Clinical update: The spine – Part A

ANATOMY

**Spinal (vertebral) column** – The spinal column is formed by the vertebra and is comprised of various levels:

- cervical (7)
- thoracic (12)
- lumbar (5)
- sacral (5)
- coccygeal (4)

The five sacral vertebrae are fused to form the sacrum, and the four coccygeal vertebrae form the coccyx. The spinal column encloses the spinal cord and meninges.

![Figure 1 – the spinal column](image)

**Spinal canal** – The spinal canal is a narrow, fluid-filled space in the spinal column.

**Spinal cord** – The spinal cord extends from the foramen magnum (within the skull) to the upper part of the lumbar region. There is no spinal cord beyond the first lumbar vertebra.

**Spinal nerve roots** – There are 31 pairs of spinal nerves. They emerge as paired nerve roots from the anterior and posterior spinal cord. Each nerve is then formed by the union of the paired roots.

**Intervertebral discs** – The intervertebral disc is a circular piece of cushioning tissue between each of the vertebrae. Their function is mechanical, allowing movement between the axial and appendicular skeleton and the head. They also assist weight bearing and help protect the spinal cord and nerve roots. Each intervertebral disc is known as a level. There is one disc (level) between two vertebrae.
Level – Certain spinal procedures require the specification of the level at which the procedure is being performed. The level of the vertebra is the numbered vertebra, e.g. L4 is the fourth lumbar vertebra. The term level in relation to spinal surgery refers to the number of levels operated on. Documentation of ‘L4/5’ means the disc is between L4 and L5 (i.e. one vertebral interspace or one disc level). For example, T1/T2 = one level, T1/T4 = three levels.

Spinal foramen – Foramen means opening. Its use in relation to the spine applies to any opening allowing passage of the spinal nerves from the vertebral canal.

Pedicles – The pedicle is a stub of bone that connects the lamina to the vertebral body to form the vertebral arch.

Vertebral lamina – The vertebral lamina is part of the vertebra at the back portion of the vertebral arch that forms the roof of the canal through which the spinal cord and nerve roots pass.

Vertebral arch – The vertebral arch is a circle of bone around the canal through which the spinal cord passes. It is composed of a floor at the back of the vertebra, walls (the pedicles), and a ceiling where two laminae join.

DISEASES/CONDITIONS OF THE SPINE

Cord compression – Compression of the cord occurs where disease or injury creates pressure against the spinal cord. Compression may be caused by different types of lesions that result in segmental sensory, motor, reflex and sphincter deficits. Compression is more commonly caused by lesions outside the spinal cord (extramedullary) than by lesions within it (intramedullary). Lesions that compress the spinal cord may also compress the nerve roots (see Radiculopathy).

Disc herniation – Disc herniation, or prolapse, occurs when the outer case of the disc splits resulting in the gel inside bulging out of the disc. This bulging may cause pain by pressing on the spinal cord or nerve root.

Dislocation – A dislocation of the spine occurs when the vertebrae are misaligned. A subluxation is a partial dislocation. Vertebral dislocations are usually due to trauma and typically involve the facets.

Fracture, compression – In compression fractures, the vertebrae collapses. Compression fractures can be the result of either pathological processes or trauma.
Fracture, pathological – Pathological fractures occur where the bone has been weakened by disease such as with osteoporosis or malignancy. They are common in the thoracic spine (usually below T6) and lumbar spine and may occur with no preceding or only minimal trauma (eg, a minor fall, sudden bending, lifting, coughing).

Fracture, traumatic – Traumatic fractures occur as a result of injury and may involve the vertebral body, lamina and pedicles as well as the spinous, articular, and transverse processes.

Myelopathy – Diseases or disorders of the spinal cord are referred to as myelopathy. Where this includes disc disorders which impact on the spinal cord, it may result in cord compression.

Osteoporosis – Osteoporosis is a progressive metabolic bone disease that decreases bone density, with deterioration of bone structure. Bone weakness leads to fractures with minor or inapparent trauma, particularly in the thoracic and lumbar spine, wrist, and hip.

Radiculopathy – Radiculopathy is any disease or disorder impacting on the spinal nerve roots. It is frequently due to compression caused by stenosis or herniation.

