Clinical Application of Pathology

Vertebral Column

Systems: Bone

Causes: Congenital, Degenerative, Cancer

Quizzes: IMED4121 – Musculo-Skeletal, Vertebral column & back pain

Introduction

In the pediatric population congenital anomalies are the most frequent cause of problems. In adults, degenerative conditions are the most common cause of back pain.

Note: Spinal injuries are in a separate module. Primary bone tumours are in the Bone Tumour module.

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Saturday, August 13, 2016
CONGENITAL

Fusion of Vertebrae

**Block vertebrae:** these are formed when two or more vertebral bodies fuse. The height of the vertebral bodies is normal. In partial fusion it is the anterior aspect that fuses while a rudiment of the disc remains within the posterior portion. The intervening disc is atrophied and calcified. The fusion can also include the posterior elements.

**Sites:** It occurs in the thoracic and lumbar region. In Klippel-Feil syndrome the fused vertebrae are in the cervical region.

**Clinical:** it is often asymptomatic, except in Klippel-Feil syndrome which also has an association with hemivertebrae as well.

**Imaging:** The adjacent vertebrae fuse through their intervertebral discs and also through other intervertebral joints so that it can lead to blocking or stretching of the exiting nerve roots from that segment. It may lead to certain neurological problems depending on the severity of the block. It can increase stress on the inferior and the superior intervertebral joints. It can lead to an abnormal angle in the spine.

In the images below, courtesy of Dr A Goel and Dr Sam Kyle. Radiopaedia.org, the plain radiography on the left shows fusion of the 3rd and 4th cervical vertebrae – arrows at disc level. The anterior-posterior width of the vertebral bodies at the site of fusion is less than at the level of the uninvolved portions of the vertebral bodies which creates a trapezoidal vertebral shape. This distinguishes it from a vertebral fusion secondary to infection of the disc. Sometimes fusion occurs at more than one level as in the example of the lumbar spine MRI on the right– arrows indicate the atrophic disc levels at the T12-L1 and the L2-L3 levels. Again note the trapezoid shape.

**Klippel-Feil deformity:** term refers to the triad of a short neck, a low posterior hairline and limitation of neck movements which are due to fusion of two or more cervical vertebrae – usually the first three cervical vertebrae. Only 50% patients have all three features. The level above a fused block will be excessively mobile and can cause cord compression which may reduce during flexion of the neck. In the MRI image below, courtesy of Dr Sinéad Culleton. Radiopaedia.org, the narrowed wasp-
waist sign is seen at C6-C7 and there is fusion of C2-C3, as well as C5-C7. In addition there is posterior displacement of C4, with respect to C5 – see arrow - impinging on the cervical cord during flexion. The 25 year old patient had surgery with an anterior fusion at C4-C5 which, by preventing movement backwards during extension, was able to decompress the level of the localized canal stenosis.

![Image of MRI scan showing cervical spine with arrow indicating impingement on the cervical cord.

Atlanto-occipital fusion (occipito-cervical fusion)

**Definition:** fusion or partial fusion of the occiput and the atlas (C1), usually accompanied by deformity of the foramen magnum which is reduced in size and irregular in shape.

**Anatomy:** in normal individuals the tip of the odontoid process of C2 lies below a line drawn on a lateral radiograph between the posterior margin of the hard palate and the posterior rim of the foramen magnum (Chamberlain’s line). However, the odontoid can project above this line as much as 7 mm as a normal feature.
When there is fusion of C1 and the occiput, the odontoid extends above Chamberlain’s line. There can be complete assimilation of the C1 into the occiput which narrows the upper cervical spinal canal at the level of the foramen magnum causing pressure on the spinal cord and medulla. This will cause neurologic disorders.

**Incidence:** is present in 1% of the population.

**Macroscopic:** in its mildest form, the distance between the posterior arch of the atlas and the occipital bone is reduced and does not change with flexion and extension. However, assimilation of the atlas implies bony fusion is complete and the atlas cannot be seen separate from the occipital bone. The relationship of the atlas with the axis (C2) is maintained so the odontoid peg appears excessively high. The condition can be found in 6% of patients with the Chiari Type I malformation of the brain. When there is basilar invagination as an isolated anomaly, Chiari Type I malformations are found in 70% of cases.

Note; Chiari Type 1 consists of cerebellar ectopia; parts of the cerebellar hemispheres lie 3 mm below the level of the foramen magnum where these can cause localized medulla and cord compression.

