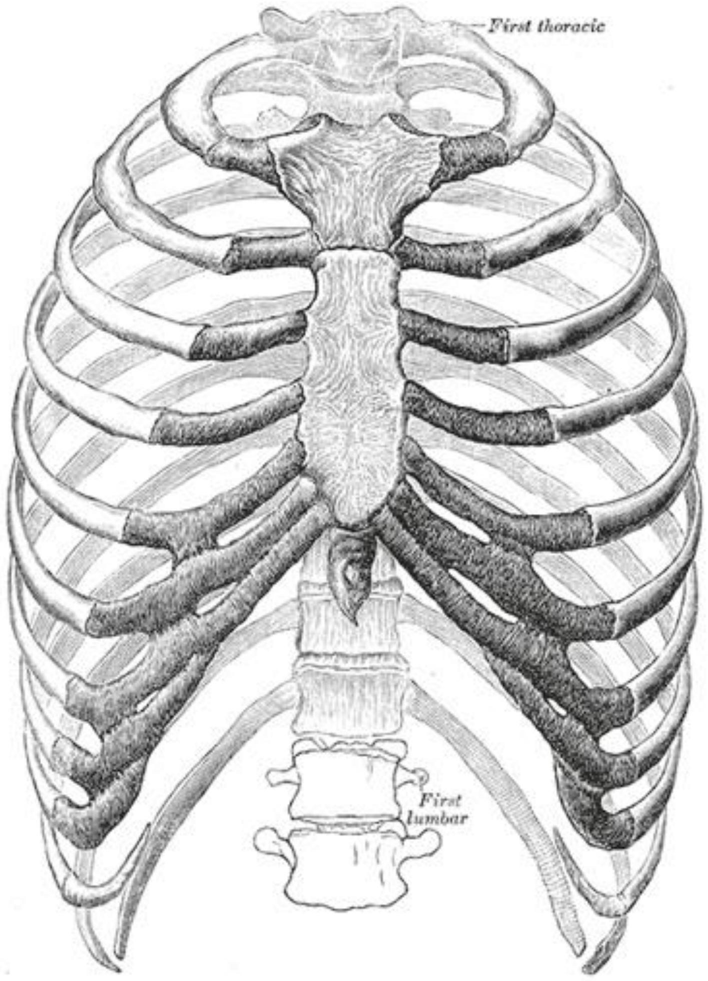

The Vertebral Column Anatomy

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Contents

The Vertebral column

Bones

The vertebral column (also known as the backbone or the spine), is a column of approximately 33 small bones, called **vertebrae.** The column runs from the cranium down to the apex of the coccyx, on the posterior aspect of the body. Its functions are:

- **Protection**: it encloses the spinal cord, shielding it from damage
- **Support**: it carries the weight of the body above the pelvis (below the pelvis, the lower limbs take over)
- **Axis**: the vertebral column forms the central axis of the body.
- **Movement**: it has roles in both posture and movement

The vertebral column is composed of a series of 31 separate bones known as vertebrae. There are:

- 7 cervical or neck vertebrae
- 12 thoracic vertebrae
- 5 lumbar vertebrae
- The sacrum is composed of five fused vertebrae
- 3 - 5 coccygeal vertebrae which are sometimes fused

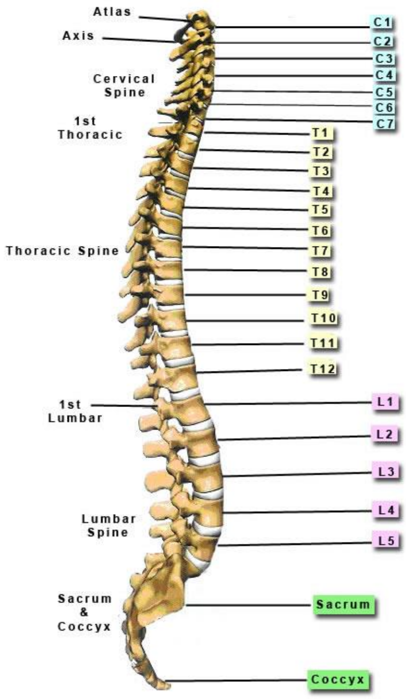


Figure 1 Vertebral column

The bones are numbered from the top down

Each vertebra is composed of a body (anteriorly), which consists of a large anterior middle portion called the centrum, and a vertebral, or, neural, arch (posteriorly). The body is composed of cancellous bone, which is the spongy type of osseous tissue, covered by a thin coating of cortical bone (or compact bone), the hard and dense type of osseous tissue. The upper and lower surfaces of the body of the vertebra are flattened and rough in order to give attachment to the intervertebral discs. These surfaces are the vertebral endplates which are in direct contact with the intervertebral discs and form the joint. The endplates are formed from a thickened layer of the cancellous bone of the vertebral body, the top layer being denser. The endplates function to contain the adjacent discs, to evenly spread the applied loads, and to provide anchorage for the collagen fibres of the disc. They also act as a semi-permeable interface for the exchange of water and solutes.

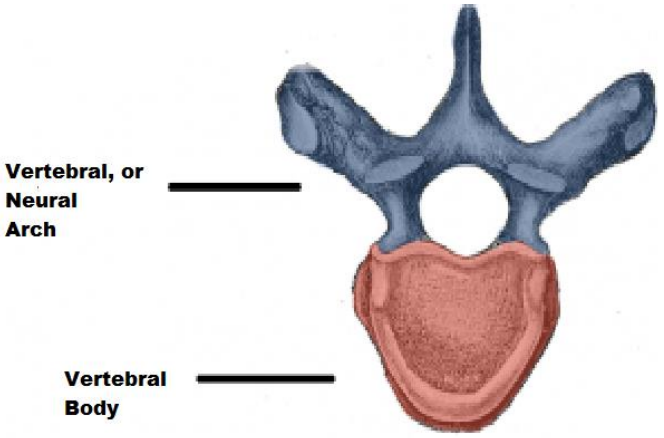


Figure 2 A Typical Vertebra

The vertebral arch is made up of thicker coverings of cortical bone and has named bony components.

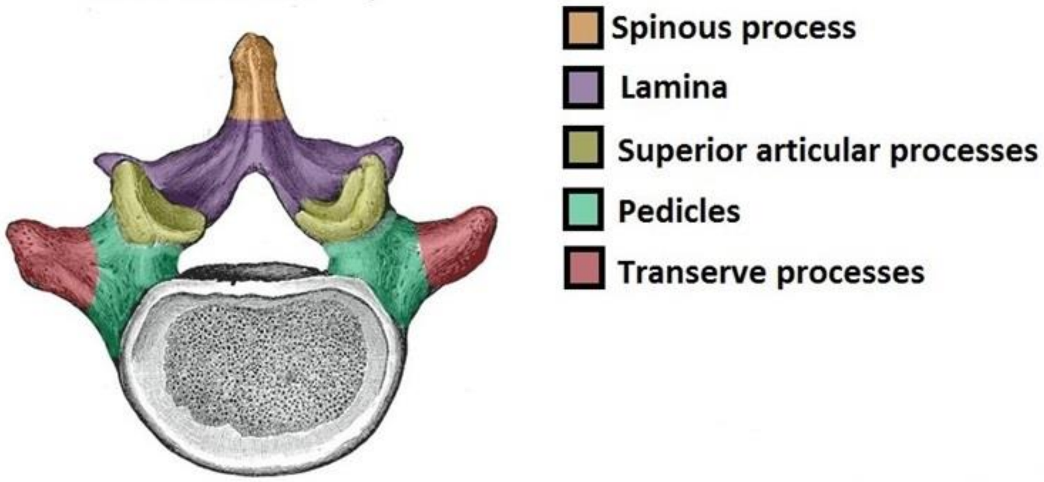


Figure 3 Typical vertebra - named components

The neural, or vertebral, arch forms an opening, the vertebral foramen. The summation of these foramina up the vertebral column forms the vertebral, or neural, canal, which encloses the spinal cord.

Protruding from the back and sides of the vertebra are the **processes**.

- The **spinous process** - from the back
- The **transverse processes** from the sides

These are present for muscle attachments for the spinal muscles.

The neural arch is formed by the pieces of bone between the processes:

- The **pedicles** - between the vertebral body and transverse process
- The **laminae**
  - Between the transverse processes and spinous process
  - The upper surfaces of the laminae are rough to give attachment to the ligamentum flavum (Pl. Ligamenta flava)

Also, at the point of where the pedicles and laminae meet are the **articular processes**. These are the components parts of the facet joints between the vertebrae.

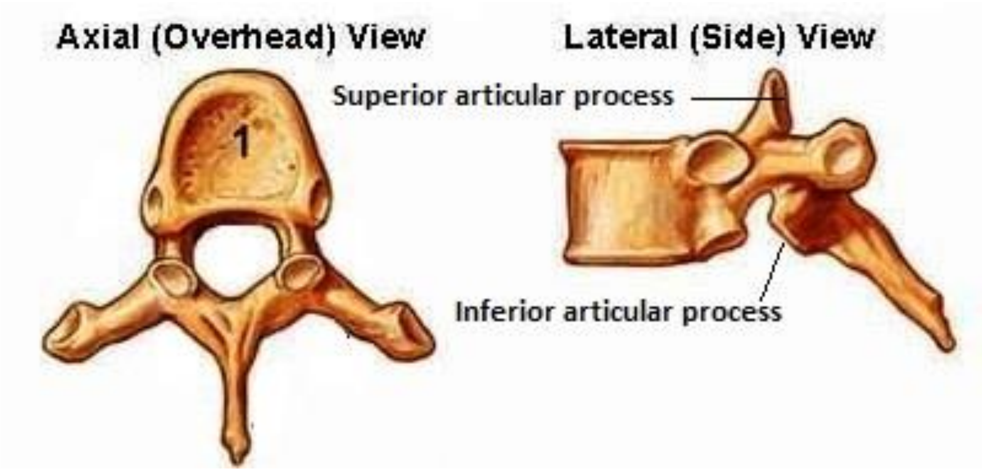
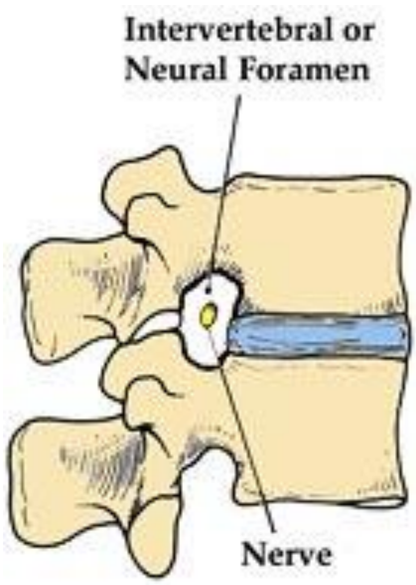


Figure 4 Articular facets - zygapophyseal joints

These facets joints, or zygapophyseal joints, are synovial joints (gliding) and define what type of movement occurs between the bones - see later. These superior and inferior arrticular facets are joined by a thin portion of the neural arch called the **pars interarticularis.**



Above and below the pedicles are shallow depressions called vertebral notches (*superior* and *inferior*). When the vertebrae articulate the notches align with those on adjacent vertebrae and these form the openings of the vertebral foramina. The foramina allow the entry and exit of the spinal nerves from each vertebra, together with associated blood vessels from the vertebral canal.

Figure 5 Intervertebral foramen

Now this only describes the common factors of a 'typical vertebra'. There are differences in the shape of the vertebrae along its length. The thirty-three vertebrae in the human vertebral column are named after the regions they occupy.

The Occiput, Atlas and Axis

The Occiput, Atlas and Axis

The vertebral column cannot really considered complete without including the lowermost bone in the skull, the occiput:

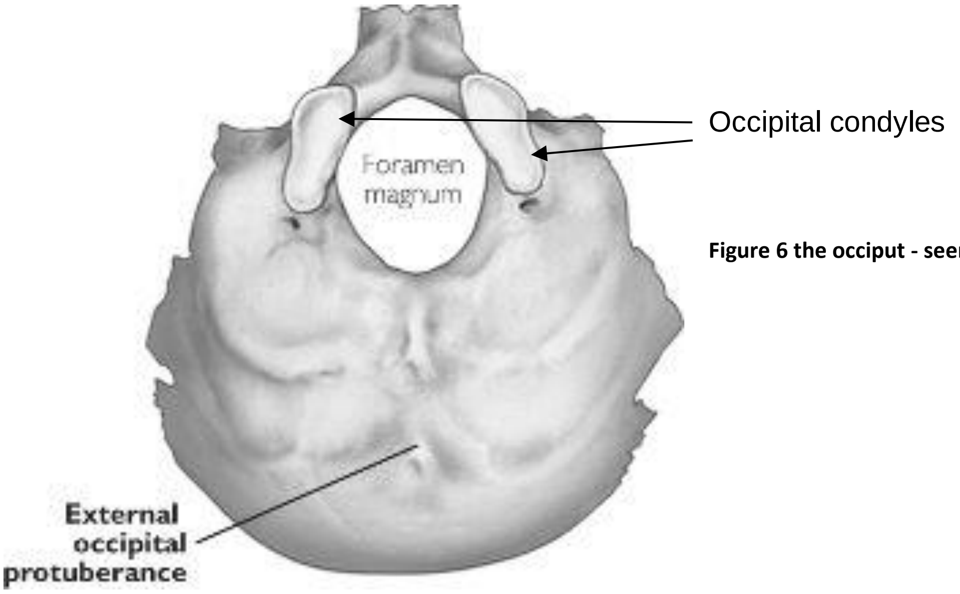


Figure 6 the occiput - seen from below

The occiput is a bone that forms the base of the head. It has two articular facets at its base: the occipital condyles. The occiput sits on top of the atlas, C1, and shares a joint with it; the **occipitoatlantal joint.**

Joints, Ligaments and Movements

The joint between the occiput and the atlas is the occipitoatlantal (O/A) joint. It is a synovial joint of a condylar type; it has two articular facets, permitting movement in one plane.

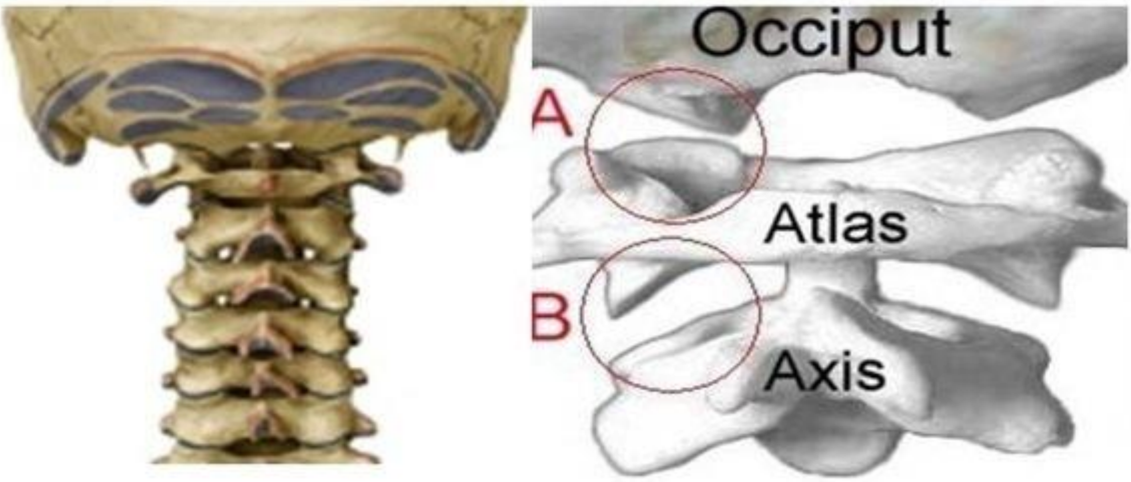


Figure 7 Occipitoatlantal joint

Ligaments

The occipitoatlantal joint is a condylar joint and functions essentially like a hinge, so there are ligaments present to stabilise it to prevent erroneous movements.