Spinal cord injury – Injury to the spinal cord occurs when the spinal cord is penetrated or when damage to the vertebrae, ligaments, or discs of the spinal column results in bruising, crushing or tearing of spinal cord tissue. Frequent causes of damage are trauma (car accident, falls, diving etc) or disease (polio, spina bifida, Friedreich’s Ataxia etc).

Spinal stenosis – Spinal stenosis is narrowing of the spinal canal and may be congenital or acquired. Stenosis may result in compression of the cord or nerve roots, causing back pain. The most common causes of acquired stenosis are osteoarthritis, degenerative disc disorders, spondylosis, and spondylolisthesis with compression of the cauda equina.
**Figure 7 – Spinal stenosis**

**Spondylosis** – Spondylosis is a descriptive term that refers to degeneration (wear and tear) of the vertebrae. Clinically, spondylosis usually occurs with nerve root compression/radiculopathy (see **Radiculopathy**) or myelopathy (see **Myelopathy**).

**Spondylolisthesis** – Spondylolisthesis is the forward slipping of one vertebra over another. When this occurs, the nerves may become compressed in the canal, causing pain.

**EFFECTS OF SPINAL CORD INJURY**

Nerves run from the spinal column to specific areas of the body. By noting where a person has weakness, paralysis, or other loss of function (and therefore nerve damage), a neurologist can determine where the spinal column is damaged. The Merck Manual details the effects of spinal injury:

<table>
<thead>
<tr>
<th>Level of Injury</th>
<th>Effect*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between C2 and C5</td>
<td>Paralysis of some or all muscles used for breathing and all arm and leg muscles. Typically, fatal unless a ventilator is used.</td>
</tr>
<tr>
<td>Between C5 to C6</td>
<td>Paralysis of legs, trunk, hand and wrist. Weakness of the muscles that move the shoulder and elbow.</td>
</tr>
<tr>
<td>Between C6 to C7</td>
<td>Paralysis of legs, trunk and part of the wrists and hands. Normal movement of the shoulders and elbows.</td>
</tr>
<tr>
<td>Between C7 and C8</td>
<td>Paralysis of legs, trunk and hands.</td>
</tr>
<tr>
<td>C8 to T1</td>
<td>Paralysis of the legs and trunk. Weakness of the muscles that move fingers and hands. Horner syndrome (with a drooping eyelid, a constricted pupil, and reduced sweating on one side of the face). Possibly normal movement of the shoulders and elbows.</td>
</tr>
<tr>
<td>T2 to T4</td>
<td>Paralysis of the legs and trunk. Loss of sensation below the nipples. Normal movement of the shoulders and elbows.</td>
</tr>
<tr>
<td>T5 to T8</td>
<td>Paralysis of the legs and lower trunk. Loss of sensation below the rib cage.</td>
</tr>
<tr>
<td>T9 to T11</td>
<td>Paralysis of the legs. Loss of sensation below the navel.</td>
</tr>
<tr>
<td>T11 to L1</td>
<td>Paralysis of and loss of sensation in the hips and legs.</td>
</tr>
<tr>
<td>L2 to S2</td>
<td>Various patterns of leg weakness and numbness, depending on the precise level of injury.</td>
</tr>
<tr>
<td>S3 to S5</td>
<td>Numbness in the perineum.</td>
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</tbody>
</table>

* Loss of bladder and bowel control can occur with severe injury anywhere along the spinal column.
References:

Campagne, D 2014, Verteb...
Clinical update: The spine – Part B

SPINAL FUSION AND INTERNAL FIXATION

The spinal fusion surgical procedure is designed to abolish motion between the vertebrae. It is believed that elimination of motion will relieve pain caused by conditions such as degenerative disc disease, prolapsed intervertebral disc, spondylolisthesis, spinal stenosis and a weak or unstable spine from fractures or tumours. Spinal fusion is also performed to correct scoliosis, to prevent the progression of scoliosis and to stabilise the spine particularly in neuromuscular disorders.

Spinal fusion involves joining or fusing two or more vertebra together in order to stabilise the spine. Bone graft is packed between the vertebrae to promote growth of new bone and over time fuses bone together.

<table>
<thead>
<tr>
<th>Bone graft type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autograft</td>
<td>Bone from patient’s body, e.g. harvested from iliac crest, spine or ribs during fusion surgery</td>
</tr>
<tr>
<td>Allograft</td>
<td>Donor bone, e.g. from bone bank</td>
</tr>
<tr>
<td>Bone graft substitutes/stimulators</td>
<td>Man-made or manipulated natural bone, e.g.</td>
</tr>
<tr>
<td></td>
<td>• Bone morphogenetic protein (BMP), e.g. ‘Infuse’</td>
</tr>
<tr>
<td></td>
<td>• Ceramic-based Bone Graft Extenders</td>
</tr>
<tr>
<td></td>
<td>• Demineralized Bone Matrix (DBM)</td>
</tr>
<tr>
<td></td>
<td>• Autologous growth factor (AGF)</td>
</tr>
</tbody>
</table>

A combination of bone graft types may be used in the one procedure, e.g. iliac crest bone (autograft), allograft and Infuse (bone graft substitute).

Common spinal fusion procedures are:

- Anterior cervical discectomy and fusion (ACDF)
- Anterior lumbar interbody fusion (ALIF)
- Posterior lumbar interbody fusion (PLIF)
- Transforaminal lumbar interbody fusion (TLIF)
- Direct lateral interbody fusion (DLIF)
- Extreme lateral interbody fusion (ELIF or XLIF)
-Posterolateral fusion (PLF)

Access is anterior (front of body), posterior or posterolateral (rear of body, requiring a laminectomy or foramenotomy to access the interbody space), transforaminal (posterior access but through the side of the foramen) or lateral/extreme lateral (side of body).

Fusion may be performed on the cervical, thoracic, lumbar (most common) or lumbosacral spine.

In an interbody fusion, bone graft is placed between the vertebrae where the intervertebral disc would normally be. Bone graft may be placed in an interbody cage, which is a porous cylinder that allows bone to grow through and into the next vertebral body; interbody cages are made of titanium alloy, carbon fibre, PEEK (polyetheretherketone) polymer or allograft bone.
In a posterolateral fusion, the bone graft is placed between the transverse processes of the vertebrae.

Advances in surgical techniques, instruments and monitoring mean that many spinal fusion procedures are able to be performed using minimally invasive techniques.

Spinal fusion may be performed with or without internal fixation/instrumentation but most procedures involve instrumentation to provide immediate stabilisation and maintain alignment of the spine whilst the bone graft fuses.

**Spinal internal fixation/instrumentation** includes the use of implants such as:

- Screws
  - Pedicle screws are placed through the pedicle bone and into the vertebral body
  - Provide anchor points for attachment of rods
- Hooks
  - Alternative to screws
- Rods
  - Used to bridge a length of spine
  - Connect to screws/hooks
  - Nonsegmental fixation is attached at the top and bottom of the fusion area only
    - Harrington rods designed for scoliosis surgery are an example of nonsegmental fixation but are largely superseded now
  - Segmental fixation is attached at multiple levels of the fusion area
    - More common than nonsegmental
    - CD (Cotrel-Dubousset) instrumentation used in scoliosis surgery is an example of segmental fixation
- Plates
  - May be used instead of rods to connect to screws/hooks
  - May be used to span short segments of the spine

Spinal internal fixation/instrumentation may be used without spinal fusion, for example, for stabilisation of traumatic or neoplastic (metastatic) bone fractures.
Back Surgery - L4-5 and L5-S1 Laminectomy, Discectomy and Spinal Fusion

Documentation examples

The examples below demonstrate the type of documentation seen in spinal surgery and are for information only.

Example 1:

**Diagnosis**
Right C5 radiculopathy

**Operation**
C4/5 ACDF with plate
8mm Synthes cervios cage used with TCP substitute with Vectra plate and 4x16mm self-drilling screws

**Operative note**

With the patient under GA, lying supine with his neck extended to improve access, the anterior cervical region was prepared with alcoholic iodine. A skin incision was made to the anterior cervical region. A skin incision was made to the anterior cervical region. A skin incision was made to the anterior cervical region. The image intensifier was used to confirm the C4/C5 level. The anterior 2/3 of the disc space was cleared of soft tissue and degenerate disc material. The anteroinferior edge of the C4 vertebral body was nibbled away and the dense sub-endplate bone was drilled to harvest bone for later use in the interbody cage. The posterior 1/3 of the disc space was then cleared with the high speed drill and punch rongeurs so that the spinal canal and both root canals could be identified and decompressed. Particular attention was paid to decompression of the right C5 root by removal of the posterolateral osteophytes out beyond the pedicle. Haemostasis was assured, then a large 8mm Synthes cage was hammered into the disc space. The wound was then closed in layers. Dressings.
Example 2:

**Diagnosis**
Lumbar spine L4-5-S1 foraminal stenosis

**Operation**

*Procedure*
Lumbar spine L4-5 posterior fusion, L5-S1 PLIF + decompression

*Operative note*

GA / prone / IV ABx
Posterior midline incision
Erector spinae retracted

Foramin + transverse processes identified

<table>
<thead>
<tr>
<th>Item</th>
<th>L</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x sacrum screw 7.5 x 35 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II level check</td>
<td>L4</td>
<td>6.5x45</td>
</tr>
<tr>
<td>5 screws</td>
<td>L5</td>
<td>6.5x45</td>
</tr>
<tr>
<td>60mm rods</td>
<td>S1</td>
<td>7.5x35</td>
</tr>
</tbody>
</table>

Distracted, tightened
L5/S1 disc approached from right
Discectomy/decortication
Interbody fusion with graft/cage
Decompression L4-5-S1
Posterolateral autologous bone graft
Vancomycin powder

II

1 – V  2 – OV  3 – OM  Primipore

Example 3:

**Diagnosis**
Pathological # L3 secondary to bone metastases; compression of spinal nerve roots

**Operation**

*Procedure*
Lumbar decompression, rhizolysis, screw and rod fixation

*Operative procedure*
Under fluoroscopic guidance, pedicle screw placements performed at the L2 and L4 levels. At the L2 level, I placed 2 x 4.5 x 45mm pedicle screws. Similar placements were performed at the L4 level. A decompressive laminectomy was performed from L2 to L4 and decompression of the lateral recess. The spinal nerve roots at this level were rhizolysed. Two parallel lordotic rods (8cm) were then secured onto the polyaxial pedicle screw heads and a 50mm cross link attached at the level of L3 vertebral body.
INTERVERTEBRAL DISC PROSTHESIS

Intervertebral disc prosthesis or artificial disc replacement is an alternative to spinal fusion to treat severe disc degeneration. The procedure is also known as total disc replacement. The intervertebral disc is surgically removed and the prosthesis inserted in its place. The intervertebral disc prosthesis consists of endplates and a core. The endplates are anchored into the vertebral bodies above and below the disc space and the core sits between the endplates. The core is designed like the original disc, that is, to allow natural motion or movement of the spine and to keep the normal space between vertebrae.

Prosthetic disc nucleus (PDN) replacement or partial disc replacement is an alternative procedure. Only the inner (‘jelly’) nucleus of the disc is replaced; the annulus (outside of the disc) is retained.

C5-6, C6-7 Anterior Cervical Decompression and Total Disc Replacement

HALO

A halo provides immobilisation of the cervical spine, usually after trauma or spinal surgery.

The device consists of a metal ring which is fixed to the skull with metal or titanium pins under local anaesthetic. Adjustable stabilisation bars connect the ring to a vest worn around the patient’s chest. The device is able to provide immobilisation of the head and neck as the skull is ‘locked down’ to the solid thoracic spine, which is a relatively immobile segment of the body.

The halo device is generally required to be worn for three months. Over this time, frequent checks of the correct position and tightness of the device are required.
Cervical Spine Fractures with Application of Halo Fixation

A. Four cranial pins are drilled directly into the skull.

B. A halo apparatus is attached to the cranial pins.

C. Four rods are used to secure the halo fixator to a vest unit to completely immobilize the head and neck.

References