Fusion of C2 with C3 occurs in 60% of patients with occipito-atlantal fusion. Image courtesy of Dr Henry Knipe, Radiopaedia.org. The arrow indicates the disc level between the fused C2 and C3 in a patient with occipito-atlantal fusion.

![Image](image-url)

**Partial fusion of the 5th lumbar vertebra and the 1st sacral** can cause localized weakness of the spine, especially after severe exertion.

**Hemi-vertebrae**

**Definition:** failure or improper development of a lateral half of a vertebral body.

**Incidence:** one per 1000 live births.

**Clinical:** patient has a scoliotic deformity due to the acute lateral angulation of the spine. Otherwise it is of no clinical importance.

**Imaging:** on plain radiographs the vertebra looks triangular. Those in the thoracic region have only one rib which is on the side of the ossified half. The image, courtesy of Dr Yuranga Weerakkody, Radiopaedia.org, shows a hemivertebra involving the 3rd thoracic with absence of a rib on the left side (arrow).
Associated conditions: variations in the number of ribs, fusion of two or more ribs and rudimentary development of some of the remainder.

Vertebral Clefts

Definition of Types:

1. is when there is partial (butterfly vertebrae) or complete failure of fusion of the two lateral centres of chondrification in the mid-sagittal plane.

2. Failure of fusion in the coronal plane can also occur which separates the vertebral body into an anterior and posterior portion. Either the anterior or posterior half of a vertebral body may fail to develop which results in a ventral or a dorsal hemivertebra. The dorsal is more common and because of the absence of normal ossification anterior to it, a sharp gibbus deformity occurs.

In the image that follows, courtesy of Dr Henry Knipe. Radiopaedia.org, rID42824, one sees a dorsal hemivertebra of an upper lumbar vertebra with a sharp gibbus of the thoracic spine above that level – see arrow.

3. A cleft can be present in the midline of the C1 arch which may simulate a vertical odontoid fracture. This is rare – 0.2% of the population - and can only occur when there are two centres of
ossification for the arch, instead of one. The bony defect, which ranges from 1-5 millimetres in width, is bridged by fibrocartilagenous tissue, resulting in what is generally believed to be a stable atlas. Usually there are no clinical aspects, except when there has been trauma and it is necessary to decide whether the break is congenital or a fracture, as the latter would be unstable. CT scan can assist as in the example that follows (courtesy of E Karavelioglu, E Kacar, A Karavelioglu, Y Gonul, M Guven. Neurology India 2014, 62 (3): 303-304).

4. In the lumbosacral region, the vertical cleft in the midline of the vertebral arch is called **spina bifida**. It is associated with soft-tissue defects or when there is a meningocele. It is called **spina bifida occulta** when there are no soft-tissue malformations associated with it. Commonly found in the arch of the 5th lumbar or the 1st sacral vertebra.

The contribution of this to low back pain is controversial.

**Neural Arch Defects**

**Definition**: Congenital spondylolisthesis - Dysplastic facets or abnormal orientation of the facet joints are the cause for spondylolisthesis.

**Sites**: commonest site for a cleft is the arch of the 5th lumbar vertebrae and next the 4th lumbar. Rarely may be seen in the cervical spine, with the 6th cervical vertebra being most frequent. Bilateral clefts commonest and cause a forward displacement of one vertebra on the one below it.

**Terminology**: spondylolysis: clefts without displacement of the vertebra. Spondylolisthesis – clefts with displacement.

The degree of Spondylolisthesis is classified by Meyerding’s method which divides the antero-posterior width of the sacrum into 4 parts. A forward slip of L5 on S1 for a distance of one quarter of the AP width of S1, is called a first-degree spondylolisthesis. Complete displacement of L5 on S1, so that L5 comes to lie in front of the sacrum can happen and is referred to as fourth-degree spondylolisthesis.

**Imaging**: The spondylolisthesis can usually be seen on a plain radiograph but CT scan may add a little more information. In the images below (courtesy of Dr Jeremy Jones and A/Prof Frank Gaillard. Radiopaedia.org) see a Grade I type in the left image of L4 on L5 – see arrow and on the right a reconstructed CT scan showing a Grade II of L5 on S1.
**MRI:** may visualize oedema in the marrow around the site of an acute spondylolytic defect.

MRI also is helpful in identifying the presence of nerve root compression as a result of foraminal or central canal stenosis.

**Electromyography** may identify a concomitant radiculopathy or polyradiculopathy, which may be present as a result of spondylolisthesis.

