subluxations in the cervical spine.

Nonoperative Treatment
• Medical treatment
• Cervical orthosis
• Close follow-up with physical examination and radiographic analysis

Operative Treatment

Goals of Surgery
• Operative treatment should prevent or minimize the risk of neurologic deterioration and therefore the risk of paralysis and sudden death.
• Fusion procedures are used in RA patients to decrease motion and to reduce synovial pannus formation and inflammation in the joints.
• Fusion procedures also are used to stabilize the cervical spine to prevent neurologic injury.
• Once neurologic deficits exist, surgical outcomes less successful.

Potential Indications for Surgery
• In the presence or absence of neurologic signs or symptoms
• Atlantoaxial subluxation with a posterior atlantodental interval of 14 mm
• Subaxial subluxation = 5 mm
• Subaxial subluxation and an SCD of 14 mm or less
• Cervical medullary angle of less than 135 degrees
• Has a high incidence of progressive myelopathy (Table 14-4, Box 14-1)
Minimal trauma has been shown to produce unstable fractures.

**Diagnostic Tools**
- Plain radiographs
- Used to help establish the diagnosis (Fig. 14–1)
- Plain x-rays, computed tomography (CT), MRI, or bone scan
- Indicated in patients with back pain following any trauma, even minor, to rule out occult fracture
- Difficult to demonstrate fractures because of the excessive bone formation or associated osteoporosis

**Treatment**
- Thoracolumbar fractures may benefit from surgical stabilization, especially when associated with neurologic compromise or instability.
- Displaced fractures, late diagnosis, nonunion, or osteolysis of the spine are potential indications for surgical stabilization.
- Posterior segmental instrumentation and fusion without distraction or compression are often recommended.
- Bracing tends to not work in these patients because the long lever arms are difficult to immobilize adequately.

![Flowing Anteriorlateral Osteosclerosis](image)

**Inflammatory Spinal Disorders**

**Immune Mediated Disorders Affecting the Spine**

**Rheumatoid Arthritis**
- Rheumatoid arthritis (RA) is a chronic, progressive, systemic, inflammatory disease primarily affecting synovial joints.
- Prevalence in the adult general population is about 1%.
- RA affects the cervical spine in up to 85% of individuals.
- Of those with cervical RA, 58% develop a neurologic deficit.
- Once a myelopathy develops, 75%-90% will progress.
- Patients at highest risk for progression are males with severe peripheral disease, on steroids, or both.

**Anatomy and Biomechanics**
- The intimate relationship among the facet joints, ligaments, vertebrae, and spinal cord in the upper cervical spine makes instability in this region potentially harmful.
- Cine-radiography motion studies of cervical motion in RA patients revealed abnormal kinematics that can lead to uncontrolled movement of the vertebrae, resulting in spinal cord compression (i.e., dynamic instability).

**Pathophysiology**
- Synovitis and pannus formation are the hallmarks of the disease that leads to bone, cartilage, and ligament erosion. The resultant ligamentous laxity can lead to subluxation, instability, and neural (cord or root) compression.
- The spectrum of neurologic symptoms is broad and can range from mild neck pain and occipital headaches to myelopathy, paralysis, and death.
- C1–C2 instability is the most common cervical abnormality seen.
- Of RA patients, 50%-61% develop one or a combination of the following three cervical spine instability patterns:
  - Atlantoaxial instability
    - Most common instability (50%) pattern noted in RA
    - Translation of C1 on C2
    - Most subluxations are anterior and result from attenuation of the transverse and apical spinal ligaments
  - Basilar invagination
    - Cranial migration of the odontoid above the transverse diameter of the foramen magnum
    - Caused by erosion and bone loss between occiput-C1 and C1-C2 articulations
• Bisphosphonates
• Nasal calcitonin
• Symptomatic spinal stenosis with neurological claudication responds well to medical therapy with calcitonin and bisphosphonates (Hadjipavlou et al. 2001).

Operative Treatment
• Decompression rarely is necessary.

Complications
• Decompression can lead to spinal instability.
• Increased intraoperative bleeding can occur.

Endocrinopathies Affecting the Spine
• Can lead to severe osteoporosis and osteomalacia

Glucocorticoid Excess
• Causes include Cushing's disease, iatrogenic steroid treatment, and adrenal tumors
• Mechanisms include the following:
  • Decreased calcium absorption across the intestinal wall through a decrease in calcium-binding proteins
  • Increased urinary calcium excretion
  • Increased bone resorption
1. Resorption of bony matrix proteins
2. Secondary elevated PTH in response to low serum calcium
• Spinal manifestations
  • Severe osteoporosis—even with Prednisone intake of 10 mg by mouth every day
  • Compression fractures resulting in thoracic kyphosis secondary to Cushing's disease in young adults (Angela et al. 1999).

Type 1 Diabetes
• Calcium and negative nitrogen balance leads to osteoporosis through calcium and bony matrix resorption.
• Spinal manifestations include accelerated osteoporosis and increased susceptibility to disk herniation.
• Undersulfated glycosaminoglycan in proteoglycans of lumbar disks leading to possible weakness in the anulus fibrosus (Robinson et al. 1998).

Hyperparathyroidism
• PTH is released in response to low serum, ionized calcium
• PTH binds to osteoblast receptors, activating bone turnover and releasing interleukin-6 (IL-6).
• IL-6 causes osteoclast activation and the net resorption of calcium.
• PTH increases renal calcium resorption, phosphate excretion, and vitamin D production.
• PTH can be elevated primarily or secondarily (i.e., renal disease or Cushing's disease).
• Laboratory values show elevated serum calcium.
• Severe skeletal calcium loss leads to osteomalacia and lytic bone lesions (Brown tumors).