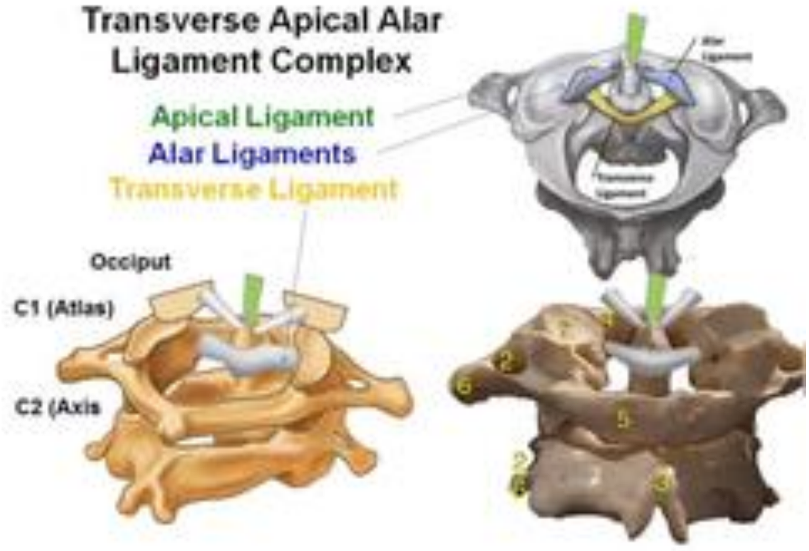


Figure 8 Apical and Alar Ligaments

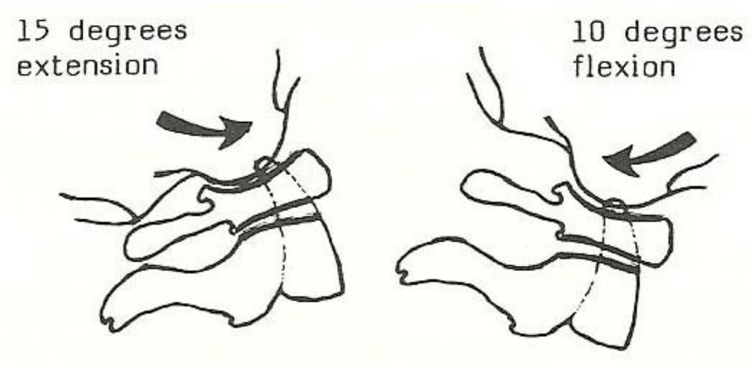
Structures that stabilise the occiput with the atlas and axis are:

- **The apical ligament**
  - From the top of the dens up to the front margin of the foramen magnum
  - It secures the dens of C2 to the occiput
- **The alar ligaments**
  - These are from the top sides of the dens, moving up and laterally, to the front margins of the foramen magnum
  - They are the primary restraints to rotation of the upper cervical motion unit
  - Together with the tectorial membrane the alar ligaments limit flexion
  - They limit the side-bending of the occiput on the atlas, via tightening of the contralateral alar ligament, focussing movement below C1/2 and the rest of the cervical spine
  - At mid-position of the head they are slack. By turning the head in one direction, the alar ligament contralateral to the direction of rotation tightens, while the ipsilateral ligament slackens
- **The transverse ligament**
  - This is a band that passes across the shaft of the dens, holding it against the articular facet on anterior margin of C1
  - It ensures that rotation is the only movement that occurs at C1/2
  - It also stabilises the dens, preventing compression of the spinal cord
- **The anterior and posterior longitudinal ligaments**
  - At the level of the occipitoatlantal joint, it called the **tectorial membrane**. It also limits flexion and distraction

Movements

Occipitoatlantal joint

As was mentioned earlier, this is a condylar joint, but functions like a hinge, only allowing flexion and extension



The joint plane of the O/A and C1/2 are largely in the transverse plane (across the neck). The facets of the occiput are convex and angled down and out, whereas the superior facets of the atlas are reciprocally concave and angled up and in. It only allows flexion/extension (nod if you understand)

Figure 9 O/A joint showing flexion/extension

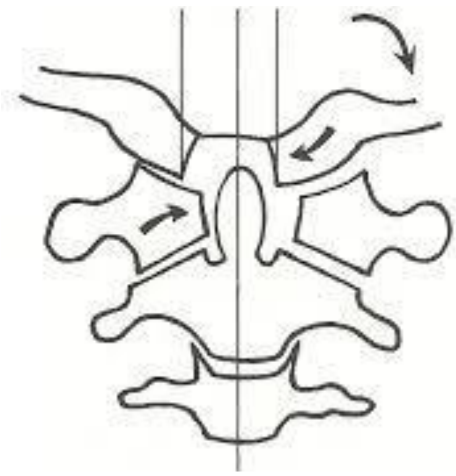


Figure 10 Occipitoatlantal joint from front

It is best to see the O/A joint and C1/2 as a unit.

This diagram shows attempted side-bending at the O/A joint. Note the movement is entirely denied by the presence of the dens (see below).

The atlas and axis: C1 and C2

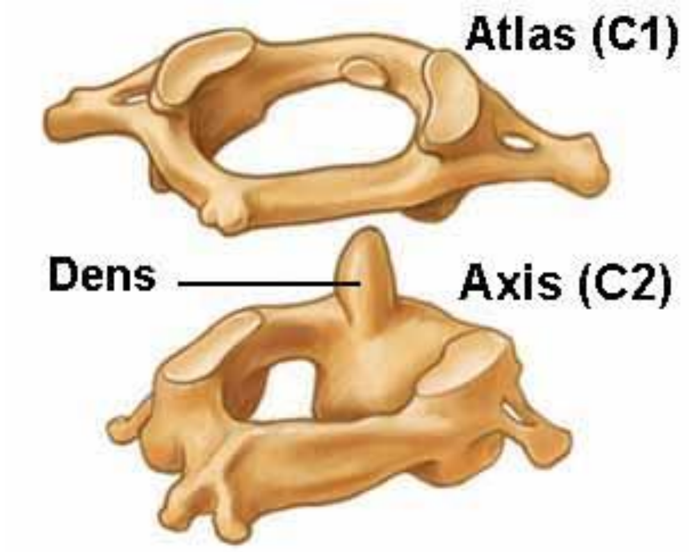


Figure 11 the Atlas and Axis bones

Note here that C1 has no vertebral body or spinous process but has a tubercle posteriorly

C2 does have a vertebral body and, in addition to this, a bony process protruding straight up and into the arch of C1 where the body of C1 'should' be. This process it called the **Dens**, or the **Odontoid Process**.

The occiput, atlas and axis are different from the rest of the vertebral column in that they do not have any intervertebral discs. Between these joints are only synovial joints.

Joints and Movements

Figure 12 C1 and C2 together

The movement that occurs at C1/2 is entirely rotation

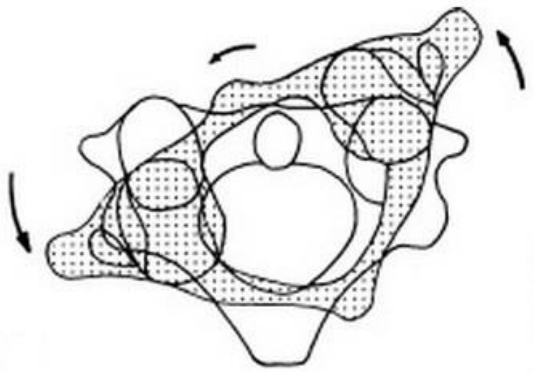


Figure 13 Rotation at C1/2

Note that the axis of movement at C1/2 is the dens itself; the atlas rotates around it. Hence this configuration of joints and the fact that it is synovial, creates a situation allowing a great deal of rotation.

The Cervical Spine

The cervical spine consists of 7 bones. The top two are the atlas and axis and have been covered above.

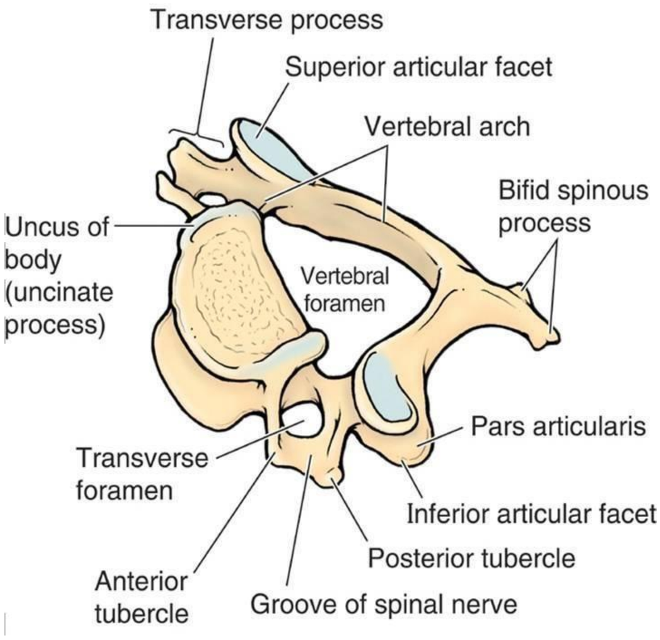


Figure 14 Cervical Vertebra

The cervical vertebrae all share certain characteristics:

- The spinous process is bifid - it is 'Y' shaped, except C7
    - The concavity of the bifid process contains the **Ligamentum Nuchae**
- The transverse processes are also bifid
    - For muscle attachments
- There is a hole in the transverse processes
    - For the vertebral artery
- The vertebral body is relatively small
- The vertebral canal is relatively large and is triangular in shape

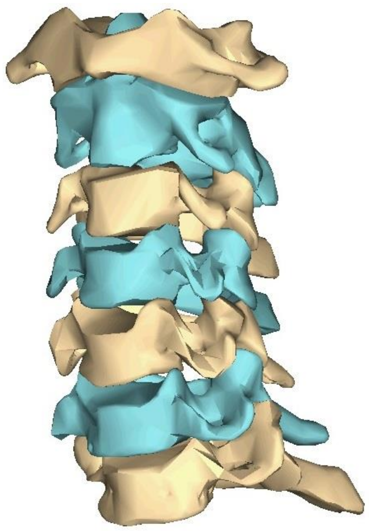
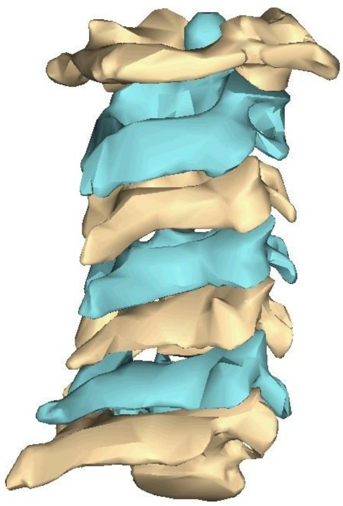
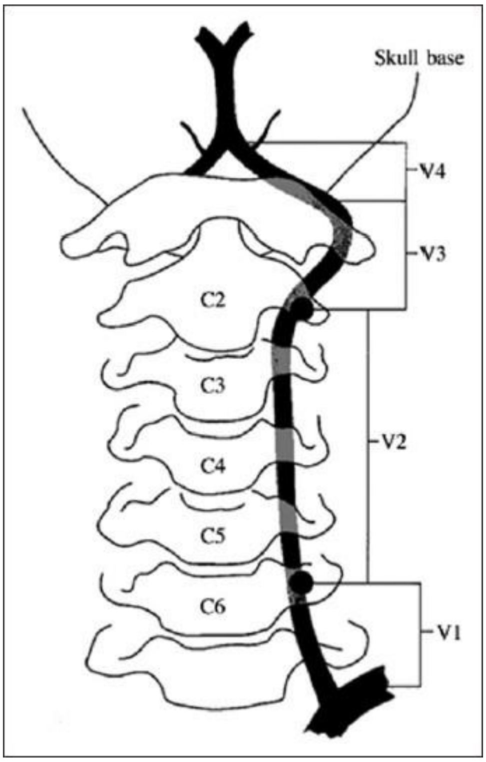


Figure 15 Cervical spine seen from anterolateral and posterolateral aspects

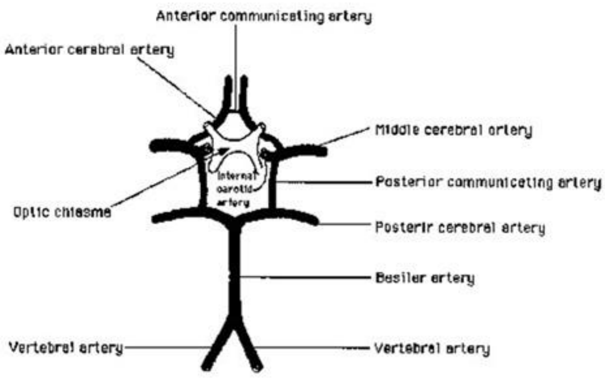


The Vertebral Artery

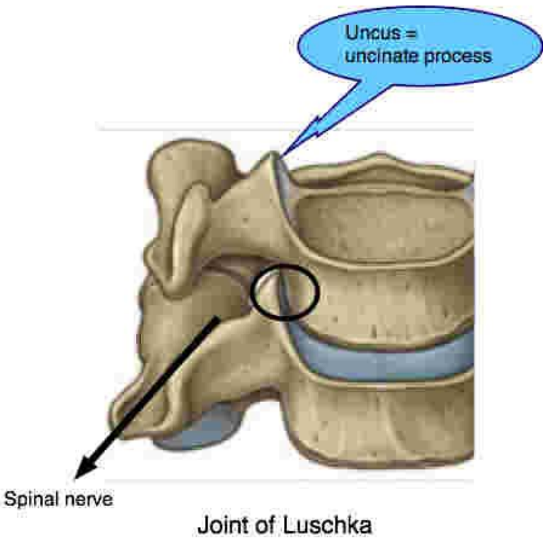


The vertebral artery is an artery that runs up in the foraminae in the transverse processes of the cervical spine, as seen in the diagram of Fig 16.

Figure 16 Vertebral artery



The two branches pass up through the foraminae, to and through C1. Then the two branches come together to form the basilar artery and enter the foramen magnum. There it supplies the brain stem before merging with the arterial circle of Willis.



In addition to the characteristics listed above, the vertebral bodies of C3 to C7 have a different shape to elsewhere in the spinal column. The vertebral body has a 'lip' at its lateral edge; an **uncus**, or **uncinate process**

Figure 17 Cervical vertebra seen from the front, showing the uncus

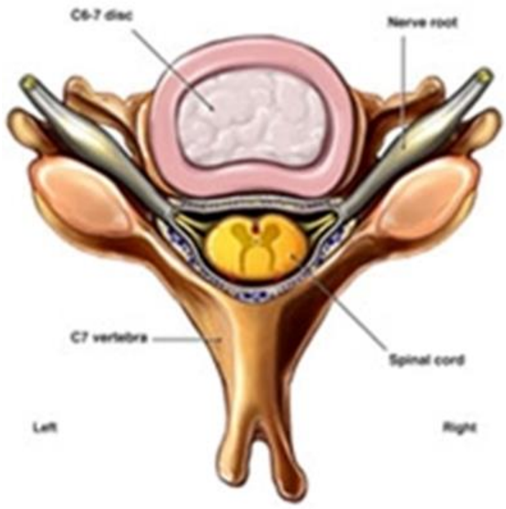
This bony part prevents a vertebra from sliding backwards off the vertebra below it (i.e. it prevents posterior linear translation movements of the vertebral bodies) and limits lateral flexion (side-bending). Luschka's joints involve the vertebral uncinate processes.

Joints, ligaments and movements

All movement between the vertebrae are entirely dependent upon the distance of their separation. This separation is created by the intervertebral disc but is also facilitated by the uncinate processes.

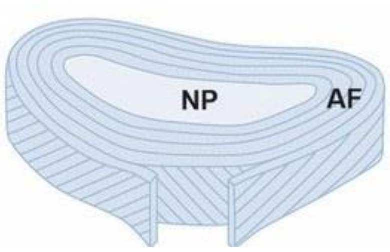
Intervertebral Disc

Figure 18 Intervertebral Disc



An intervertebral disc is a secondary cartilaginous joint (**symphysis**) consists of:

- The **Annulus Fibrosus**
    - The outmost rings of the disc
    - These are attached to the vertebral bodies either side and hold them together
- The **Nucleus pulposus**
    - The central, gelatinous, region, which keeps the two vertebrae apart



The outer layers of the disc consist of concentric layers of tough fibrocartilage, collectively named the **annulus fibrosus**.