**Clinical features:** Taken from Beth Froese. Medscape Feb 18, 2016

- Hamstring tightness is observed almost universally, even in low-grade spondylolisthesis.
- Lumbar spasm may be present.
- A palpable step-off is noted with slips equal to or greater than grade 2.
- With higher degrees of spondylolisthesis, an increased lumbosacral kyphosis is seen (50% or greater) along with a compensatory thoracolumbar lordosis. Truncal shortening may be present. With severe slips, the rib cage may rest on the iliac crest.
- Dermatomal weakness if a radiculopathy or an element of stenosis is present.
- A waddling gait may be noted secondary to hamstring tightness producing a shortened stride length.
- If spondylolisthesis is not present, spondylolysis presents with paraspinal spasm, pain provocation with lumbar spine extension, and tight hamstrings.

**Microscopy:** at the site of the spondylolisthesis there may be found a fibrocartilaginous mesh that often bridges the gap between the edges of the‘ fracture’ site.

**Treatment:** Most patients with congenital low-grade spondylolisthesis are often asymptomatic but if pain is an issue can be treated conservatively. If symptoms become acute, the patient should be restricted from sports until they are asymptomatic. The protocol includes activity and exercise that reduces extension stress.

The goals of exercise are to improve abdominal strength and increase flexibility. Since tight hamstrings are almost always part of the clinical picture, appropriate hamstring stretching is important. Instruction in pelvic tilt exercises may help reduce any postural component causing increased lumbar lordosis which increases low back pain.

Younger patients have a higher risk for progression of congenital spondylolisthesis. Serial radiographic studies (standing lateral films only) should be performed every 6 months to follow
these patients. Progression rarely occurs after adolescence. Patients with a unilateral pars defect may be prone to developing an acquired contralateral pars defect with extension stress.

**Surgical treatment**: is indicated when any type of spondylolisthesis is accompanied by a neurologic deficit. **Medical treatment**: NSAIDs are used most commonly while narcotic analgesics are used for breakthrough pain.

**Complications**: The most common complication of spondylolisthesis is nerve root impingement/radiculopathy at the level of spondylolisthesis. Spinal stenosis and cauda equina syndrome may occur when a significant slip has occurred.

Disk degeneration occurs at the level of the spondylolisthesis faster than at other levels of the spine, increasing the risk of discogenic low back pain.

**Prognosis**: patients with grade 1 or grade 2 slips do well with conservative management. Patients may return to exercise once they are asymptomatic. A flexion-based home exercise protocol is vital. Overall long-term outcome is favourable, when lower grades of spondylolisthesis are not accompanied by neurologic impairment. Higher grades of spondylolisthesis have a variable prognosis with regard to persistent low back pain. Surgical intervention does provide improvement in claudication or radicular symptoms. Discogenic pain may produce more persistent lower lumbar discomfort.

**Transitional vertebrae**

**Definition**: is one that has characteristics and features of vertebrae from adjacent vertebral segments and they occur at the junction between spinal morphological segments.

**Types**:
- atlanto-occipital junction
  - (a) atlanto-occipital assimilation - complete or partial fusion of C1 and the occiput. Image courtesy of Dr Ajush Goel and Assoc Prof Frank Gaillard. Radiopaedia.org. Arrow on the level of fusion.
- (b) occipital vertebra (3rd occipital condyle)- an additional bone or arch between C1 and the occiput. It can form a pseudoarthrosis with the odontoid process or anterior arch of the atlas and can cause problems to the neurosurgeon trying to access the foramen magnum. Image courtesy of A.Goel and F.Gaillard. Radiopaedia.org. See arrows on the reconstructed CT coronal view and axial CT.
The image below, courtesy of R. Singh. Open Access Case Reports, shows the bony arch labelled third occipital condyle (TOC) on the anterior margin of the foramen magnum on the basilar part of the occipital bone on the external surface of the skull. It shows how access is limited to the foramen magnum (FM).

- cervicothoracic junction – a cervical rib arising from C7. Incidence is 1 in 200. A cervical rib represents a persistent ossification of the C7 lateral costal element which typically becomes re-absorbed during development but failure of this process results in an elongated transverse process or complete rib that can be anteriorly fused with the T1 first rib below.

On radiographs, cervical ribs can be distinguished because their transverse processes are directed inferolaterally, whereas those of the adjacent thoracic spine are directed anterolaterally. Clinically these can cause the thoracic outlet syndrome with compression of parts of the brachial plexus or the subclavian artery. In the image, courtesy of Wikipedia, the arrows indicate bilateral cervical ribs.
• thoracolumbar junction – an additional rib can be present arising from the 1st lumbar vertebra – see arrow.

