Vertebral Column
The normal vertebral column is made up of 29 vertebrae (7 cervical, 12 thoracic, 5 lumbar and 5 sacral) and the coccyx. Anteriorly, the vertebrae are connected via secondary cartilaginous joints, which form the intervertebral discs. Posteriorly, the neural arch has paired synovial joints, known as facets or zygapophyseal joints.

The overall contour of the spine in the coronal plane is straight. However, in the sagittal plane the contour changes with development. At birth, there is a kyphotic posture to the whole spine (primary curves). With development of the erect posture, lordotic (secondary) curves develop in the cervical and lumbar spines.

Overall, spine alignment is altered in many conditions. Scoliosis (Slide 1 and Slide 2), which is a descriptive term for lateral curvature, is usually accompanied by rotational abnormality as well. This can be due to congenital deformity (Slide 1 and Slide 2), degeneration or associated with numerous neuro-muscular conditions. The most common type, however, is idiopathic.

One way to quantify the degree of curvature is to use the Cobb Measurement Method. The curvature is measured by drawing a line along the upper and lower end plates of the respective upper and lower vertebrae that are most tilted. The angle between these lines is then measured, usually by drawing additional lines at perpendicular angles to the end-plates.

Sagittal plane alignment can also be altered by disease and injury. This is manifested clinically with abnormal kyphosis (Slide 1, Slide 2, Slide 3 and Slide 4) or lordosis (Slide 1, Slide 2 and Slide 3).

Atlanto-Axial Joint
The C1 and C2 vertebrae are unique in their form and function. They are the articulation between the spine and the skull and constitute the cranio-cervical junction. They have close relationships with the base of the brain, spinal cord, cranial nerves, vertebral arteries, jugular veins and the naso-pharynx. Due to this critical position, injury or disease in this area can have significant effects, including cord compression and vertebral instability (Slide 1 and Slide 2).

Cranio-Vertebral Junction
Assessment of the various bony landmarks seen on lateral radiographs is important in determining normal and abnormal anatomy. There are a number of radiographic lines used:

McRae's line: from the anterior to the posterior lips of the foramen magnum. The tip of the odontoid should not project above.

Chamberlain's line: from the hard palate to its posterior lip and on to the posterior lip of foramen magnum. The odontoid tip should be less than 3mm above this line.

McGregor's line: from the posterior lip of the hard palate to the most caudal part of the occipital bone. The odontoid tip should be less than 4.5mm above this line.

Vertebral Artery
The third part of the vertebral artery transverses this region and has important relationships to all the bones. The bilateral and tortuous nature allows for blood to the brain in any position of the cranio-vertebral junction.

The third part of the artery passes through the transverse process of the first cervical vertebrae, then turns posteriorly, to lie in a groove on the superior surface of the posterior arch. It then turns medial to enter the dura.

As there are a large number of important anatomical structures adjacent to this region, a number of surgical approaches have been used to gain access, depending on the position and nature of the pathology.

Posterior Ponticle
The clinical significance of this anomaly is debatable. Some studies have reported that there is an increased risk of vertebrobasilar artery insufficiency due to compression or restriction of the vertebral artery whilst others have stated that there is no increased risk of vertebral artery compromise. Thus, testing for vertebrobasilar artery insufficiency must be performed prior to cervical spine manipulation.

Anomalies of the Dens (Syn. Odontoid Process)
Anomalies (congenital, acquired or traumatic) of the dens are not uncommon; they often result in atlanto-axial instability and may require surgical intervention. Hypoplasia of the dens may lead to invagination into the basilar part of the occipital bone.

Osteoporosis
Osteoporosis is a metabolic bone disorder characterized by decreased amounts of normal-quality bone resulting in an increased susceptibility to fracture.

Although most commonly found in post-menopausal females (Slide 1 and Slide 2), it can also be secondary to immobilization as well as a number of underlying conditions, e.g. steroid use, alcoholism and malignancy.

Imaging
Changes in Vertebral Body Shape
The normal vertebral body has essentially parallel end-plates, although there may be slight end-plate concavity with 1-2mm of central depression. In the thoracic spine, the anterior height of the vertebral body may be 1-2mm less than the posterior. This does not imply collapse and may be seen in contiguous vertebral bodies.

Osteoporosis may result in vertebral compression, which can be acutely painful or pass unnoticed by the patient. Wedging usually affects the upper end-plate more than the lower, so that the difference in height between anterior and posterior surfaces of the vertebral bodies is over 2mm. The radionuclide bone scan shows marked focal increase in uptake. Significant collapse results in flattening of the vertebral body, which usually does not expand significantly. Expansion in collapse is a feature of Paget's disease and occasionally of primary and secondary bone tumors. In most cases, a collapsed osteoporotic vertebra is said to implode. Callus formation is not usually seen in collapsed osteoporotic vertebrae but is seen in patients with Cushing's disease. Collapse in osteoporosis is not generalized throughout the spine and it is unusual to find many vertebral bodies affected by collapse in contiguity.

'Codfish' vertebrae resemble fish vertebrae in shape, with deep, smooth, biconcave end-plate depressions. This feature is seen in any condition associated with bone softening, including osteomalacia. In osteoporosis, the depressions may be more marked on the upper end-plates and affected bodies are not always contiguous. In osteomalacia, the change is seen more diffusely throughout the spine.

In young adults, a codfish type vertebral body may be seen, where the upper and lower end-plates show smooth depressions slightly posterior to the coronal mid-plane. This change lies around the discal nucleus, as can be seen at discotomy and MRI and usually occurs in the lumbar spine, where the discs are largest.

Osteoporotic patients form less new bone as part of a degenerative process and are probably more susceptible to vertebral collapse than those who have normal mineralization or are hyperostotic, as in diffuse idiopathic skeletal hyperostosis.