Figure 19 Schematic diagram of a disc

The diagram here shows how the fibres of the annulus are arranged at right angles to each other. This creates great tensile strength that binds the two vertebral bodies together.

The centre of the disc consists of a gelatinous, almost liquid centre, called the **nucleus pulposus**. This picture (fig. 8) shows the annulus and nucleus pulpous in a dissection sample.

Figure 20 Picture of cross-section of disc

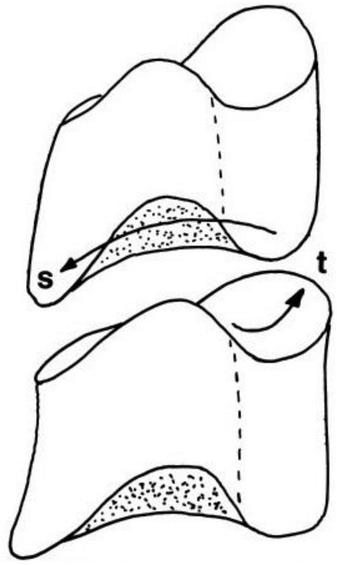
The whole disc is frequently described as a 'shock absorber', but this is inadequate. It is a structure that holds two adjacent vertebrae together, whilst keeping them apart at the same time. This is a joint. The elements of this symphysis put together create a narrow flexible region of relatively limited movement. In principle, it acts like a ball between two boards; it allows movement in any direction.

The type of movement that will occur depends upon the alignment of the facet joints at that level of the spine (e.g. fig 23)

What type of movement that occurs at any level of the spine depends upon the zygapophyseal joints? These are small, synovial, facets joints of the gliding type. Here the direction of the face of the facet defines the direction of movement.

The intervertebral discs are situated between the bodies of the vertebrae along the entire length of the vertebral column from C2/3 (the joint between C2 and C3 in the neck) down to the lumbosacral joint (L5/S1)

There is a gross misconception (I often hear with people attending my clinic) that discs can 'slip out of place' and can be 'manipulated back into place' again.



The uncinate processes create a unique shape in the cervical spine, giving it a saddle shape. The upper surface of the vertebral body is concave in the transverse plane and convex in the sagittal plane. This complementary shape of apposite bodies facilitates flexion/extension and side-bending.

Figure 21 Cervical spine - shape of bodies

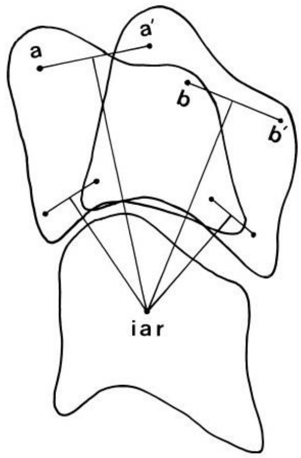
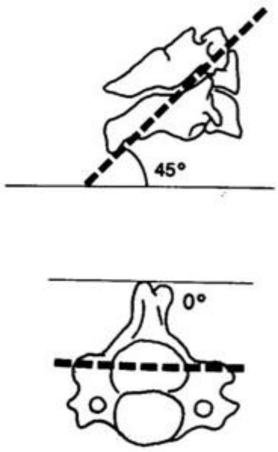
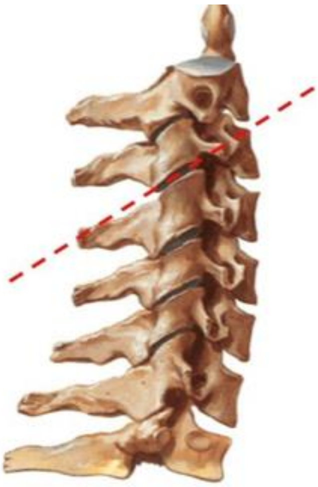


Figure 22 axis of flexion and extension





This diagram shows the zygapophyseal (facet) joints of the cervical spine. Note that the plane of the facets is about 45° to the horizontal. Hence the disc space, along with the horizontal plane of the O/A and the C1/2 joint, allows a great deal of movement, especially rotation, in the neck

Figure 23 Facet joints in the cervical spine

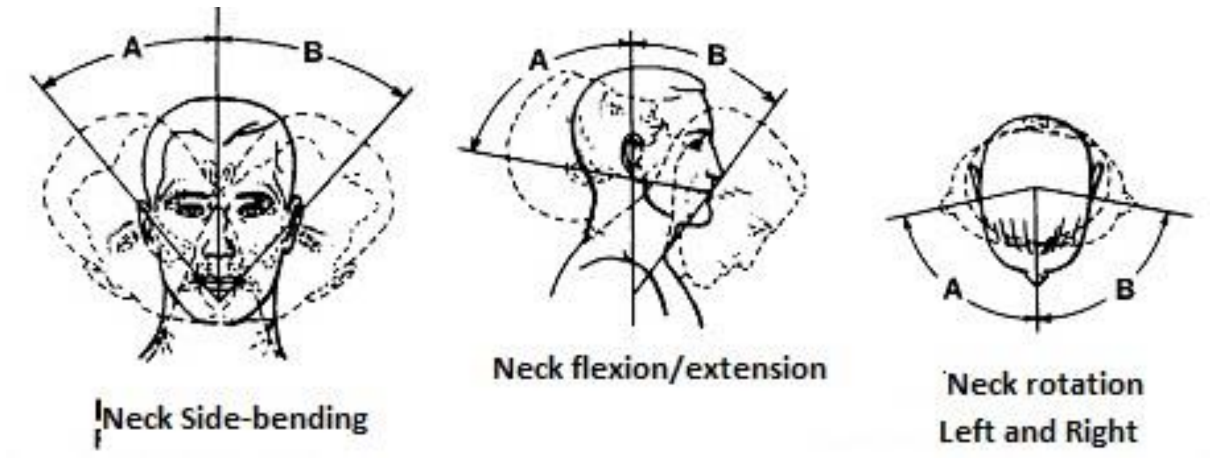


Figure 24 Gross movement of the neck

This is gross movement. However, the type of movement that occurs between each bone changes down the spine. This is due to the centre of axis of the spine at that level.

Figure 25 Axis of rotation in cervical spine

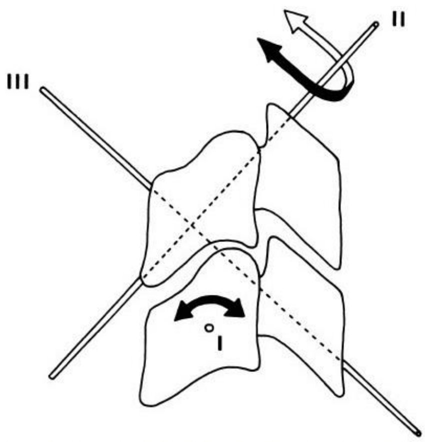


Fig 25 shows the planes of motion in the cervical spine

I. Is the axis of flexion/extension
II. Is the axis of rotation. It is a modified axis and is perpendicular to the zygapophyseal joints
III. Is perpendicular to II, but no motion can occur along this axis

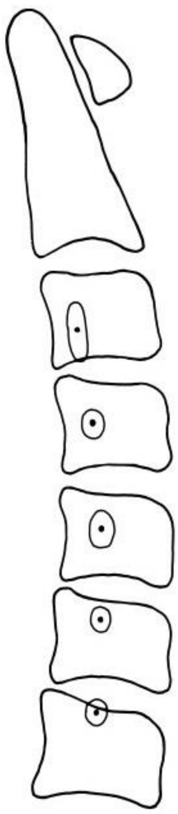


Figure 26 Axes of rotation of cervical spine

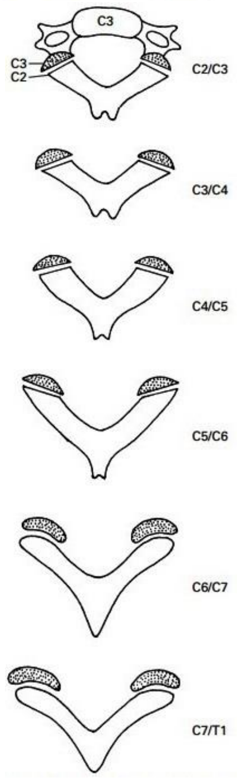
Fig. 26 is a diagram of an idealised schematic showing the axes of centres of movement (rotation) in the cervical spine.

As was stated above, the axis of rotation of C1/2 is the dens itself. This diagram shows how the axis of rotation tends to shift forwards down the neck.

This will a point to consider later when we see the type of movement in the thoracic and lumbar spines

The direction of the plane of the facets defines what type of movement occurs at each level

Figure 27 Plane of facets of c-Spine



Hence, broadly speaking, there are three axes of movement at every level of the spine:

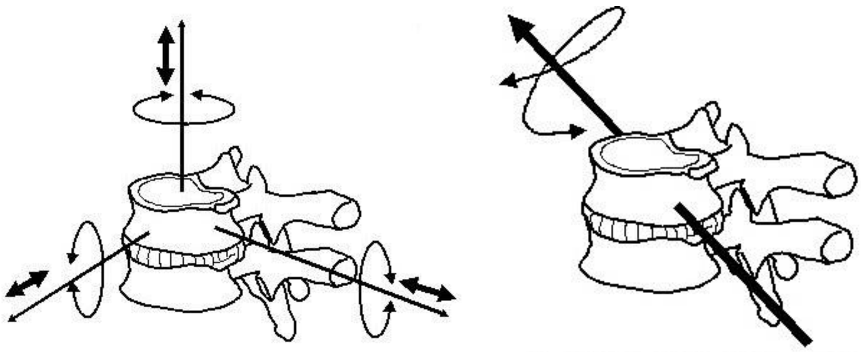


Figure 28 Movements that occur at the intervertebral joints

So, considering the alignment of the facets, the usual movement that takes place towards greatest ease is side bending a rotation in contralateral directions, e.g. rotation left with side-bending right. This generality can vary with degrees of flexion and extension. The diagram shows that rotation increases with flexion.

Seeing the cervical spine from the side, via x-ray:

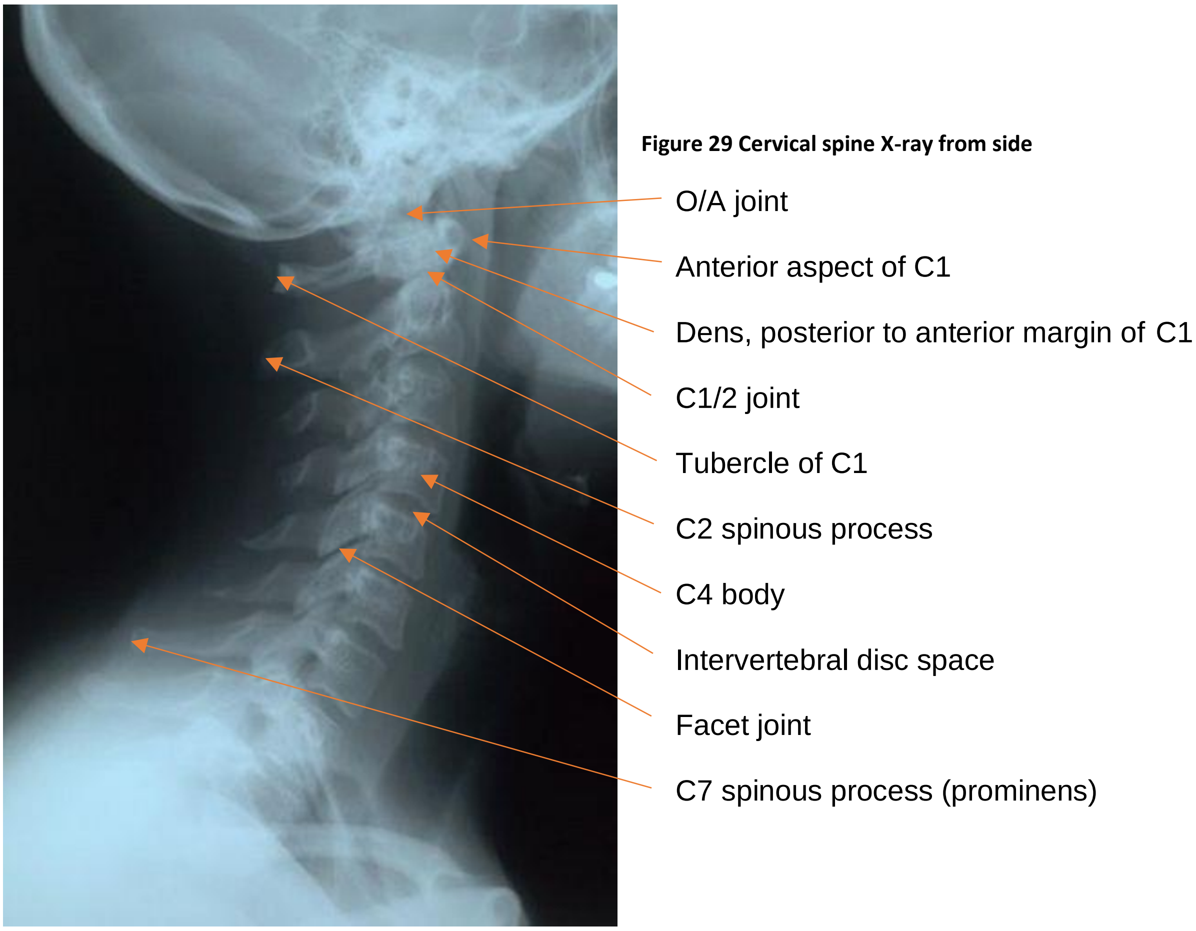


Figure 29 Cervical spine X-ray from side

Ligaments of the spine

There are several ligaments that are along the length of the spine. The general function of these is to limit its movement and hence provide stability. The ligaments at the base of the head have already been covered above.

Let us list these ligaments from posterior to anterior

Figure 30 Ligamentum nuchae

- **Ligamentum Nuchae**
  - This runs down the posterior of the cervical spine from the external occipital protuberance of the skull to the spinous process of C7 (prominens)
  - The ligamentum nuchae continues as the supraspinous ligament
  - Its function is to limit flexion of the neck and to assist in maintaining the cervical lordosis (holding the head up)
- **Supraspinous ligament**
  - The connects the ends of all the spinous processes down the spine to S1
  - It limits flexion of the spine

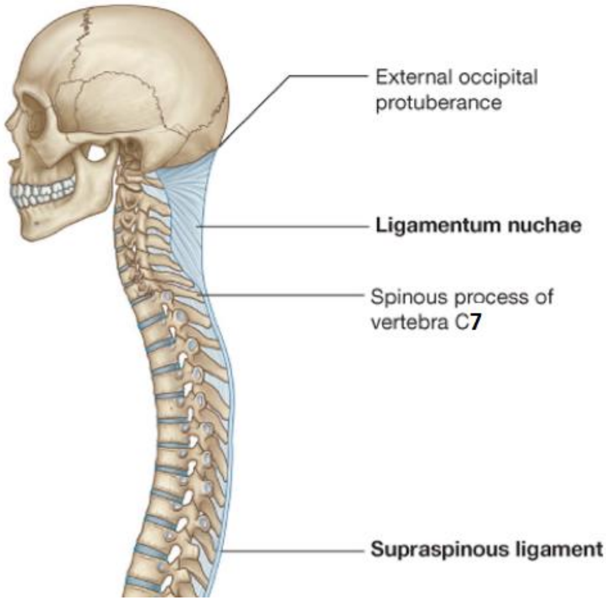
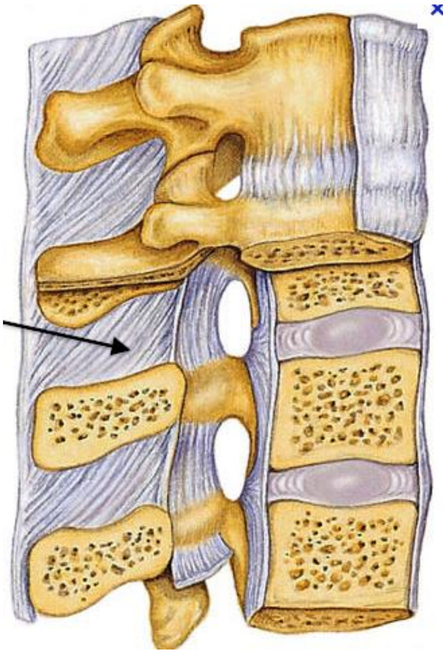