• lumbosacral junction – a lumbosacral transitional vertebra. This is the most common and can be a source of low back pain. The 5th lumbar vertebra may be partially sacralised, often with one transverse process fused with the sacrum – see arrow and the other one free and only a rudimentary disc between them. Or the 1st sacral segment may become partially lumbarized in the same manner creating the appearance of 6 lumbar vertebrae.
**Treatment** – back strengthening exercises can relieve some of the low back pain that can arise from this condition.

**Diastematomyelia**

**Definition:** this rare condition is a vertical division of the spinal cord or cauda equine caused by an osseous or fibrocartilaginous septum which is attached anteriorly to one of the vertebral bodies.

**Site:** usually found in the lumbar region (1\textsuperscript{st} to the 3\textsuperscript{rd} lumbar vertebrae) but can occur in the thoracic and cervical region.

**Clinical:** the patient shows impaired innervation to the lower limbs. There can be an associated meningocoele.

**Imaging:** The MRI below, courtesy of Dr Hani Al Salam. Radiopaedia.org, rID 7568, shows in axial and coronal view what has happened to the cord and cauda equine. K is the kidney.

CT scan is better to demonstrate the bony septum. The white arrow indicates the bony septum/spur and the two black arrows are the two halves of the spinal cord.
Combined myelographic and post-myelographic CT scan is the most effective diagnostic tool in demonstrating the detailed bone, intradural and extradural pathological anatomy of the affected and adjacent spinal canal levels and of the bony spur.

**Diagnosis:** The condition can be diagnosed pre-natal in the early to mid- third trimester using ultrasound. This can also detect whether it is an isolated condition or whether there are any serious neural tube defects.

**Treatment:** Asymptomatic patients do not require surgical treatment. These patients should have regular neurological examinations since it is known that the condition can deteriorate. If any progression is identified, then a resection is performed.

Surgical intervention, first performed in 1983, is warranted in patients who present with new onset neurological signs and symptoms or have a history of progressive neurological manifestations. There is decompression of neural elements and removal of the bony spur. This may be done with or without resection and repair of the duplicated dural sacs but repair of the duplicated dural sacs is preferred since the dural abnormality may partly contribute to the "tethering" process responsible for the symptoms..

**Prognosis:** Variable; good if it presents as a closed defect, and poor if associated with spina bifida.

**Sacral agenesis (Caudal Regressive Syndrome)**

**Definition:** This is a rare condition with several forms, varying from partial absence of the sacral bones to absence of the thoracic and lumbar vertebrae and pelvis. It is associated with a high incidence of neurogenic bladder, as well as vesicoureteral reflux, hydronephrosis and infection.

**Incidence:** 1 per 60,000 live births

**Genetics:** Inherited as a dominant and is very often correlated with a mutation in the Hb9 (also called HlxB9) gene.

**Gender:** both sexes equally affected.

**Pathogenesis:** The condition arises from some factor present during the 3rd week to 7th week of foetal development. Formation of the sacrum/lower back and corresponding nervous system is usually nearing completion by the 4th week of development but the exact aetiology is unknown.

**Types:** MRI imaging allows differentiation of two broad groups

- **group 1:**
  - the conus medullaris is blunt and *ends above the normal level*; there is sometimes an associated dilated central canal or a cerebrospinal fluid–filled cyst at the lower end of the conus
  - these patients have major sacral deformities

- **group 2:**
  - the conus medullaris is elongated and tethered by a thickened filum terminale or intraspinal lipoma and *ends below the normal level*. Neurologic disturbances are more severe in this group

**Clinical:** In patients where only a small part of the spine is absent, there may be no clinical signs.
In severe cases there may be a severe neurologic deficit below the level of the vertebral anomaly and who may have abduction and flexion deformities of the legs, with popliteal webbing so the legs cannot be straightened. The legs may be fused together (sirenomelia -mermaid syndrome) and there can be inadequate bowel and bladder control. There may also be dislocation of the hips. Associated anomalies include renal agenesis, congenital heart defects, imperforate anus, cleft lip or palate and microcephaly.

There is no cognitive impairment associated with this disability.

**Imaging:** Ultrasound can diagnose the condition at 22 weeks gestation. Plain radiograph will confirm the situation postnatal – see below courtesy of Dr Paresh K Desai. Radiopaedia.org, rID 10791.