Hyperthyroidism
• Causes include primary hyperthyroidism or iatrogenic from excessive thyroid hormone replacement.
• Elevated levels promote bone formation and resorption.
• The net result is bone loss.
• Hyperthyroidism leads to progressive osteoporosis.
• There is an elevated risk of hip and compression fractures in women.

Miscellaneous Disorders Affecting the Spine

Diffuse Idiopathic Skeletal Hyperostosis (Table 14-3)
• There is a generalized ossification of ligaments of unknown origin.
• The spine is the most commonly affected area.
• Prevalence in males older than 50 is 25% and in females older than 50 is 15%.
• This is less commonly seen in African-American and Native American populations.

Anatomy
• Longitudinal ligaments of the spine, in particular the anterior longitudinal ligament, are most often affected.

Pathophysiology
• The ligament ossification leads to an increased fracture risk. Fractures are commonly caused by a hyperextension force to the thoracolumbar spine; these patients have an increased incidence of spinal cord injury because of the presence of rigidly fused spinal segments. These segments produce long lever arms and are highly unstable.

<table>
<thead>
<tr>
<th>Table 14-3: Diagnostic Criteria for Diffuse Idiopathic Skeletal Hyperostosis*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of apophyseal joint bony ankylosis and sacroiliac joint erosion, spondylosis, or intraarticular osseseous fusion</td>
</tr>
<tr>
<td>Relative preservation of intervertebral disk height in the involved vertebral segment and absence of extensive disk disease</td>
</tr>
<tr>
<td>Flowing calcification and ossification along the anterolateral aspect of at least four contiguous vertebral body segments</td>
</tr>
</tbody>
</table>

* Thoracic vertebrae are involved in 100% of cases (T7-T11 most common), lumbar in 58%-95%, and cervical segments in 65%-76%.
elevated phosphate levels, leading to excessive bony calcium loss.
• Calcium loss from bone—Osteolytic brown tumors

Genetic Disorders
• Type I vitamin D-dependent rickets
• Abnormal kidney development—Deficient 1-α-hydroxylase
• Type II vitamin D-dependent rickets
• Abnormal vitamin D receptor
• X-linked hypophosphatemic rickets (Vera et al. 1997)
• Mutation in the PHEx gene—loss of PO₄ in renal tubules
• No PO₄ available for bone mineralization
• Osteopenia secondary to abnormal osteoblasts

Therapeutic and Environmental Causes
• P-450 activation increased by certain drugs, which may inactivate vitamin D production (e.g., phenytoin or cadmium)

Heavy Metals
• Aluminum and iron ingestion inhibits the formation of hydroxyapatite crystals and inhibits osteoblast function.

Pathophysiology
• Natural history is bone pain, stress, and fragility fractures.
• Manifestations mimic osteopenic and osteolytic disorders.

Some of the Spine Manifestations
• Compression fractures
• Spinal stenosis—vitamin D-resistant rickets (Velan et al. 2001)
• Seen in the Japanese population but less frequent in Western populations
• Can affect any spinal level
• Lower back pain (Air Faraj et al. 2003, Videnian et al. 1998)
• Incidence high where vitamin D deficiency is endemic
• Mandatory screening for serum vitamin D levels
• Bone pain mimicking ankylosing spondylitis (AS) (Akkus et al. 2001)
• Resolves with oral vitamin D and calcium intake
• Cervical spondylarthropathy (Kumar et al. 1997)
• Debilitating neck pain from renal osteodystrophy
• Surgical fusion may decrease pain and allow increased activity

Diagnostic Tools
• Plain radiographs
• Indistinguishable on radiographs from osteoporosis.
• Looser's transformation = radiolucent lines (microfractures)
• Laboratory levels
• Hypocalcemia, hypophosphatemia, and elevated PTH
• Low serum and urine 25-OH vitamin D
• Urine calcium < 100 mg/24 hrs
• Iliac biopsy for confirmation

Medical Treatment
• Much more responsive to dietary vitamin D, calcium, and phosphate than causes of osteoporosis

Disorders of Bone Remodeling
Paget's Disease (Osteitis Deformans)
• It is the second most common disorder of bone.
• Focal disorder of bone affects all elements of skeletal remodeling (resorption, formation, and mineralization).
• One third of patients with Paget's disease have spinal involvement.
• Most patients are asymptomatic, and the diagnosis is usually made incidentally by routine chemistry or radiographs.

Pathophysiology
• The primary defect is an exaggeration of osteoclastic bone resorption, initially producing localized bone loss. This is followed by pronounced bone formation, resulting in enlarged and deformed bones.
• Spinal stenosis and back pain are common.
• One third of these patients have symptomatic spinal stenosis.
• Half of these patients have back pain.
• Facet arthropathy may result in both back pain and symptoms of spinal stenosis.
• Nerve compression results from an expansion of pagetoid vertebral bodies.

Diagnostic Tools
• Plain radiographs
• Bone diameter is expanded, cortices are thickened, and trabeculae are coarse and widely separated. Vertebral bodies may have a framed-picture appearance.
• Laboratory tests
• Serum alkaline phosphatase (elevated) and calcium (normal)
• Urinary hydroxyproline excretion (elevated)
• Bone scan
• Most sensitive test in identifying pagetic bone lesions
• Lesions with markedly increased uptake
• MRI
• Only indicated when the disease causes suspected neural compression

Nonoperative Treatment
• Acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs)