Anatomy

The spine is a very complex mechanical structure that is highly flexible yet very strong and stable. In the normal spine, regardless of your position or activity, including sleeping, there is always some type of physical demand being placed on it.

The primary functions of the spine include:

• Protecting the spinal cord, nerve roots, and internal organs
• Providing flexibility of motion
• Providing structural support and balance for upright posture. The spine bears the load of the head, shoulders and arms, and upper body. The upper body weight is then distributed to the hips and legs. The spine attempts to keep the body’s weight balanced evenly over the pelvis. This reduces the amount of work required by the spinal muscles and can eliminate muscle fatigue and back pain.

The normal adult spine is balanced over the pelvis, requiring minimal workload on the muscles to maintain and upright posture. Loss of spinal balance can result in strain to the spinal muscles and deformity of the spine as it attempts to maintain an upright posture.
Regions of the Spine

There are 33 vertebrae in the spine. The illustration is a lateral (side) view of a normal spine and it shows the locations of the five major spinal levels.

- The cervical region has seven vertebrae (C1 through C7).
- The thoracic region has 12 vertebrae (T1 through T12).
- The lumbar region has five vertebrae (L1 through L5).
- The sacral region consists of five vertebrae all fused together to form one continuous bone mass known as the sacrum.
- The coccygeal region consists of four vertebrae, all fused together to form the coccyx or tailbone.
Vertebrae

Although the vertebrae have slightly different appearances as they range from the cervical spine to the lumbar spine, they all have the same basic structures, and the structures have the same names. Only the first and second cervical vertebrae are structurally different in order to support the skull.

Each vertebra has an anterior arch and a posterior arch, which form a hole called a foramen. The spinal cord passes through the foramen of each vertebra.

The anterior arch is called the vertebral body. Discs connect one vertebral body to another to allow motion of the spine and cushion it against heavy loads. Together, the vertebral bodies and discs bear about 80 percent of the load to the spine.

The posterior arch consists of the pedicles, laminae, and processes.
The pedicles are two short cylinders of bone that extend from the vertebral body. Nerve roots branch off the spinal cord and exit to the body between the pedicles of two vertebrae. If the spine becomes unstable, the pedicles may compress the nerve root and cause pain or numbness.

Laminae are two flattened plates of bone that form the walls of the posterior arch. Over time, the laminae may thicken, a process called stenosis. This thickening compresses the spinal cord and/or nerves causing pain or numbness.

The articular, transverse, and spinous processes project off the laminae. Ligaments and tendons attach to the processes. The articular processes join one vertebra to another posteriorly.

The transverse processes extend out on either side of the laminae. The spinous process is the bony projection that can be felt through the back of someone’s skin.

Detailed views of a vertebra and vertebral segment. The drawing to the left represents a top view of a lumbar vertebra. The drawing to the right is a lateral (side) view of a segment of three lumbar vertebrae.
Curves of the Spine

When viewed from the front or back, the normal spine is in a straight line, with each vertebra sitting directly on top of the other. A side-to-side curve in the spine is called scoliosis.

When viewed from the side, the normal spine has three gradual curves:

- The neck has a lordotic curve; it curves towards the front.
- The thoracic spine has a kyphotic curve; it curves towards the back.
- The lumbar spine also has a lordotic curve.

These curves help the spine to support the load of the head and upper body, and maintain balance in the upright position.

Scoliosis: An abnormal spinal condition called scoliosis is shown in this drawing. Scoliosis is a lateral (sideways) curvature of the spine.

Spondylolisthesis: Spondylolisthesis is an abnormal spinal condition in which one vertebra slips or is displaced over another vertebra. The drawing shows spondylolisthesis as a result of a lumbar vertebra (L5) slipping over the sacrum (S1).
Abnormal Anatomy:

**Kyphosis**: This drawing depicts the spinal condition of kyphosis. Kyphosis is an abnormal increase in normal kyphotic (posterior) curvature of the thoracic spine which can result in a noticeable round back deformity.

**Lordosis**: This drawing represents the spinal condition of lordosis. Lordosis is the abnormal increase in normal lordotic (anterior) curvature of the lumbar spine. This can lead to a noticeable “sway-back” appearance.
Abnormal Anatomy: Arthritis

This drawing illustrates degenerative and hypertrophic arthritis between the third, fourth, and fifth lumbar vertebrae, as well as the lumbosacral joint (L5–S1 disc space). The degeneration of the intervertebral discs has reduced the height of the discs.