![Radiograph](image)

**Treatment:** a permanent colostomy may be necessary if there is also imperforate anus. Incontinence may require the survivor to self-catheterize. If the legs are unable to be straightened, popliteal release may be done surgically or even amputation of the legs at the level of the hip or knee. Children more mildly affected may have normal gait and no need for assistive devices for walking. Others may walk with bracing or crutches.

**Prognosis:**

Adults with this disability live independently, attend university, and have careers in various fields.

**ACQUIRED**

**Schmorl’s Nodes**

**Definition:** are herniations of the nucleus pulposus of an intervertebral disc into the vertebral body at the site where blood vessels penetrate the cartilaginous vertebral body end-plates and where defects in chondrification have occurred which will persist throughout life. The protrusions may occur due to a defect in the vertebral body end-plate itself or to an abnormality in the underlying subchondral bone.
Sites: most common between the 7th thoracic and first lumbar vertebrae.

Incidence: found in 75% of autopsies.

Age: all ages

Gender: more frequent in males.

Clinical presentation: usually asymptomatic except when there is an acute Schmorl’s node which is associated with inflammation and symptoms.

An asymptomatic Schmorl’s node may be traceable to a specific occurrence of acute non-radiating low back pain in the patient’s history in which an acute Schmorl’s node or simple endplate fracture occurred.

Pathology: 66% involve the middle third of the vertebral body. Schmorl’s nodes may be seen in osteoporosis, osteomalacia, Paget’s disease, hyperparathyroidism, infection, neoplasm, degenerative disc disease and juvenile kyphosis (Scheuermann’s disease). In the 3rd decade of life the discs become avascular and the central nucleus pulposus is gradually replaced by fibrous tissue.

Etiology: believed probably associated with vertebral development in early life, the nucleus pulposus pressing on the weakest part of the end plate in addition to various strains on the vertebrae and the intervertebral disc along the spine during spinal movements, especially torsional movements.

Imaging: Plain films may show the abnormality and at several levels. One sees a small nodular lucent lesion of either the inferior or superior end plate, surrounded by a sclerotic margin. CT scan with sagittal reconstruction gives better imaging. See image below, courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID 4638. Arrow indicates the site of protrusion of nucleus pulposus into the vertebral body.

The confirmation of a site is shown on the lumbar discogram shown below, where contrast leaks from the nucleus into the area of the vertebral body. Courtesy of Dr Jeremy Jones. Radiopaedia.org, rID 35827. The disc below that shows contrast confined normally within the nucleus pulposus.
MRI has a particular role in demonstrating whether a Schmorl’s node is acute or long standing. One can see bone marrow oedema and peripheral enhancement in the acute node.

In the image below, courtesy of Dr Chris O’Donnell. Radiopaedia.org, rID26869, the short arrow indicates the site of the protrusion and the long arrow points to the high signal of marrow oedema.

**Treatment:** most cases are asymptomatic and chance findings. If back pain is a problem, oral analgesics are prescribed. If the pain is very severe, surgeons can perform an interbody fusion.
Degenerative

Disc protrusion and herniation

Definition:
Disc protrusion is a focal or diffuse protrusion of the disc with an intact annulus fibrosus. Disc herniation is a focal bulging of the disc due to the extrusion of the nucleus pulposus through a tear in the annulus fibrosis. When the tear is posteriorly, the nuclear fragments bulge into the spinal canal or in the neural foramen, compressing the thecal sac or nerve roots.

Sites: 95% occur at the L4-L5 or the L5-S1 level.

Incidence: 55% of adults have disc bulging. There is lifetime incidence of 2% for symptomatic disc herniation.

Peak age: commonest onset is between 30 years and 50 years. Unusual < 20 years or > 60 years. Far lateral disc herniations occur in the older age group (average age 65).

Gender: males and females equal but women present about 10 years later than men.

Pathogenesis: The nucleus pulposus presses against the annulus, causing the disc to bulge outward. With further progression, the nucleus herniates completely through a break in the annulus and squeezes out of the disc, placing pressure on the spinal canal or nerve roots. In addition, the nucleus releases chemicals that can irritate the surrounding nerves causing inflammation and pain.

Clinical features:
When the protrusion or herniation is in an anterior direction in the lumbar region, it may be a cause of low back pain. General symptoms of posterior lumbar disc protrusion/herniation include one or more, of the following: (1) typical sciatica symptoms such as numbness, weakness, and/or tingling in the leg and/or foot, leg and/or foot pain, lower back pain, and/or pain in the buttock; and (2) loss of bladder or bowel control, indicating onset of the cauda equina syndrome.

80% of general population will experience back pain but only 2-3% will have sciatica. MRI scans show that between 20% and 35% of working age adults have asymptomatic disc herniation.

Pain is initially in the low back and the patient is flexed anteriorly or laterally to decrease the pain. Pain is eased in the supine position, aggravated by standing or sitting position. Pain is increased by coughing, sneezing or bowel movements. The patient may have decreased sensation in the L5-S1 territory. Positive straight leg-raising test reproduces the patient’s pain on the same side but sometimes on the contralateral side.

Risk factors: Abnormal activities, such as repetitive bending, twisting, and lifting, can increase abnormal pressure on the nucleus of the disc and injure the annulus, leading to herniation. Lumbar disc herniation occurs as a result of sudden stress, such as from an accident. Poor posture and obesity can place additional stress on the lumbar spine. With aging, discs gradually dry out, lose their strength and resiliency, and easily induce the occurrence of herniation because the annulus may crack allowing nucleus material to squeeze through.
Imaging: herniation can be classified as: **Central** - this can affect the traversing nerve roots bilaterally. If large enough it can cause the cauda equina syndrome. The CT image below, courtesy of Assoc Prof F Gaillard, Radiopaedia.org, rID 6104 shows the arrow pointing to part of the disc which is bulging centrally, with no nerve root compression.

Posterolateral – this is the commonest type, with the herniation passing to one side of the posterior longitudinal ligament. Impingement occurs on the nerve root of the lower vertebra. The diagram is courtesy of Dr Matt Skalski. Radiopaedia.org, rID 32040. The MRI is courtesy of Dr Bruno Di Muzio. Radiopaedia.org, rID 32036 and the long arrow is indicating the posterolateral disc protrusion which has impinged on the nerve root emerging from the dural sac – small arrow.

Foraminal – impingement of exiting nerve root belonging to the vertebra above.

Extraforaminal or far lateral.
Other types: diagrams courtesy of Dr Matt Skalski, Radiopaedia.org, rID 32040

With the disc sequestration, the free fragment may impinge upon the nerve root of the vertebral level above the disc as it passes out through the neural foramen and also on the root of the nerve at the same level as itself, as the latter exits from the dural sac.

Treatment and Prognosis: quoted from F Postacchini, Spine 1996 June 1; 21(11):1383-7. Results of surgery compared with conservative management for lumbar disc herniation.

- 60% recover in 1 week
- 90% 1 month
- 95% recovery in 3 months with low back pain
- 75% recovery in 3 months with sciatica

- Operation versus non-operation
  - results equal at 4 years
  - almost equal at 1 year
  - due to prevalence of back pain
  - nonoperative treatment best usually

- There is favorable response to nonoperative treatment, even in the presence of neurological deficit
- Thus, isolated neurological deficit without function impairing pain doesn’t warrant surgical intervention
- Several studies have shown that most herniated discs reabsorb with time, particularly large and herniated or extruded discs
- Conservative measures should be trialled for 6 weeks before surgery
- For patients with persistent pain and neurologic compromise unresponsive to conservative measures surgery should not be delayed beyond 6 months because of risk of chronic disability

Complications: long term degenerative changes occurring in the facet joints may cause recurrence of low back pain.
Facet Joint Degeneration

Spondylosis of the Facet joints (apophyseal joints) occurs when musculoligamentous laxity is followed by degenerative disc disease which increases the mechanical constraints acting on them. Cervical and especially lumbar lordosis move the axial loading of the intervertebral disc toward the neural arch. Spondylosis causes various painful syndromes that can be mistaken for disc protrusion compressing nerves. This is because there is a rich sensory innervation of these articulations which are innervated by sensory divisions of the posterior branches of two adjacent radicular nerves.

Pathological changes:

- Osteophytes in 60%
- Narrowing of the joint space – 50%
- Facet hypertrophy leading to subluxations and articular instability
- Subchondral sclerosis – 30%
- Bony erosions of articular surfaces – 10% - leading to a scalloped appearance of the joints with a pseudo-arthritic appearance.

Imaging: CT scan is the best modality to define the bone detail of the facet joints. In the image below, from a post-myelogram CT scan, the structures are named.

Degenerative spondylolisthesis is a disease of the older adult that develops as a result of facet arthritis and joint remodeling. Joint arthritis, and ligamentum flavum weakness, may result in slippage of a vertebra. Degenerative forms are more likely to occur in women and persons older than fifty. These patients present with less prominent physical findings. Pain often is provoked with lumbar spine extension. If lumbar stenosis is present, reflexes may be diminished and radicular changes present.

Synovial Cyst

Definition: is a smooth, well circumscribed extradural cystic mass arising adjacent to a degenerated facet joint.

Site: 85% involve the L4-L5 level. The cysts predominate in areas of greatest spinal mobility. It is always associated with spondylosis of the facet joints.
Macroscopic pathology: it is a true cyst and communicates with the facet joint. It has a fibrous capsule lined by synovium and contains a clear or xanthochromic serous fluid as there may be episodes of haemorrhage.

Clinical features:

- Symptoms and signs vary depending upon the size and location of the cyst.
- Usually causes intermittent lumbar pain with or without radiculopathy.
- Sciatic neuralgia occurs by compression of the nerve root in the lateral recess.
- Rarely can cause a cauda equine syndrome.
- Sudden exacerbation of pain will occur if haemorrhage occurs in the cyst.

Imaging: On CT scan the cyst varies in appearance depending upon its fluid content. Following the injection of intravenous contrast, the capsule often enhances – see arrow below.

MRI – courtesy of Dr Roberto Schubert. Radiopaedia.org, rID 14352 – long arrow points to the cyst and the short arrows indicate the facet joints.
Treatment and prognosis

The patient is positioned prone, followed by CT guided access into the inferior articular recess using a spinal needle. Once an intra-articular location is confirmed with contrast, and communication with the synovial cyst is demonstrated, rupture of the cyst is attempted using a steroid and anaesthetic mixture.

As part of a laminectomy for disc protrusion, an associated synovial cyst may be removed at the same time.

Malignant conditions of the vertebral column.

Primary tumours such as Haemangioma, myeloma and lymphoma are described in the Bone Tumour module.

Secondary tumours - Metastases:

Definition: Metastasis is the transference of malignant cells to other parts of the body by way of the blood or lymphatic vessels or membranous surfaces.

Sites: although the lung and the liver are the most common sites for metastasis, the spine is the third most common.

Incidence: 30% of patients with systemic cancer have spinal metastases.

Age: most common in the 40 – 65 years age group.

Gender: more common in men than in women.

Pathogenesis: Spread from primary tumours elsewhere to the spine is mainly by the arterial route. Retrograde spread through the Batson plexus during Valsalva manoeuver is postulated. Direct invasion through the intervertebral foramina can also occur. Besides the mass effect, an epidural mass can cause cord distortion, resulting in demyelination. Venous congestion and vasogenic oedema of the spinal cord results in venous infarction and haemorrhage.

70% of symptomatic lesions are found in the thoracic region of the spine, (especially at the level of T4-T7), 20% in the lumbar region and 10% in the cervical spine. More than 50% of patients with spinal metastasis have several levels of involvement. About 40% of patients have involvement of several non-contiguous segments.

Intradural extramedullary and intramedullary seeding of systemic cancer is unusual. These sites account for 5% and 1% of spinal metastases, respectively. Isolated epidural involvement accounts for less than 10% of cases; it is particularly common in lymphoma and renal cell carcinoma.

Primary sources of spinal metastatic disease include the following: Lung - 31%, Breast - 24%, GI tract - 9%, Prostate - 8%, Lymphoma - 6%, Melanoma - 4%, Kidney - 1%, Others including multiple myeloma - 13%, Unknown site of primary - 2%.

Clinical features: 90% of symptomatic patients complain of bone and/or back pain, followed by radicular pain. 50% have a neurological deficit, with half being motor or sensory loss and half having
bowel and bladder dysfunction. 5-10% of patients with cancer present with cord compression as their initial symptom: 50% are non-ambulatory at diagnosis, and 15% are paraplegic

**Imaging:** Plain radiography and CT of the entire spine are performed, followed by MRI with and without intravenous contrast enhancement to delineate a specific site.

Plain radiography – most metastases are osteolytic so the plain radiograph is used to show erosion of the pedicles or the vertebral body which is characteristic of metastatic disease and is found in 90% of symptomatic patients when bone destruction reaches 30-50%.

60% of cases are localized at the anterior portion of the vertebral body. In 30% of cases, the lesion infiltrates the pedicle or lamina. A few patients have disease in both posterior and anterior parts of the spine. There may be a surrounding soft tissue mass.

In the CT image -left, there is a sarcoma metastasis in the left side of the sacrum which has extended into the buttock – arrow on perimeter of the buttock extension and shown on MRI – right image. Further metastases are shown in the right lower lobe of the lung on a chest radiograph – see below.

The left MRI image below, courtesy of Dr Brendon Friesen, Radiopaedia.org, rID :29318 shows metastases in L3 and T11 from a renal cell carcinoma with compression of the cauda equine – see arrow.

The right image, courtesy of Dr Ashutosh Gandhi, Radiopaedia.org, rID: 19758, shows multiple metastases in T1, T5, T6 and T7- straight arrow plus intradural, extramedullary metastases at T5- T6 – see block arrow.
Osteoblastic changes are common in prostate cancer (90%) and Hodgkin disease; they are occasionally seen in metastases from breast cancer (10%), lymphoma, small cell carcinoma of the lung, transitional cell carcinoma of the renal tract and gastrointestinal carcinomas (stomach, colon and pancreas) and carcinoid tumours. These may occur as rounded sclerotic densities or as a diffuse sclerosis involving an entire vertebral body or multiple bones. The density within the lesion is fairly uniform, amorphous and homogeneous similar to cortical bone. The normal trabecular architecture is lost. The condition that may resemble this type of metastasis is Paget’s disease of bone but there the cortex is thickened and the overall width of the bone is increased with coarsening of the trabecular pattern whereas with metastases the width of the cortex and size of the bone is normal.

CT scanning is useful when surgery is anticipated. CT myelography is used if MRI is not available which permits examination of paraspinal soft tissues and paraspinal lymph nodes, as well as sampling the CSF. CSF sampling is best deferred if evidence of near-complete or complete spinal block is noted when measuring the opening pressure of the lumbar puncture. The risk of neurologic deterioration after myelography is about 14% but is less with C1-2 puncture.

MRI is the imaging modality of choice using the sagittal scout image for rapid screening of the entire spinal axis and its surrounding soft tissues. Contrast-enhanced fat-suppressed images help to differentiate metastasis from degenerative bone marrow. Diffusion-weighted images distinguish metastasis from osteoporotic bone. Osteoporotic fractures are hypo-intense, and metastases are hyper-intense.

Nucleotide scans: these are positive in 60% of patients and will show metastases before these are visible on plain radiographs. The advantage is that this technique can scan the entire axial and appendicular skeleton and thus assess the true involvement of bone by cancer. PET-CT is very useful to stage systemic disease and can guide the extent of useful surgery to the spine.
**Treatment:** No treatment has been proven to increase the life expectancy of patients with spinal metastasis. The goal of management is pain control and functional preservation. The ability to ambulate at the time of presentation is a favorable prognostic sign. Loss of sphincter control is a poor prognostic feature and mostly irreversible. Other problems include pain of pathologic fractures and hypercalcemia. *Hormonal manipulation*, such as tamoxifen to treat breast cancer, preserves bone mineralization because of its estrogen-agonistic effect.

Both steroids and nonsteroidal anti-inflammatory drugs (NSAIDs) are commonly used to manage bone pain. Use of spinal orthotics and physiotherapy are also useful. 80% of patients have symptoms improve within 48 hours of treatment with dexamethasone.

*Gabapentin* is frequently used to treat neuropathic pain and is well tolerated.

*Radiation therapy* is also effective in treating pain caused by bone metastasis.

*Hypercalcemia* is common in patients with osteolytic metastasis, and it is also found in those with paraneoplastic syndrome that produces parathyroid hormone–related protein. Patients with hypercalcemia commonly present with polyuria, and some, with pre-renal failure. Initial treatment is rehydration and administration of a steroid. *Bisphosphonate* is useful to control the osteolytic process. It inhibits osteoclast function, decreasing bone resorption.

**Surgery:** early radical resection of a single lesion in the spine is being used recently with adjuvant stereotactic radiation therapy to eradicate the disease. This approach allows for decompression, stabilization, and suppression of local recurrence.

**Prognosis:** Factors associated with better prognosis with survival of more than 3 months and improved quality of life include location of the primary tumor, extent of visceral metastases, and systemic chemotherapy adverse effects. Median survival is 10 months. However, paralysis and/or bowel and bladder involvement compromises the quality of life of patients with cancer and puts an additional burden on their caregivers. Cord compression is normally seen as a pre-terminal event with median survival at that stage being about 3 months.

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