Figure 31 Supraspinous Ligament



- **Interspinous ligament**
  - These are situated between the spinous processes
  - They limit flexion of the spine

Figure 32 Interspinous ligament

- **Ligamentum flavum**
  - This is situated between the laminae of the vertebrae
  - Even though it is defined as a ligament, it has an elastic component
  - It limits flexion of the spine

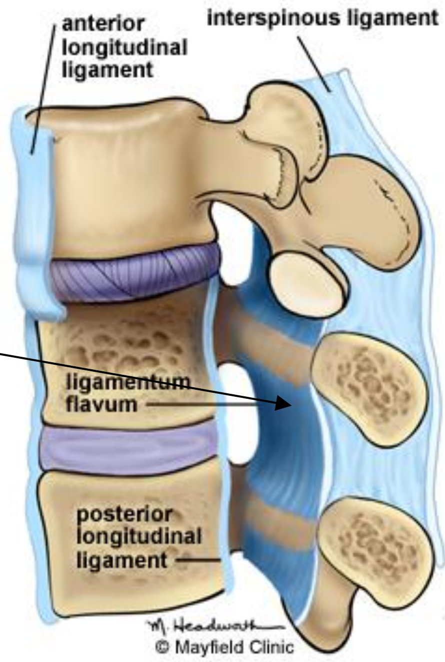
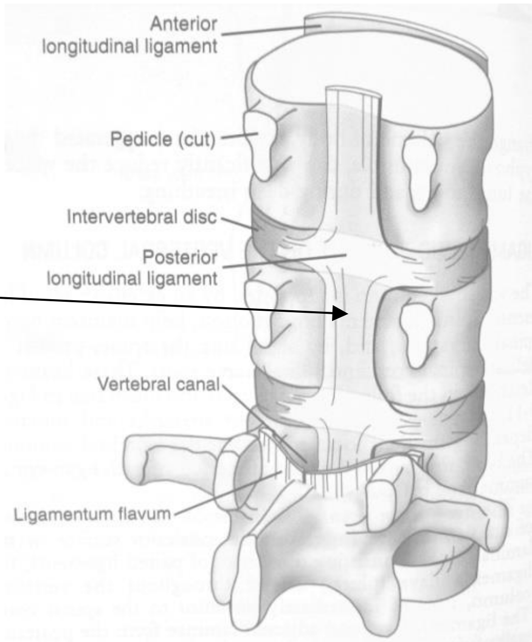


Figure 33 Ligamentum flavum

- **Posterior longitudinal ligament**
  - This ligament runs along the entire length of the spine, along the posterior surfaces of the vertebral bodies and intervertebral discs
  - Its function is to limit flexion and to reinforce the posterior annulus fibrosus of the disc



- **Anterior longitudinal ligament**
  - This is situated along the entire length of the vertebral column on its anterior aspect
  - It limits extension of the spine

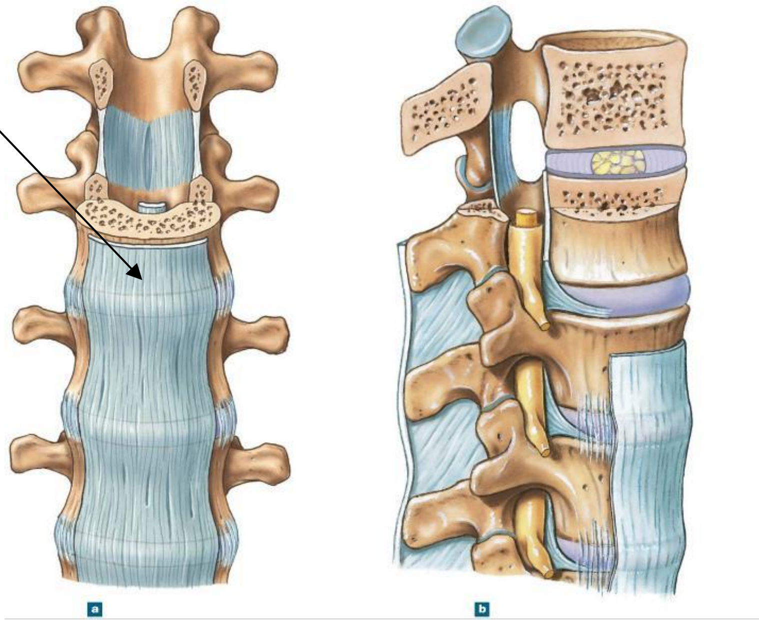


Figure 34 Anterior longitudinal ligament

The Thoracic Spine

The thoracic spine consists of 12 bones, the vertebrae of which also share a typical shape, but there are differences along its length. The bodies get bigger going down along its length. The upper four thoracic vertebrae are like cervical vertebrae in some respects, having posteriorly directed spinous processes. The lower four contain some lumbar characteristics, like large bodies and robust transverse and spinous processes.

Each segment has an articulation with a rib, giving rise to an important relationship between structure and function in this region. Therefore, somatic dysfunction in the thoracic spine will affect the rib cage, and somatic dysfunction in the rib cage will affect the thoracic spine. While this region is of major importance to respiration and circulation (including lymphatic flow), its functional capacity is also important in relation to the autonomic nervous system due to the location of the sympathetic chain ganglia.

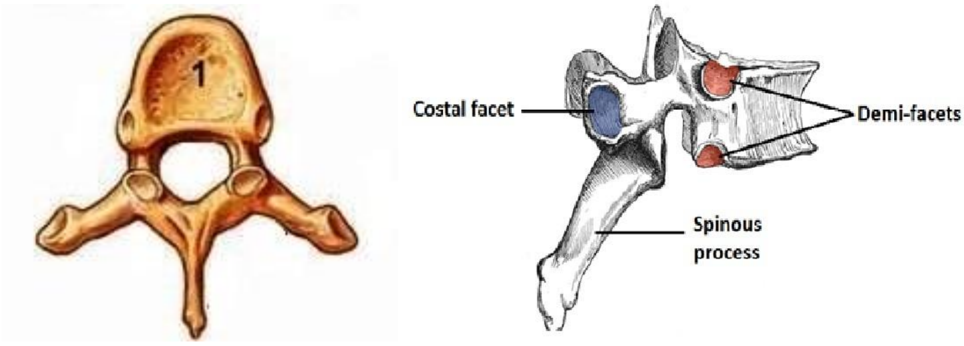


Figure 35 Typical thoracic Vertebra

Characteristics thoracic vertebrae share:

- Vertebral body is more heart shaped.
- Transverse processes are longer and point posterolateral.
- Spinous processes are longer and point more posteroinferior.
- In addition to the zygapophyseal facet joints, there are facets for the ribs on the vertebral bodies.

Joints and movements

The disc space between the thoracic vertebrae are narrower than the cervical and lumbar spine, so there is less movement between the vertebrae overall.

The direction of the plane of the facets defines the type of movement that occurs there.

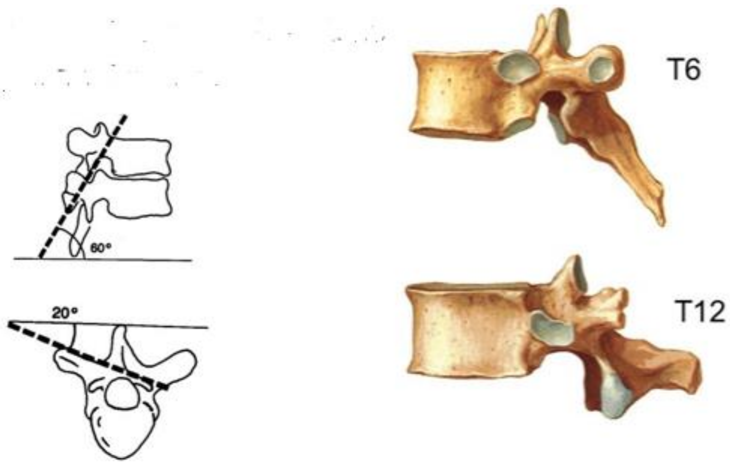


Figure 36 Direction of thoracic articular facets

This alignment of facets allows certain types of movement. With regard to rotation the centre of axis of movement is anterior to the facets, just anterior to the vertebral foramen. Here, though, rotation would be inherently limited with the presence of the ribs.

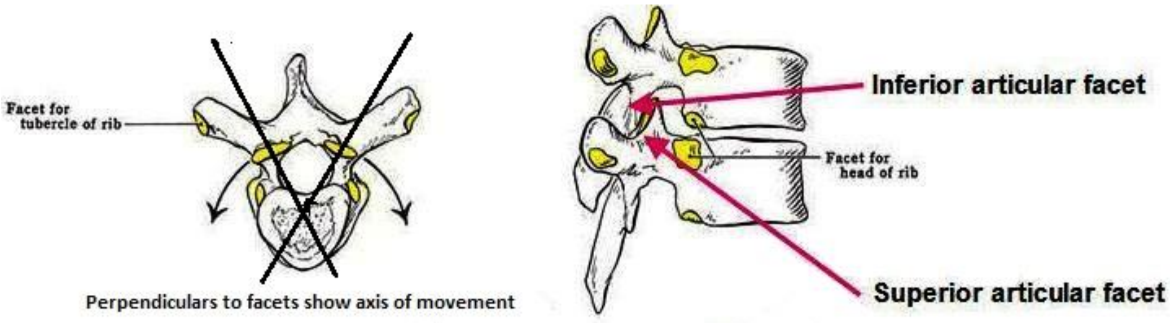
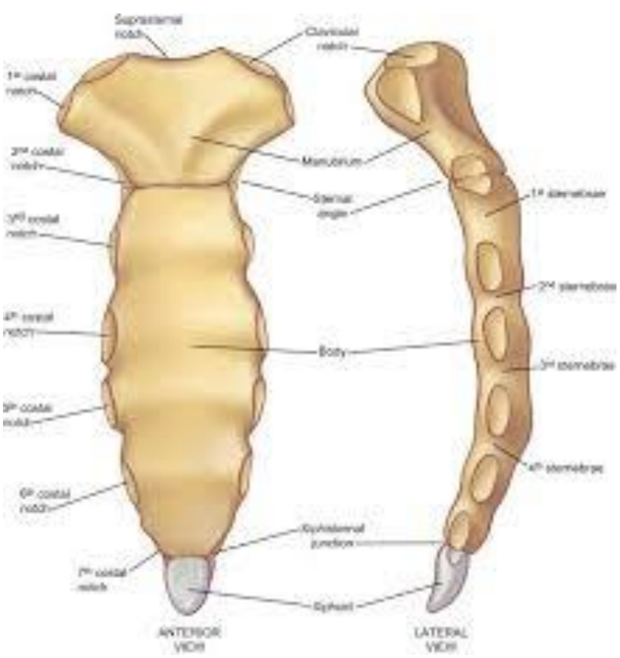


Figure 37 Thoracic spine facets and axis of movement

In addition to the discs and facets joints there are also the ribs. There are 12 pairs of ribs. Collectively they form the thoracic cage and facilitate the protection and function of the heart and lungs.



Ribs 1 - 10 articulate directly or indirectly with the sternum

- Ribs 1 – 7 articulate directly
- Ribs 8 – 10 articulate via the costal margin

Figure 38 the Sternum

The sternum is a flat bone at the front of the chest. It consists of three sections:

- The manubrium
- The body
- The xiphoid process

The clavicles and 7 pairs of ribs articulate directly with the sternum.

There is a symphysis between the manubrium and the body, allowing limited movement.

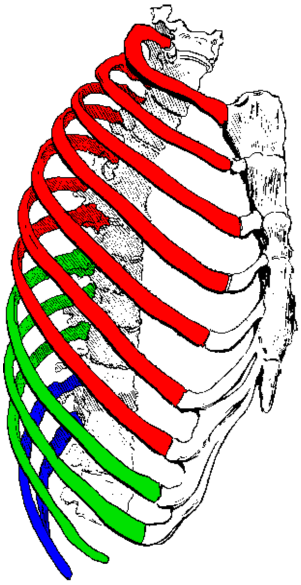


Figure 39 Side view of the rib cage

- There are 7 true ribs - these articulate directly with the sternum
- Ribs 8 - 10 are false ribs - they do not articulate directly with the sternum, but with the costal cartilages, a bar of cartilage that extends up to the sternum (costal margin)
- Ribs 11 and 12 are floating ribs - they have no anterior articulation
- The top 7 ribs articulate with the sternum via a bar a of cartilage: a synchondrosis

Ribs

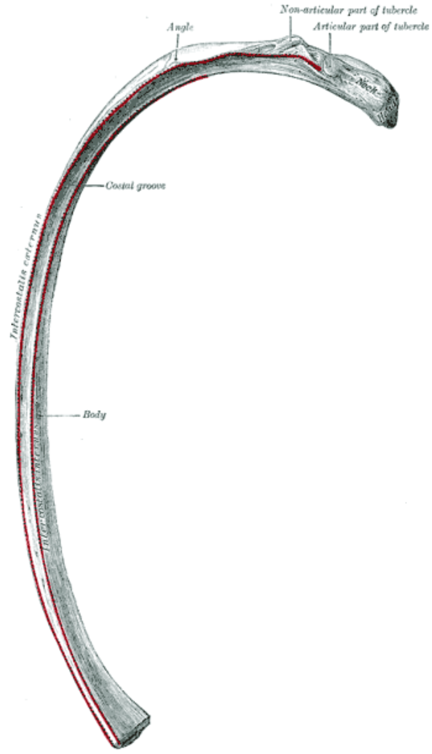


Figure 40 a typical rib

Each rib has:

- A head
- Two articular facets
  - At the **head** - for the vertebral body
  - At the **tubercle** - for the transverse process
- An angle, the most posterior part of the rib, where the rib direction changes and angles forwards
  - Except rib 1, which does not have an angle, only a tubercle
- A groove on its underside for the intercostal blood vessels and nerves

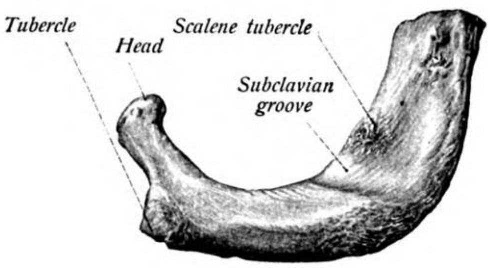


Figure 41 the First Rib

Rib 1, seen above, has:

- A head that articulates with the vertebral body
- A tubercle, which forms the posterior aspect of the costotransverse joint
- A groove on its superior side formed by the pressure of the subclavian vein
- The anterior end of the rib articulates with the superior end of the sternum immediately under the clavicle at the sternoclavicular joint

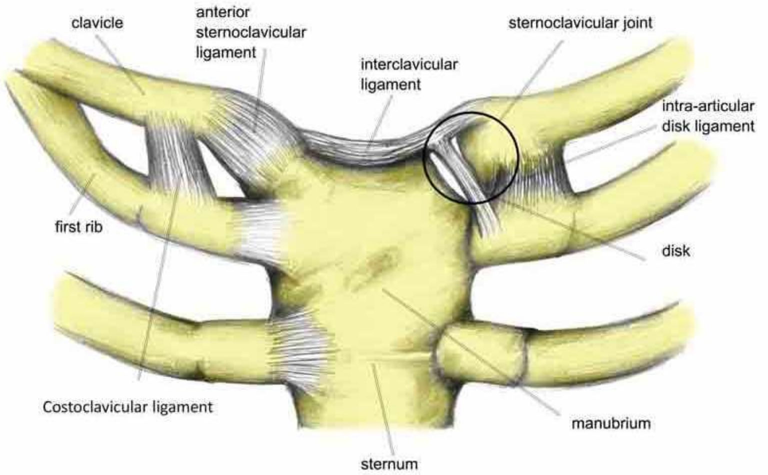


Figure 42 Sternoclavicular Joint

The sternoclavicular joint is a synovial joint of the saddle type. In addition to its own joint ligaments, it also has the supraclavicular ligament, running across the top of the sternum and joints, but also ligaments between the clavicle and the first rib.

Each rib also has:

- A body - the shaft
- All the ribs each have an articulation with the thoracic vertebral body: **Costovertebral Joint**
    - Rib 1 articulates directly with the body of T1
    - Rib 2 - 9 have a 'V' shaped head, which has an articulation between the vertebral bodies, each having a **hemifacet** on each adjacent vertebra
    - Ribs 10 - 12 have a direct articulation with their respective vertebral body
- From the head, each rib is directed backwards. Then there being a small length of rib, the neck, between the costovertebral joint and the next joint along its length. This joint between the rib and the transverse process - **Costotransverse joint**

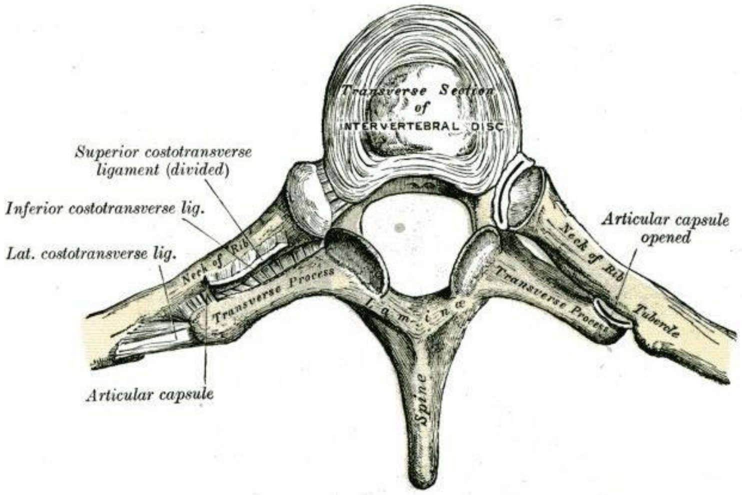


Figure 43 Thoracic spine with rib articulations

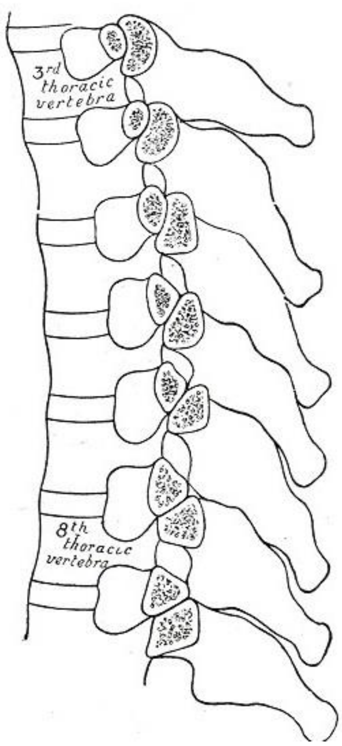


Figure 44 articular facets for ribs on vertebrae

This diagram demonstrates the variation of the articular facets for the ribs on the vertebral bodies.

T 1 and 2 only have one articular facet on their body. Between T 4 - 9 the head of the rib articulates with both adjacent vertebral bodies
T 10 - 12 again only have one articular facet on their vertebral body for the head of the rib

The vertebral bodies get larger going down the thoracic spine.

The summation of all these structures forms a cage - the rib cage, seen from above on the next page

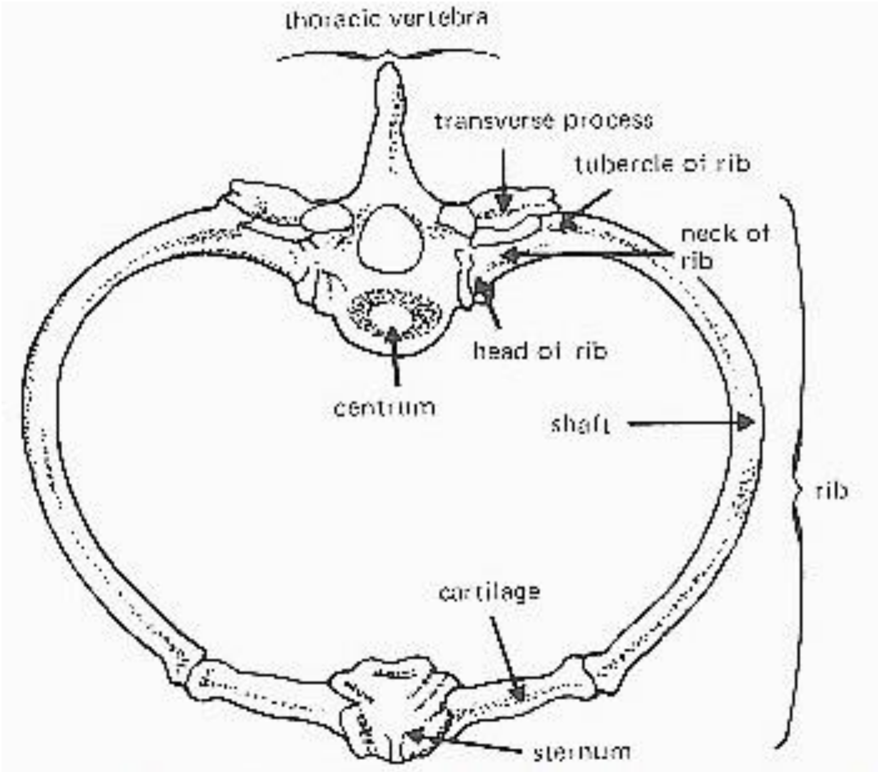
Thoracic spine anatomy

Rule of threes

- The comparative superficial spinous processes are used to locate the deeper and often difficult to palpate transverse processes.
- Rule of threes separates the thoracic vertebrae into 3 distinct groups, each with a different relationship between the spinous and transverse processes.
- The level of a thoracic spinous process and its corresponding transverse process is dependent on the region of the thoracic spine
- Anatomical landmarks are used to identify thoracic spinal segments (e.g., inferior angle of scapula: T7).
- Accurate identification is required to adequately treat spinal segment somatic dysfunctions.

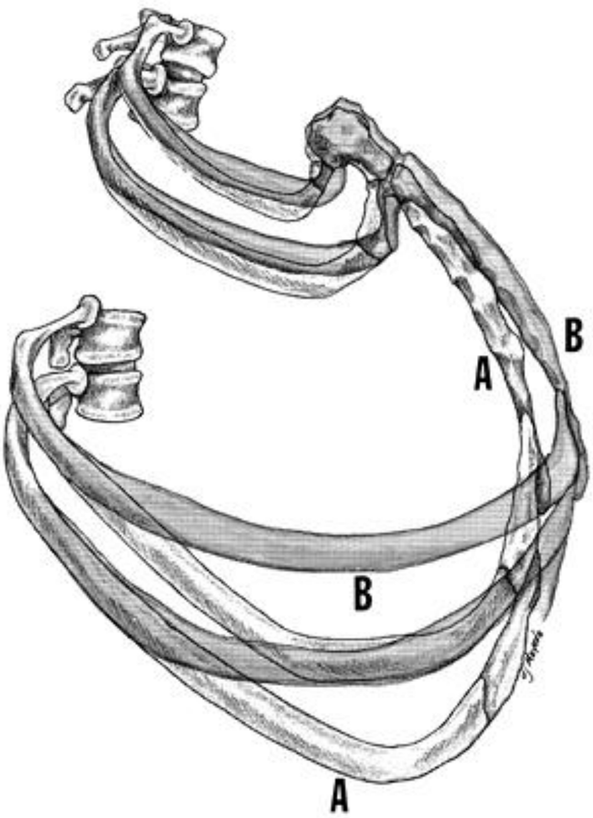
Thoracic vertebrae	**Transverse process location**	**Example**
T1–T3 & T12	At the same level as the spinous process	T2 transverse process is at the level of the T2 spinous process.
T4–T6 & T11	Halfway between its spinous process and the one above	T5 transverse process is halfway between the T5 spinous process and the T4 spinous process
T7–T9 & T10	At the level of the spinous process above	T9 transverse process is at the level of the T8 spinous process

Figure 45 the Rib Cage



This complex of joint structures, both posterior and anterior, allow for movement. The joints with the spine are all synovial gliding, allowing limited movement. However, as the rib has some length, there is an amplification effect along its length and the anterior end moves some distance. Hence the ribs can move up and down, giving us inhalation and exhalation.

Figure 46 Rib movement



The figure here shows rib movement. The ribs can move in two ways:

- **Pump handle**
  - Here the ribs move up and down at the front end, moving the sternum with them.
- **Bucket handle**
  - Here the ribs move up and down at their most lateral points, with the joints at the anterior and posterior ends of the rib allowing this.

This also demonstrates a reciprocal relationship between the thoracic spine and the ribs. If one is restricted, the other will be also.

Lumbar Spine

The five vertebrae in the lower back are the lumbar spine. The lumbar vertebrae are even larger than those in the thoracic region having more weight to bear, however, it is more flexible due to the increased disc space and the lack of ribs there. All the weight of the upper body bears down on the lumbar vertebrae and this may contribute to the problems experienced there. The pedicles are strong as are the laminae and the spinous process is thick and broad.

The vertebrae in the lumbar spine are numbered L1 through L5. These vertebrae (vertebral bodies) are the largest in the spine and support the head and trunk. For example, the L5 vertebra transfers upper body weight through the sacrum and pelvis into the legs. The sacrum consists of 5 vertebrae that are naturally fused and provides a stable platform for the spinal column. Although the bones of sacrum are fused, they are numbered S1 through S5. The pelvis is often referred to as the hip (though strictly speaking the hip is a joint)

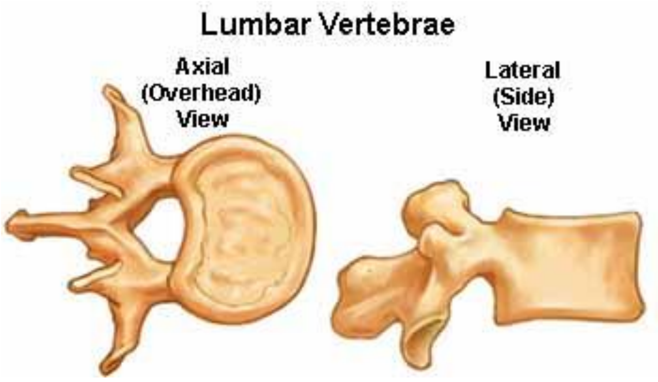


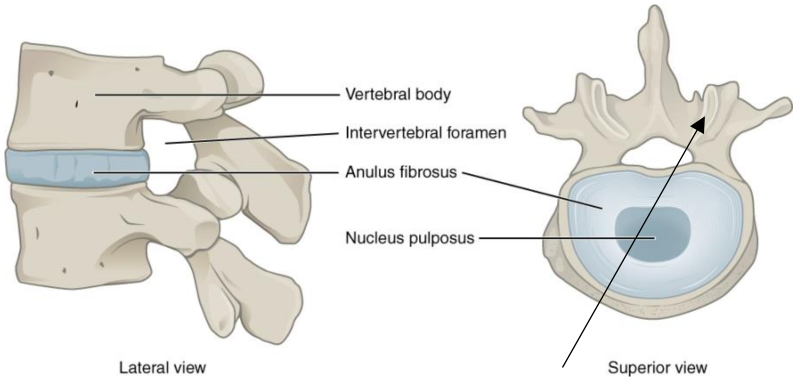
Figure 47 Typical lumbar Vertebra

Each lumbar vertebra shares a basic structure:

- **A vertebral body**
  - Largest in the spine
  - A large, kidney shaped, when viewed from above
- **Facet joints**
  - Aligned in the vertical and sagittal planes
- **Intervertebral disc**
  - Allowing the widest separation of vertebrae anywhere in the spine

Joints and movements

Figure 48 Intervertebral disc in Lumbar spine



The Articular facets in the lumbar spine are aligned largely in the sagittal plane

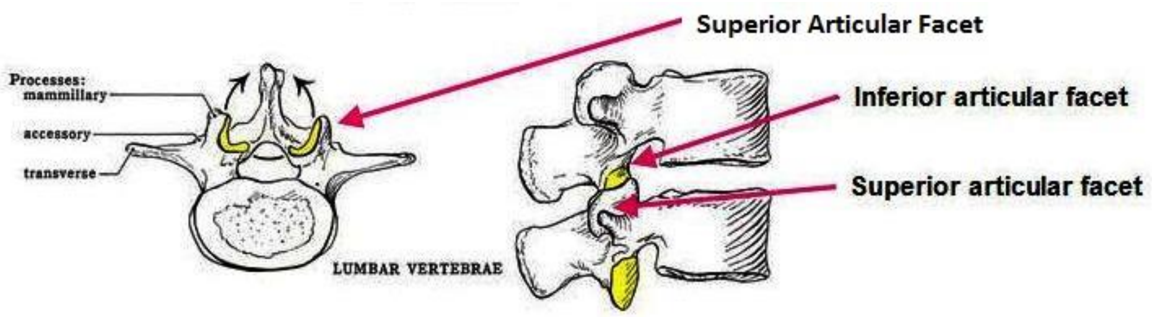
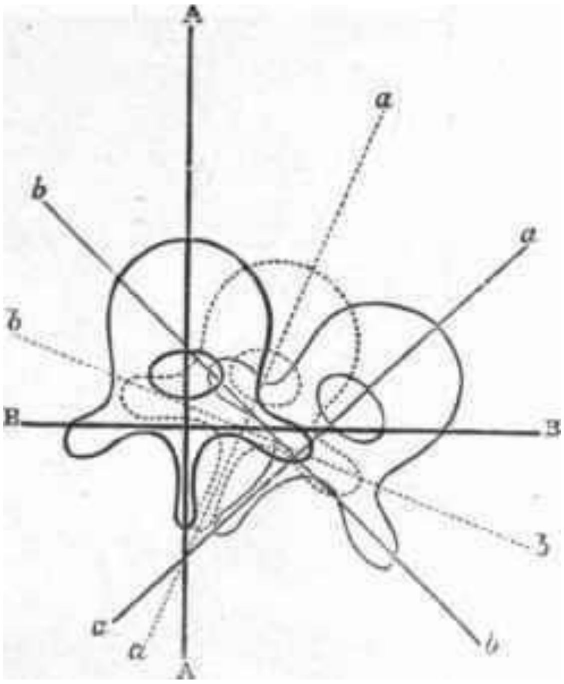
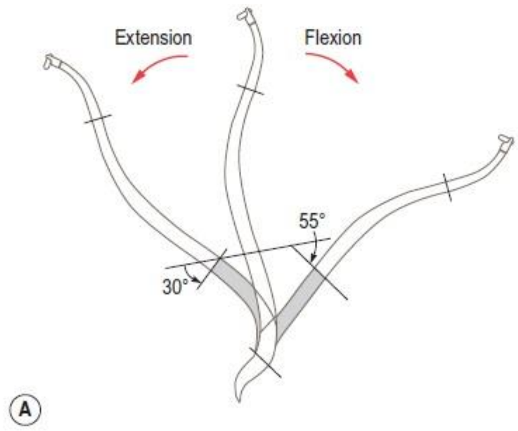


Figure 49 Lumbar spine articular facets



Even though the joints are small and gliding, the superior facets are mildly concave, so the alignment here allows some rotation movement, with the axis of rotation now posterior to the vertebra.

Figure 50 Lumbar spine axis of rotation



The facet alignment (in the sagittal plane) and significant disc space allows a great deal of flexion and extension in the lumbar spine, this complementing the movement in the hips for picking objects up.

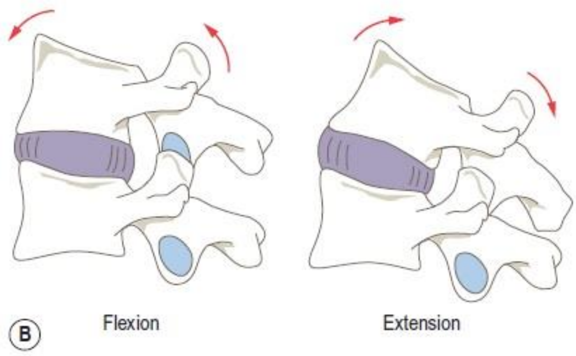


Figure 51 Range of movement in the lumbar spine

Kinematics and coupled motion of the spine

The osteopathic profession has used Fryette's model of the physiological movements of the spine to assist in the diagnosis of somatic dysfunction and the application of treatment techniques. Fryette outlined his research into the physiological movements of the vertebral column in 1918. He presented a model that indicated coupled motion occurred in the spine and displayed different coupling characteristics dependent upon spinal segmental level and posture.

The muscle energy approach is one system of segmental spinal lesion diagnosis and treatment predicated upon Fryette's Laws. Practitioners utilizing muscle energy technique (MET) use these laws of coupled motion as a predictive model both to formulate a mechanical diagnosis and to select the precisely controlled position required in the application of both muscle energy and thrust techniques. Current literature challenges the validity of Fryette's Laws.

Biomechanics

Convention dictates that intervertebral motion is described in relation to motion of the superior vertebra upon the inferior vertebra. Motion is further defined in relation to the anterior surface of the vertebral body; an example of which would be the direction of vertebral rotation, which is described in relation to the direction in which the anterior surface of the vertebra moves rather than the posterior elements.

In the clinical setting, vertebral motion is described using standard anatomical cardinal planes and axes of the body. Spinal motion can be described as rotation around, and translation along, an axis as the vertebral body moves along one of the cardinal planes. By convention the vertical axis is labelled the *y*-axis; the horizontal axis is labelled the *x*-axis; and the antero-posterior axis is the *z*-axis.

Axes of motion of the vertebral column

In biomechanical terms, flexion is anterior (sagittal) rotation of the superior vertebra around the x-axis, while there is accompanying forward (sagittal) translation of the vertebral body along the z-axis. In extension, the opposite occurs and the superior vertebra rotates posteriorly

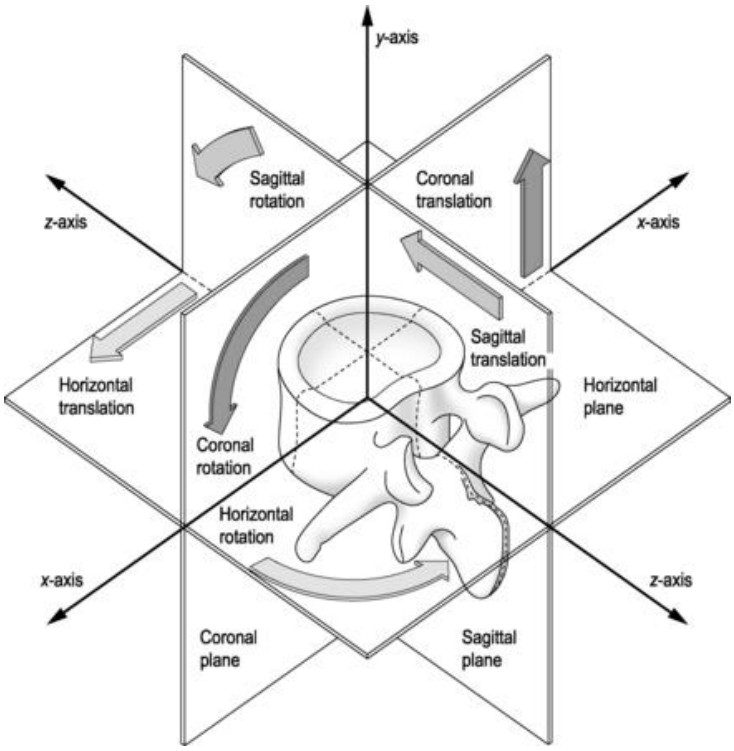


Figure 52 Axes of motion

around the x-axis and translates posteriorly along the z-axis.

In sidebending, there is bone rotation around the antero-posterior *z*-axis, but sidebending is rarely a pure movement and is generally accompanied by vertebral rotation. The combination, and association, of one movement with others is termed ‘coupled motion’. The concept of coupled motion is not recent. As early as 1905, Lovett published his observations of coupled motion of the spine.

Coupled Motion

Coupled motion is described by White and Panjabi as a ‘phenomenon of consistent association of one motion (translation or rotation) about an axis with another motion about a second axis’. Bogduk and Twomey describe coupled movements as ‘movements that occur in an unintended or unexpected direction during the execution of a desired motion’. Stokes et a simply state coupling to be when ‘a primary (or intentional) movement results in a joint also moving in other directions’. Where rotation occurs in a consistent manner as an accompaniment to sidebending it has been termed conjunct rotation. Therefore, in rotation the vertebra should rotate around the vertical *y*-axis but translation will be complex dependent upon the extent and direction of coupling movements. Coupling will cause shifting axes of motion.

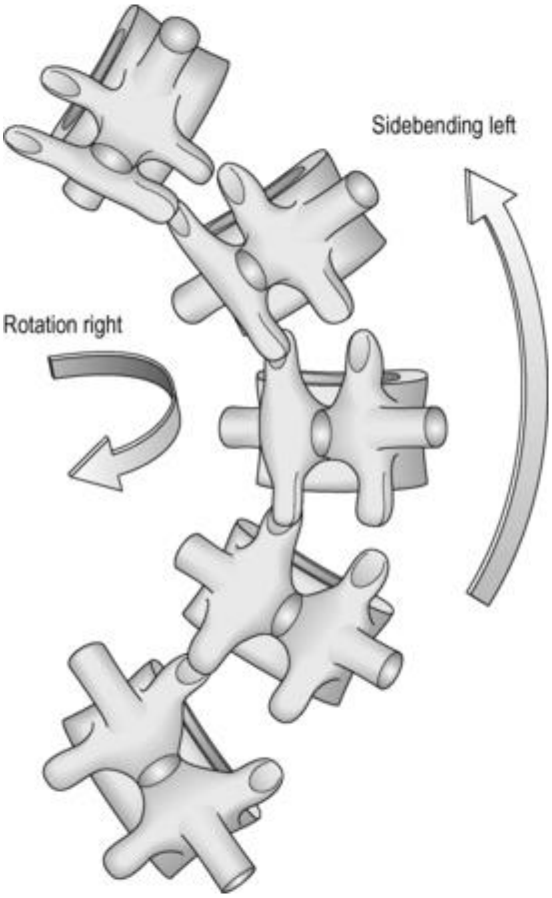


Figure 53 Type 1 movement - side-bending and rotation to contralateral sides

Greenman maintains that rotation of the spinal column is always coupled with sidebending with the exception of the atlanto-axial joint. The coupled rotation can be in the same direction as sidebending (e.g., sidebending right, rotation right) or in opposite directions (e.g. sidebending right, rotation left). The osteopathic profession developed the convention of naming the coupled movements as Type 1 and Type 2 movements

Type 1 movement. Sidebending and rotation occur to opposite sides.

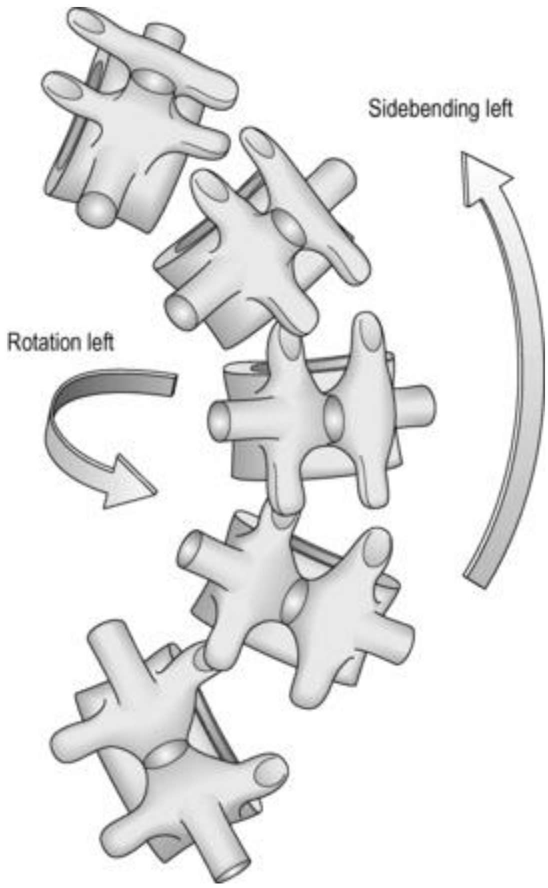


Figure 54 Type 2 movement - Side-bending and rotation to ipsilateral side

Type 2 movement. Sidebending and rotation occur to the same side.

These concepts of vertebral motion are attributed to Fryette. Fryette acknowledges the contribution made to his understanding of spinal movement by Lovett. Lovett had undertaken research on cadavers in order to understand the structure and aetiology of scoliotic curves.

Fryette acknowledged that Lovett's findings for the thoracic and lumbar spine were correct in the position Lovett had placed the spine for his cadaveric experiments but maintained they would not be true if the lumbar and thoracic spine were placed in different positions of flexion or extension. Fryette performed his own experiments upon a 'spine mounted in soft rubber' and introduced the concept of neutral (facets not engaged) and non-neutral (facets engaged and controlling vertebral motion) positioning. Fryette defined neutral 'to mean the position of any area of the spine in which the facets are idling, in the position between the beginning of flexion and the beginning of extension'. In the cervical spine below C2, the facets are considered always to be in a non-neutral position and are therefore assumed to control vertebral motion. The thoracic and lumbar regions have the possibility of neutral and non-neutral positioning. Mitchell summarizes Fryette's Laws as follows:

Fryette's Laws

• **Law 1**. Neutral sidebending produces rotation to the other side or, in other words, the sidebending group rotates itself toward the convexity of the sidebend, with maximum rotation at the apex.

• Law 2. Non-neutral (vertebra hyperflexed or hyperextended) rotation and sidebending go to the same side, individual joints acting at one time.

• **Law 3**. Introducing motion to a vertebral joint in one plane automatically reduces its mobility in the other two planes.

Research into coupled movement has been undertaken on cadavers and live subjects. Cadaver research has allowed precise measurements to be taken of coupling behaviour but has the disadvantage of being unable to reflect the activity of muscles or the accurate effects of load on different postures. Plain radiography has been superseded by the more accurate biplanar radiographic studies that allow research to be undertaken under more normal physiological conditions. Most research has been performed on the lumbar spine.

Reviews of the literature conclude that coupled motion exists but there is conflicting evidence as to the specific characteristics of coupled motion. Many authors have demonstrated a coupling relationship between sidebending and rotation but there is inconsistent reporting of the direction of coupling. Other authors maintain that sidebending and rotation are purely uniplanar motion occurring independently of each other.

Sacrum and Coccyx

The sacrum is made up five bones fused together

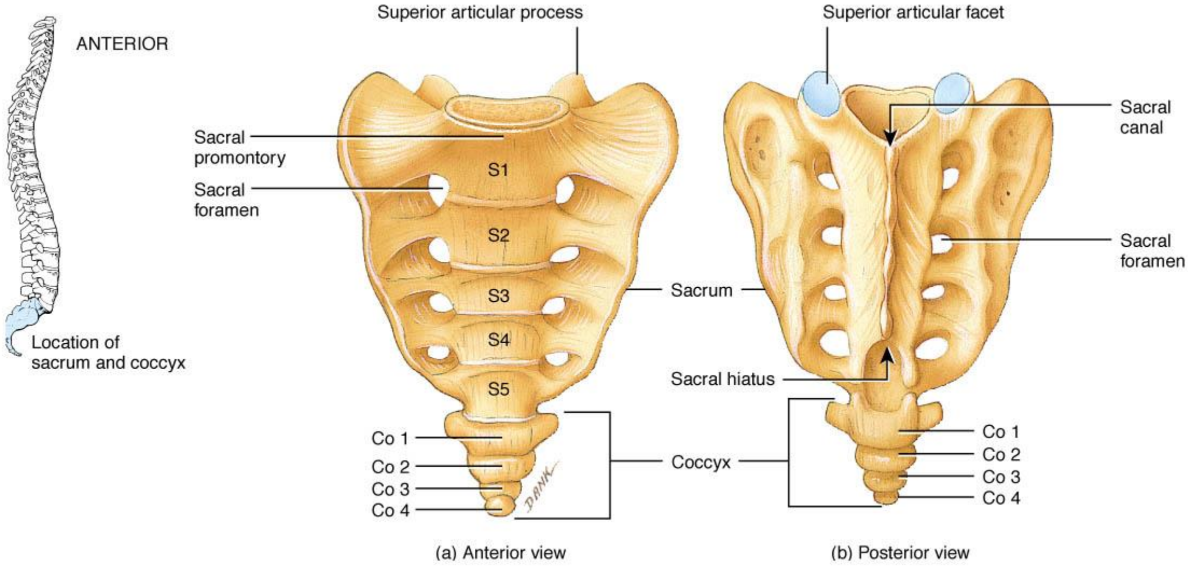


Figure 55 the Sacrum

It is described as an upside-down **triangle**, with the apex pointing inferiorly. On the lateral walls of the sacrum (S1-S3) are facets, for articulation with the pelvis at the Sacro-iliac joints.

The coccyx is a small bone of 3-5 bones fused together, which articulates with the apex of the sacrum and is recognised by its lack of **vertebral arches**. The sacrum has a vertebral canal, though the vertebral arches are fused as one, its ending at its inferior end as a hiatus (an opening). With the coccyx, though, there is no vertebral canal, so does not transmit the spinal cord.

If you want more information on the sacrum, sacroiliac joints and the pelvis, see the section on The Pelvis

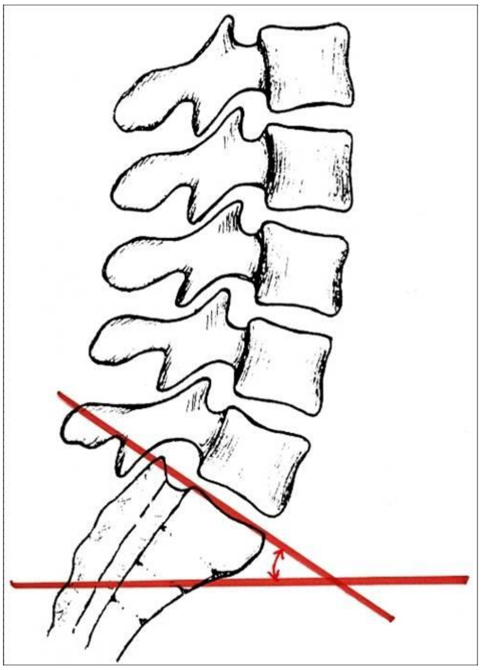


Figure 56 Sacral Angle

Joints and movements

The facets at the top of the sacrum are aligned in the transverse plane, the primary reason for this is to stabilise the lumbar spine on top of the sacrum and prevent any anterior shift of L5 on top of S1. This because of the sacral angle; the angle of inclination of the top surface of the sacrum, which is normally 30^o.

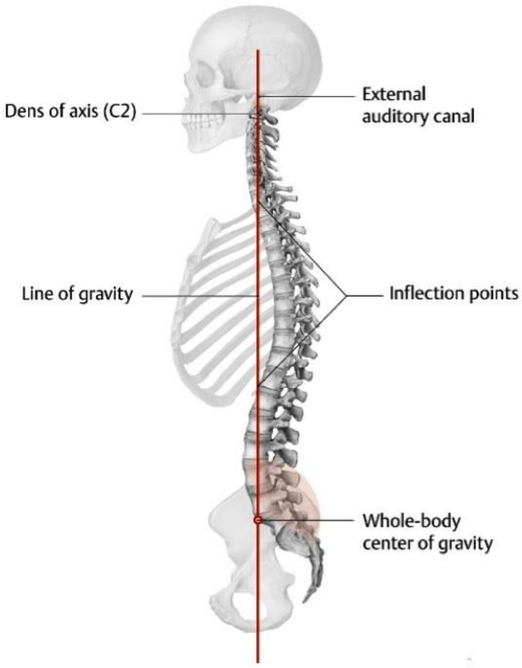
The transverse (coronal) alignment of the lumbosacral facets is present to prevent the fifth lumbar sliding forward off the upper surface of the sacrum.

Curvatures of the Spine

In the normal adult there are four curvatures in the vertebral column in the anteroposterior (A/P) plane. These serve to align the head with a vertical line through the pelvis.

- A curvature concave anterior is a kyphosis
- A curvature concave posterior is a lordosis

The function of these curvatures is help create and maintain a physiologic efficient posture.



In an ideal anatomically efficient posture, the centre of gravity falls through certain points:

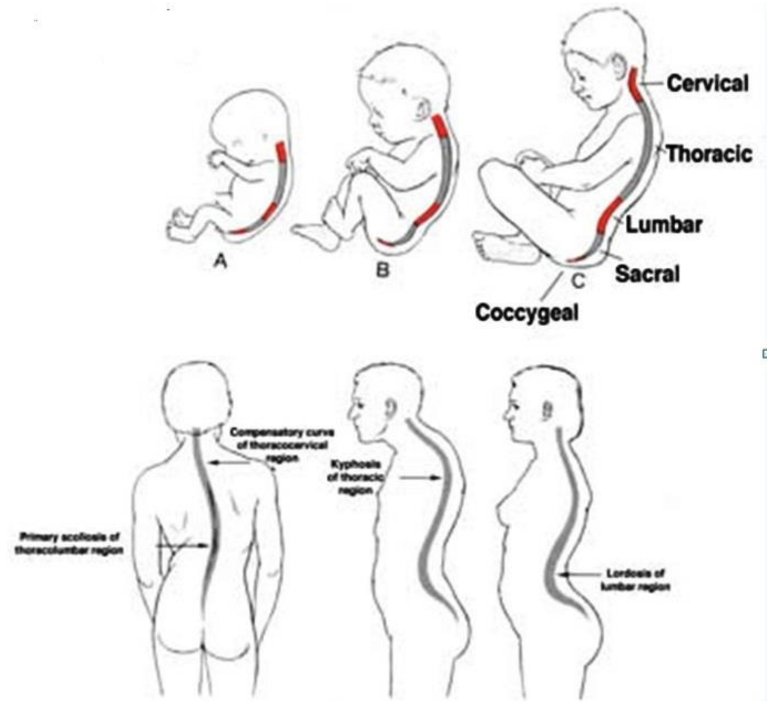
- Through the occipital base
- Through the dens
- Through the anterior edge of the body of C7
- Through the body of L1
- Through the anterior edge of S1 (sacral promontory)
- Through the hip
- Through the knee
- Through the ankle

Figure 57 Spinal centre of gravity

This format of spine is only the 'finished item', as it were. It wasn't born like this, though, the curves grew and developed.

Figure 58 Curvatures of the spine

In foetal life the whole of the spine was in a kyphosis. Then we learned to hold our head upright and the first secondary curvature developed; this is a reverse curvature, a **lordosis** - here in the cervical spine. Then we learned to walk on our hind limbs and our second secondary curvature, the lumbar lordosis, developed. Hence the normal kyphosis remains in the thoracic and sacral spines.



Deviations away from this physiologically efficient posture are usually defined in the adjective:

- **Kyphotic** - an exaggerated curvature concave anteriorly
  - If this is of significance it can create a hunchback deformity
- **Lordotic** - An exaggerated curvature concave posteriorly
  - If this is of significance it can manifest as a swayback deformity

Exaggerated kyphosis or lordosis can occur under some normal conditions (e.g. increased lumbar lordosis in pregnancy).

Scoliosis

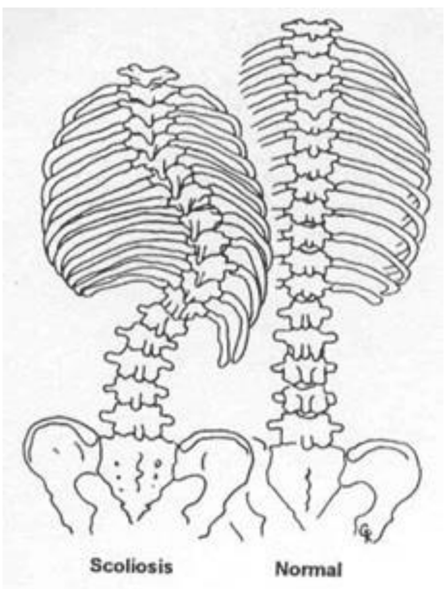
Any curvature of the vertebral column laterally away from the midline can occur normally or pathologically and is known as a **scoliosis**. A scoliosis can be both functional and organic.

Functional scoliosis

A functional scoliosis is a normal aberration of the curvature of the spine away from the line of centre of gravity. If you were walking along a bank, or even just stood on one foot, the centre of gravity would shift. The head would want to stay over the pelvis, so a curvature would appear in the spine to achieve this. If there is side bending in the normal spine, there will be contralateral rotation (to the opposite side). However, all the curvatures will normalise when both feet are returned to a level surface.

Figure 59 Functional scoliosis

Organic Scoliosis



An organic scoliosis is a curvature that develops during the growth process. Theories on causative factors vary, but it can be seen as persistent tension patterns within the fascia along, and even within, the axis of the spine. Such tension patterns will define how the bones (vertebrae, ribs and pelvis) grow.

Figure 60 Organic Scoliosis

Note the curvature of the spine and ribs. This can cause compression of internal visceral organs with their consequent dysfunction.

Rotation of the spine, particularly in the thoracic region, can have 'knock on' effects in attachments and adnexa in that region. With reference to the ribs the tension patterns that define how the spine develop and grow also effect the growth and development of the attached ribs.

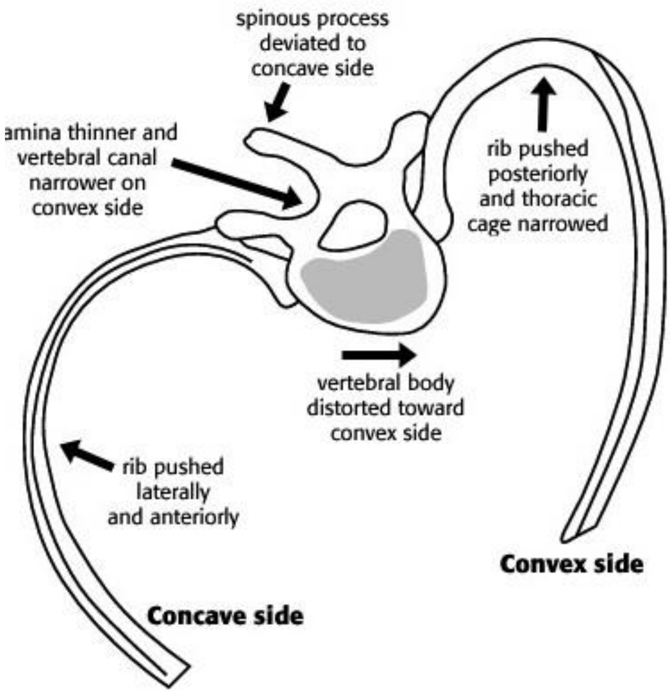


Figure 61 Scoliosis and ribs

Fig 56 here shows a level of the thoracic spine with its associated ribs.

Note:

- The rotation of the vertebral body.
- The difference in the angles of the ribs. Here the rib on the right of the diagram has a more acute angle compared with the rib on the left.
- Note that the spinous process is also being pulled over to the concave side, which also supports the concept of tension patterns of **pulling**.
- The bony configuration can affect the structure and function of the organs and viscera adjacent to the ribs
- Any organic scoliosis defines how each level of the spine grows and develops. Hence the facet joints grow and develop in response to this persistent, on-going, tension pattern and the facets do not have a normal configuration and alignment. Every vertebra will have an aberrant movement compared to normal

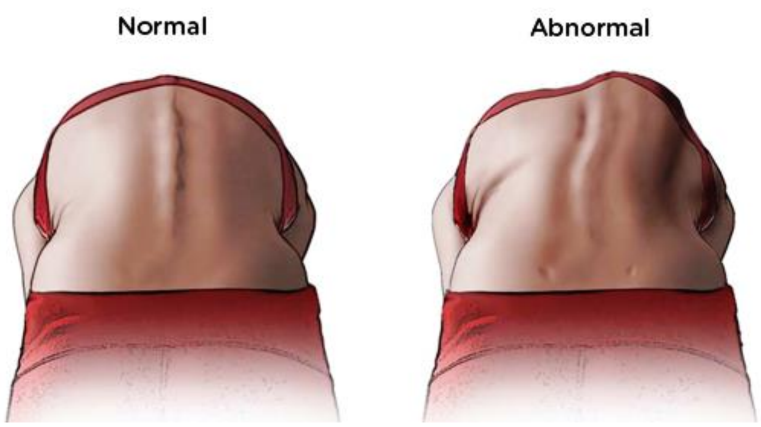


Figure 62 Scoliotic spine and ribs

Muscles moving the spine

The muscles moving the spine are numerous and complex. They can be simplified by grouping them into three groups:

- **Vertical muscles**
  - Spinalis
  - Longissimus
  - Iliocostalis
- **Oblique muscles**
  - Semispinalis
  - Multifidus
  - Rotatores
- **Deepest muscles**
  - Interspinales
  - Intertransversarii

These are long muscles, but in addition to these are:

- Suboccipital muscles
- Covering muscles

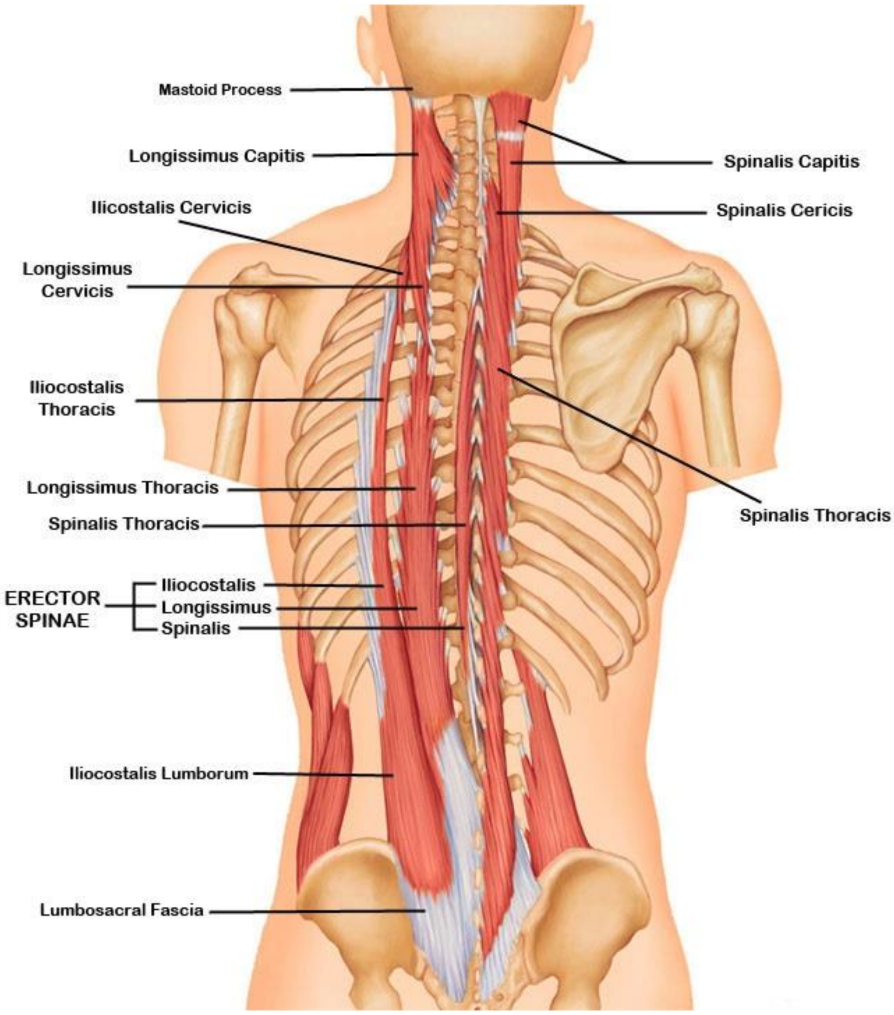


Figure 63 Spinal muscles

There are always more - but later. Taking these in groups:

Vertical Muscles

- **Spinalis**
- **Iliocostalis**
- **Longissimus**

Name	Origin	Insertion	Action	Nerve
Spinalis Thoracis, a medial continuation of the sacrospinalis	Spinous processes of T10-L2	Spinous processes of upper thoracic vertebrae	Unilaterally: Side-bends the head and neck to same side Bilaterally: Extends the vertebral column	Posterior primary division of spinal nerve
Cervicis	Lower end of ligamentum nuchae, spinous process of C7, and T1 and T2	Spinous process of C2		
Capitis *Usually inseparably connected to Semispinalis Capitis (see obliques)*				

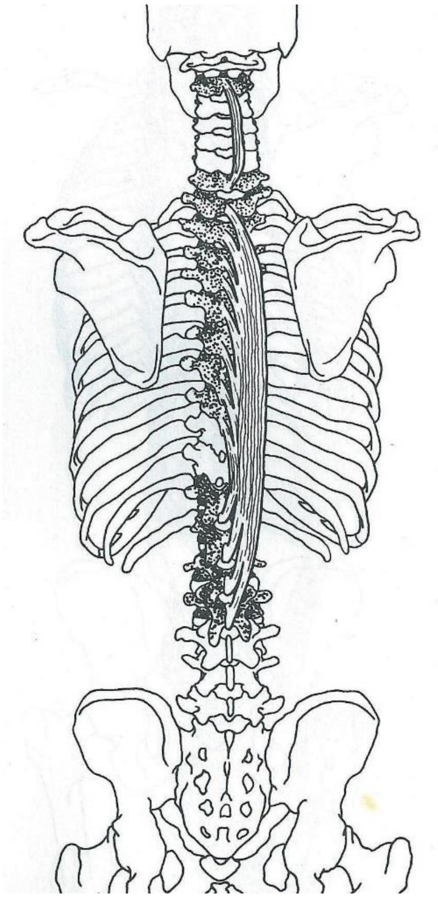


Figure 64 Spinalis

Iliocostalis

Iliocostalis is a band of muscle connecting the sacrum to the ribs to the neck

Name	Origin	Insertion	Action	Nerve
Iliocostalis				
Cervicis	Angles of ribs 3, 4, 5, 6	Posterior tubercles of transverse processes of C4, 5, 6	Unilaterally: Side-bends the head to the same side Bilaterally: Extends vertebral column	Posterior primary division of spinal nerve
Thoracis (dorsi)	From upper borders of angles of lower 6 ribs	Posterior tubercles of transverse processes of C4, 5, 6		
Lumborum	Iliac crest and thoracolumbar fascia	Inferior borders of angles of lower 6 or 7 ribs		

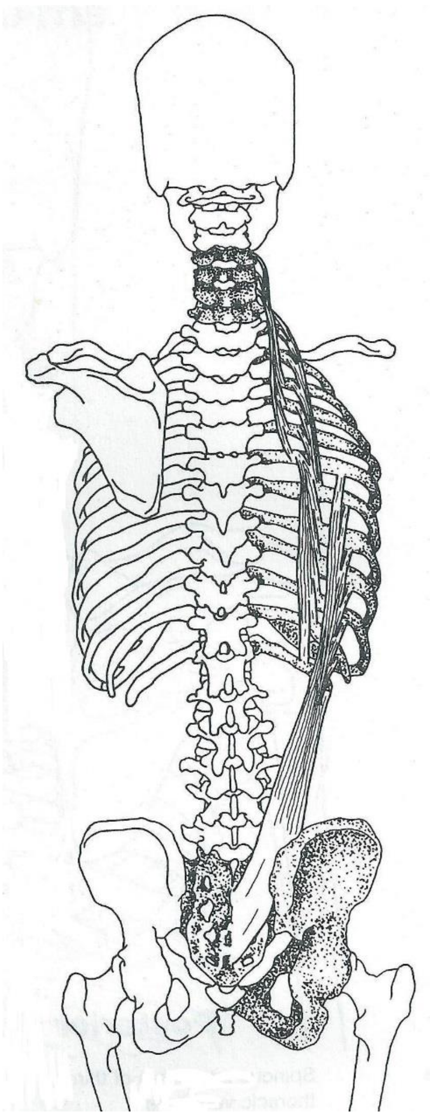
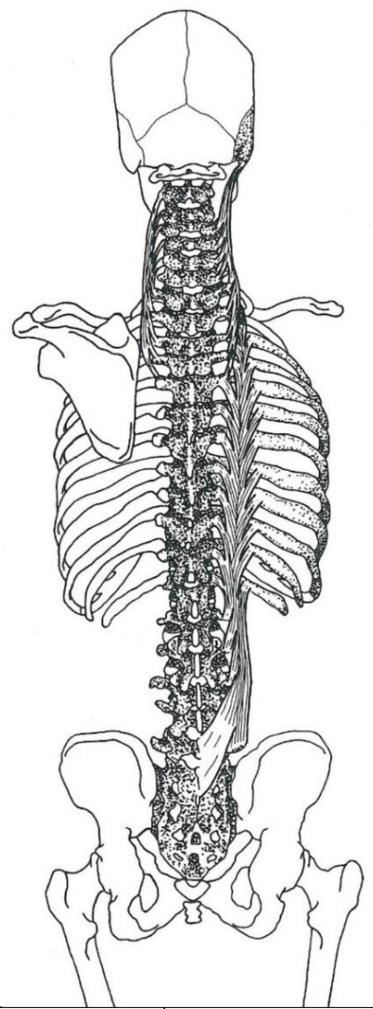


Figure 65 Iliocostalis



Longissimus

Longissimus extends from the sacrum up either side of the spine, to both the vertebrae and the ribs and on right up to the head

Figure 66 Longissimus

Name	Origin	Insertion	Action	Nerve
Longissimus				
Thoracis	Arises from the whole of the posterior surfaces of the transverse processes of the lumbar vertebrae and the thoracolumbar fascia	The tips of the transverse processes of all the thoracic vertebrae, and to the lower 9 or 10 ribs between their tubercles and angles	Unilaterally: Flex the head and neck to the same side. Bilaterally: Extend the vertebral column.	Posterior primary division of spinal nerve
Cervicis	Tops of the transverse processes of the upper four or five thoracic vertebrae	The posterior tubercles of the transverse processes of the cervical vertebrae from the second to the sixth inclusive		
Capitis	The transverse processes of the upper four or five thoracic vertebrae, and the articular processes of the lower three or four cervical vertebrae	The posterior margin of the mastoid process		

Obliques

There are three muscles in this group:

- **Semispinalis**
- **Multifidus**
- **Rotatores**

This group of muscles are deep to the vertical muscles. In the main, they pass from the transverse processes up obliquely to the spinous processes, only passing up one or two vertebrae. Their function is to rotate the spine contralaterally, to the opposite side.