There are bone spurs or hypertrophic bone adjacent to the discs and hypertrophic arthritis of the facet joints. This results in reduced range of motion of the spine. Also, the hypertrophic bone and narrowing of the intervertebral foramen can produce nerve root impingement thereby causing back and leg pain, as well as numbness and weakness of leg muscles.
Intervertebral Discs

Intervertebral discs are located between each vertebra from C2 – C3 to L5 – S1. Combined, they make up one fourth the height of the spinal column. The discs act as shock absorbers to the loads placed on the spine and allow movement of the spine. Movement at a single disc level is limited, but all of the vertebrae and discs combined allow for a significant range of motion.

The intervertebral disc is made up of two components: the annulus fibrosus and the nucleus pulposus. The annulus fibrosus is the outer portion of the disc. It is composed of layers of collagen and proteins, called lamellae. The fibers of the lamellae slant at 30-degree angles, and the fibers of each lamella run in a direction opposite the adjacent layers. This creates a structure that is exceptionally strong, yet extremely flexible.

The nucleus pulposus is the inner gel material surrounded by the annulus fibrosus. It makes up about 40 percent of the disc. This ball-like gel is contained within the lamellae. The nucleus is composed primarily of loose collagen fibers, water, and proteins. The water content of the nucleus is about 90 percent at birth and decreases to about 70 percent by the fifth decade.

Injury or aging of the annulus fibrosus may allow the nucleus pulposus to be squeezed through the annulus fibers either partially, causing the disc to bulge, or completely, allowing the disc material to escape the disc. The bulging disc or nucleus material may compress the nerves or spinal cord, causing pain.

In the early years of life, the discs have a blood supply that nourishes them. In the second and third decades, discs gradually lose this blood supply, until they are avascular. At this point, the disc begins to degenerate, or age. By the age of 50, over 95 percent of all people will have disc degeneration. The disc begins to lose water content and shrinks. The spine’s range of motion and shock-absorbing ability are decreased. This may result in injury to the nerves and vertebrae, and the aging disc itself may generate pain.
The drawings to the left and below represent the appearance of a herniated or ruptured disc. Both drawings show the disruption of the annulus fibrosus, the outer ring-like portion of an intervertebral disc.

The tissue located in the center of the intervertebral disc, the nucleus pulposus, is partially extruded from the intervertebral disc. The extruded nucleus pulposus material can exert pressure on nerves thus causing pain, numbness, and muscle weakness due to nerve damage.

**Spinal Cord and Nerve Roots**

The brain and spinal cord together make up the **central nervous system**. The spinal cord is located immediately below the brain stem. It extends through the **foramen magnum**, a hole at the base of the skull.

The spinal cord functions as a sophisticated network that carries information from the outer elements of the body (skin, muscles, ligaments, joints) through the sensory tracts, to the brain. Data is processed there, and new information such as muscle control is sent out through the motor tracts of the spinal cord.

The spinal cord ends as the **conus medullaris** at the L1 vertebral level, where it branches into the **cauda equina**, a collection of nerves that extend from the conus medullaris to the sacrum. The conus medullaris nerves float freely in spinal fluid, making it possible to pass a needle safely into the area to draw a sample of spinal fluid or inject drugs, anesthetics, or radiologic substances for x-ray, MRI or CT scan.
**Arthroplasty** is the surgical reconstruction of a joint to improve function and reduce pain. When vertebral arthroplasty is performed, an artificial disc replaces the existing diseased disc. The artificial disc code range is 84.60 – 84.69.

**Laminectomies**: Each vertebral level should be coded with procedure code 03.09. Only half of the laminectomies reported last year were principal procedures, meaning the other half were procedures secondary to other spine procedures.

**Disc excisions**: Each disc that is excised should be reported using code 80.51. The corresponding laminectomy should not be separately reported, because it is necessary to perform a laminectomy to remove the disc. However, if a laminectomy is being performed at a different level, it is acceptable to report code 03.09.

**Spinal Fusion**

Spinal fusions/refusions may be performed if the vertebrae become unstable (spondylolisthesis), degenerated, fractured, or deformed as with a curvature of the spine. Fusions of the cervical spine are most common and typically involve one or two vertebra(e). However, fusions of the lumbar spine have more varieties of hardware.

The surgical approach may be through the belly (anterior), the back (posterior), or both (so-called 360° or anterior/posterior). Most cages are placed anteriorly, although L5 – S1 is easier than L4 – L5 because the aortic arch with major blood vessels is between the incision and the spine.

**Fusions/refusions**: ICD-9-CM procedure codes for spinal fusions do not differentiate instrumented from non-instrumented fusions, nor do they identify the specific vertebra and/or the use of allograft in the fusion space. The “inclusion note” in this section, states instrumentation and bone graft are included in the fusion code. It is possible to code fusions in additional regions (thoracic, cervical, lumbar), and to code both anterior and posterior fusions. The code range for a fusion is 81.00 – 81.08 and refusions 81.30 – 81.39.

An interbody spinal fusion device may be used when a fusion is performed. This device is often called a cage or a spacer. It can be made of titanium, Polyetheretherketone (PEEK), carbon, etc. This device is coded as 84.51. Interbody devices made of allograft are not reported using code 84.51 and are included in the code for fusion.

Bone graft for spinal fusions is usually taken from the patient’s iliac crest, although allograft or bone substitutes may be mixed with the patient’s bone. Bone harvested from the patient’s iliac crest and locally should be reported using code 77.79. Physicians may choose not to take patient’s bone because of complications and pain associated with the excision. Allograft used in spinal fusions is not reported separately.

**INFUSE® Bone Graft** consists of two parts – a solution containing rhBMP-2 (recombinant human bone morphogenetic protein 2) and the ACS (absorbable collagen sponge). The protein is a genetically engineered version of a natural protein normally found in small quantities in the body. The purpose of the protein is to stimulate bone formation. INFUSE® Bone Graft is coded as 84.52.

More than 40 years ago, orthopedic surgeons determined that the protein extracts required for bone to heal or regenerate in the body were contained within the bone itself. In 1979, Dr. Marshall Urist, a professor in the Department of Orthopaedic Surgery at the University of California at Los Angeles School of Medicine, coined the term “bone morphogenetic protein” (BMP) to describe these proteins.

* Wording is taken from ICD-9-CM 2009.
Instrumentation may be used to stabilize the fusion. The different types of instrumentation include screw/hook and rod systems and plate and screw systems.

Screw/hook and rod systems are typically applied from the back (posteriorly).

Plate and screw systems are most often used in anterior cervical fusions, and occasionally in lumbar fusions. There are specially designed plates for vertebral fractures.

Variations in the instrumentation include titanium vs. stainless steel components, and variable angle vs. fixed screws. Variable angle (or polyaxial, multiaxial) screws allow surgeons to attach the screws to the spine at different angles and make it easier to attach the screws to the rods.

Transverse mechanisms (CROSSLINK® Plate, transverse mechanism, transverse connector): Longer fusions may become unstable across the vertebral column and so a supporting structure may be used to provide additional stability.

Spinal barriers are designed to reduce scarring after surgery, thus reducing pain and the need for re-operations.

Bone growth stimulators are designed to provide an electric stimulation to the spine, thus improving fusion rates. Insertion of bone growth stimulators is coded as 78.99.
ANTERIOR CERVICAL DISCECTOMY AND FUSION

Approach/Patient Position

The patient is placed in the supine position with the head in slight extension. The surgeon must then choose a right or left sided approach, usually through the left. The laryngeal nerve that controls the voice box runs on the right side of the neck, so the incision is usually left sided to avoid post-op speech problems. After choosing an operative side, the head may be rotated to allow for adequate exposure of the cervical spine.

Typically, a transverse skin incision is made. An avascular dissection plane is developed between the esophagus/trachea, medially, and the sternocleidomastoid/carotid sheath, laterally. Hand held retractors might be utilized to provide initial exposure of the anterior vertebral column and the adjacent longus colli muscles.
ANATOMY OF SPINE PROCEDURES
ANTERIOR CERVICAL DISCECTOMY AND FUSION

Techniques
1. Cloward Technique
2. Smith Robinson Technique
3. Bailey/Badgley Technique/Threaded Cervical Cage Technique

Cloward Technique – With the patient prepped in the supine position, the previously described exposure is created. The disc is excised and canal decompressed. A dowel graft is then inserted into the intradiscal space.
ANTERIOR CERVICAL DISCECTOMY AND FUSION

Techniques

Smith Robinson Technique – With the patient prepped in the supine position, the previously described exposure is created. The disc is then excised with no decompression of the canal and a horseshoe graft is placed in the intradiscal space.
ANTERIOR CERVICAL DISCECTOMY AND FUSION

Techniques

Threaded Cervical Cages – Discectomy is completed at the indicated level. Pituitaries, curettes and Kerrisons may be used to remove the disc material and cartilage to expose the posterior longitudinal ligament.

A threaded cage is inserted following the discectomy.
ANTERIOR CERVICAL DISCECTOMY AND FUSION

Technique: Cervical Plating

A variety of plate designs currently exist to stabilize the cervical spine and promote fusion. The available options for cervical plating are listed below.

Non-constrained – Bicortical non-locked bone screw
Semi-constrained – Locked bone screw with possible construct motion
Constrained – Locked bone screw with no construct motion
Rotational Load Sharing – Screw rotates about a pivot point
Translational Load Sharing – Screw translates along a slot in the plate
PLIF WITH INSTRUMENTATION
Technique: Posterior Midline (Open)

With the dura and disc annulus exposed the disc is incised and removed.

A discectomy is performed by incising the annulus with a scalpel lateral to the dural sac. This is done bilaterally (on both sides).

The main goal of this step is to remove extruded disc fragments and to provide entry to the disc space.
PLIF WITH INSTRUMENTATION

Technique: Posterior Midline (Open)

The disc space is then prepared with the surgeon’s choice of instrumentation. The goal is to achieve parallel endplates on each vertebral body (level surface) to ensure good contact with the allograft.

Once the disc space is prepared, the surgeon will insert allograft with autograft bone packed between and around them. The autograft bone is typically local bone removed during the laminectomy.

Stabilization of the grafted interspace is then performed with internal fixation (screws and a rod or plate) to aid in the fusion process.

This is achieved by placing screws in the pedicles at the levels above and below the grafted interspace and connecting them with either rods or plates.
PLIF WITH INSTRUMENTATION

Technique: Posterior Midline (Open)
Pedicle screw insertion
PLIF with instrumentation
PLIF WITH INSTRUMENTATION

Technique: Transmuscular (Muscle Splitting)

Once the tubular retractors are in place, the surgeon will perform the same procedure done through a midline incision.

Technique: Transmuscular (Muscle Splitting)

Pedicle screws at L5 – S1 with a DYNA-LOK CLASSIC® Spinal System

Viewed through a tubular retractor
LUMBAR LAMINECTOMY AND DISCECTOMY

Basic Anatomical Landmarks: Lumbar Spine

Disc Excision

When the cushioning disc between the vertebrae protrudes out of the intervertebral space ("slipped" disc, herniated disc), this may be corrected by removing all or part of the extruding disc (discectomy). There are several approaches to this including microdiscectomy, in which incision is made in the spine, or the use of agents such as papaya extract (chemonucleolysis). There are no major implants used in disc excisions.

Lumbar – Relating to the loins or the section of the back and sides between the ribs and the pelvis. In the spinal column, the last five vertebrae (from superior to inferior, L1–L5)

Laminectomy – Surgical removal of part or all of the posterior vertebral elements

Discectomy – The removal of all or part of an intervertebral disc
LUMBAR LAMINECTOMY AND DISCECTOMY

Technique: Standard Microdiscectomy

The removal of all or part of an intervertebral disc. This technique involves stripping the muscles from the spinous process through a small skin incision followed by a laminectomy and then discectomy.

Technique: Transmuscular Discectomy

Discectomy Performed Through a Tube
LUMBAR LAMINECTOMY AND DISCECTOMY

Technique: Transmuscular (Muscle Splitting)

The skin incision is made slightly off midline. The intramuscular approach enables the surgeon to access the spine in a less invasive fashion than a midline incision. It’s considered minimally invasive because it preserves the posterior musculature of the spine.

Incision Created for a Transmuscular Approach
LUMBAR LAMINECTOMY AND DISCECTOMY

Technique: Intermuscular/Paramedian Discectomy

Intermuscular Microdiscectomy – The removal of all or part of an intervertebral disc through a Wiltse incision

Wiltse Incision – Approach in which the surgeon dissects between the fascial planes of the longissimus and multifidus muscles