Name	Origin	Insertion	Action	Nerve
Semispinalis				
Dorsi	Transverse processes T6-10	Spinous processes C6-7, T1-4	Rotates spine Contralaterally	Posterior primary division of spinal nerve
Cervicis	Transverse processes T1-6	Spinous processes C2-5		
Capitis	Transverse processes C7, T1-7	Tendon unites Superior and inferior Nuchal lines of occiput	Extends head	Greater occipital nerve

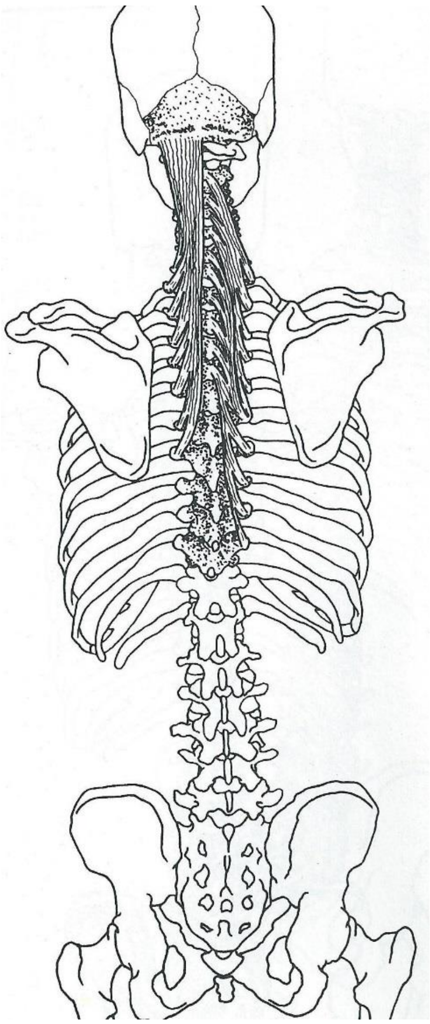


Figure 67 Semispinalis

Multifidus

Multifidus is a very thin muscle, filling the groove either side of the spinous processes from the sacrum to the axis. Its fibres originate from the transverse processes. They pass up obliquely, crossing 2 or 3 vertebral segments before inserting onto the spinous processes

Name	Origin	Insertion	Action	Nerve
Multifidus				
Sacrum	Posterior sacrum Aponeurosis with sacrospinalis Medial surface of the PSIS Posterior S/I ligaments	Fibres pass up and insert onto spinous process of vertebrae above	Rotates spine contralaterally Stabilises spine in local movements	Posterior primary division of spinal nerves
Lumbar	Mamillary processes			
Thoracic	All the transverse processes			
Cervical	Articular processes C4-7			

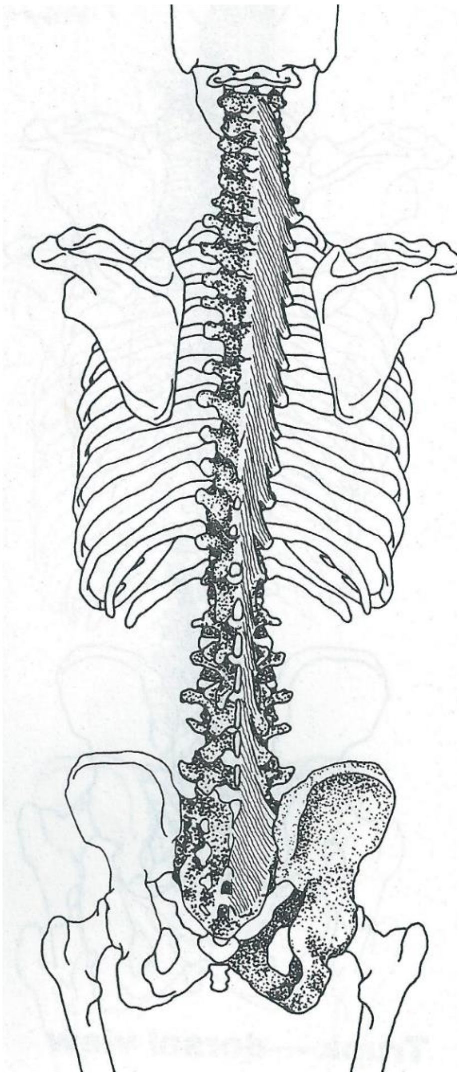


Figure 68 Multifidus: whole and in close up

Rotatores

These muscles present as a band of muscles on either side of the spine, deep to Multifidus, and are most prominent in the thoracic region.

Name	Origin	Insertion	Action	Nerve
Rotatores *They have a high number of proprioceptors and have been implicated in postural control*	The transverse processes From their posterior and Superior aspects	The lower border and lateral surface of the laminae, extending as far as the spinous processes	They rotate the spine contralaterally and stabilise the spine in local movements	Posterior roots of spinal nerves

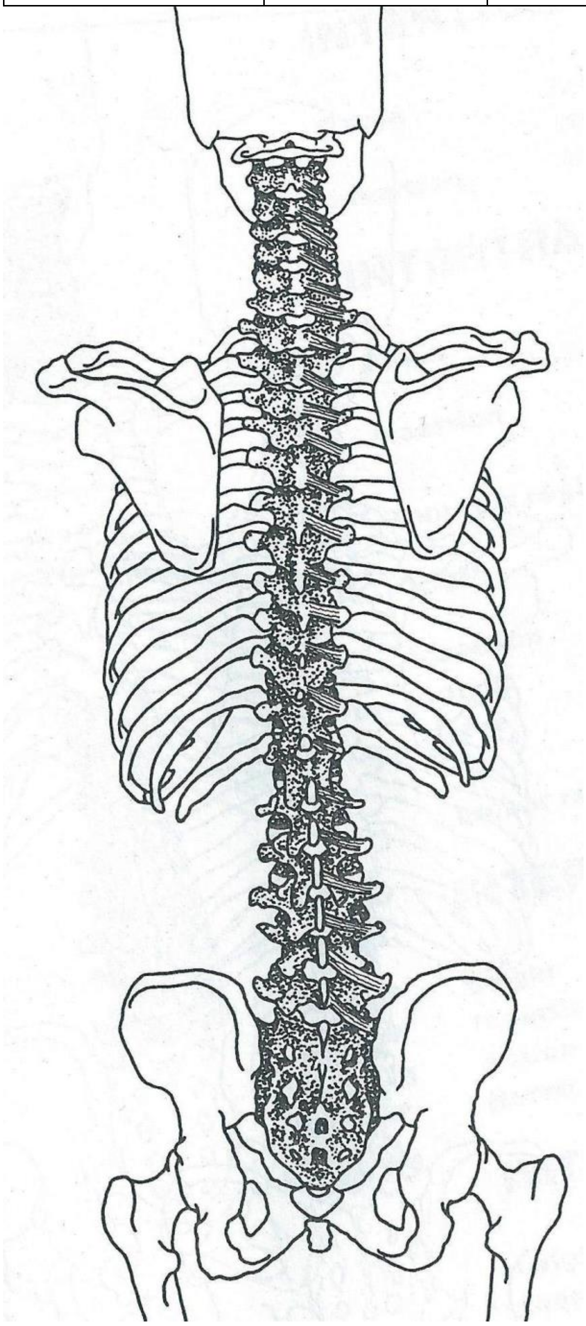
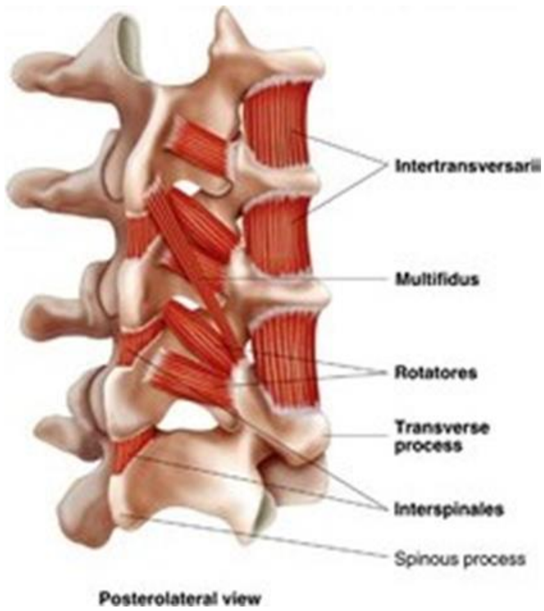


Figure 69 Rotatores



Deepest muscles

These are the deepest of all the spinal muscles. They are tiny muscles, passing between individual vertebrae. They are attached to the processes of the vertebrae and only occur in the cervical and lumbar spines, with a little overlap. They are:

- **Spinales**
- **Intertransversarii**

Name	Origin	Insertion	Action	Nerve
Spinales				
Cervical	Spinous processes C3-7	Spinous process of next vertebra above	Extends vertebral column	Posterior roots spinal nerves
Thoracic	Spinous processes T2-12			
Lumbar	Spinous processes L2-5			

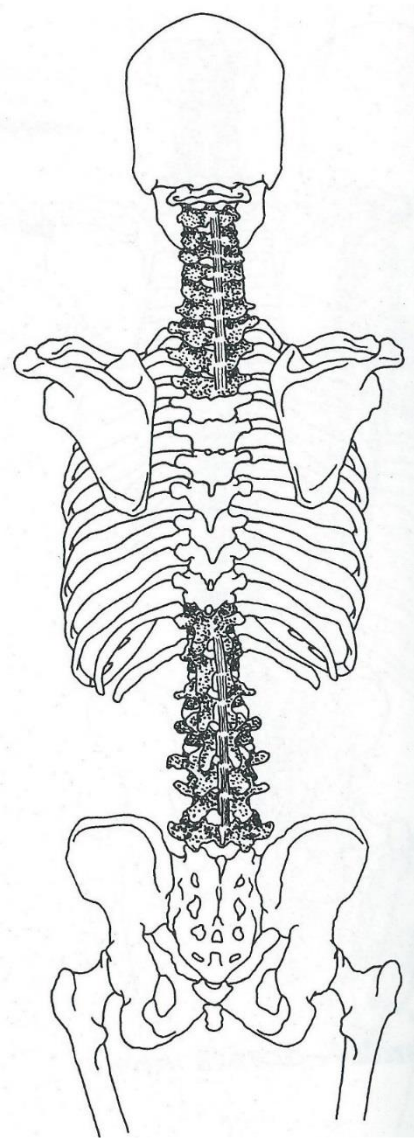
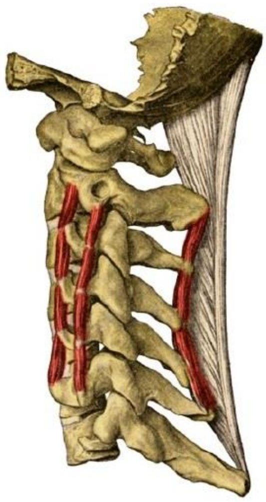
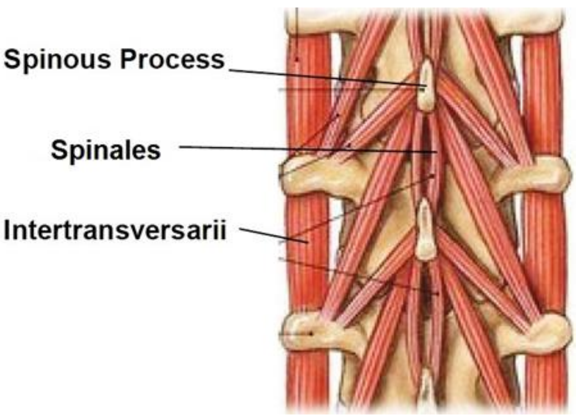


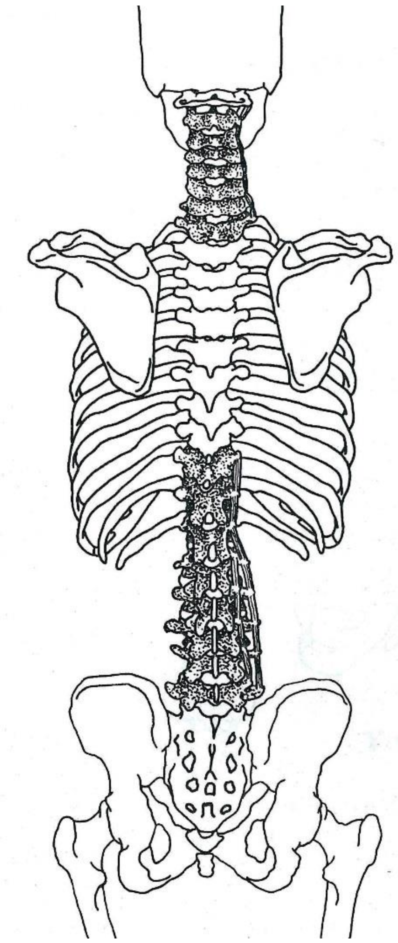
Figure 70 Spinales as a whole and in close up





Intertransversarii

Name	Origin	Insertion	Action	Nerve
Intertransversarii				
Cervical				
Anteriores	Anterior tubercle Transverse process T1 – C2	Anterior tubercle Next vertebra up	Side-bends spine Ipsilaterally	Anterior primary division spinal nerves
Posteriores	Posterior tubercle Transverse process T1 – C2	Posterior tubercle Next vertebra up	Side-bends spine ipsilaterally	
Thoracic	Transverse processes T11-L1	Transverse process next vertebra up	Side-bends spine ipsilaterally	
Lumbar				
Laterales	Transverse processes Lumbar vertebrae	Transverse process Next vertebra up	Side-bends spine ipsilaterally	Posterior primary division spinal nerves
Mediales	Mamillary process Lumbar vertebrae	Accessory process of next vertebra up	Side-bends spine ipsilaterally	Anterior primary division spinal nerves



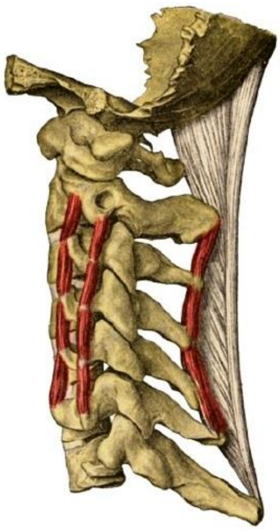
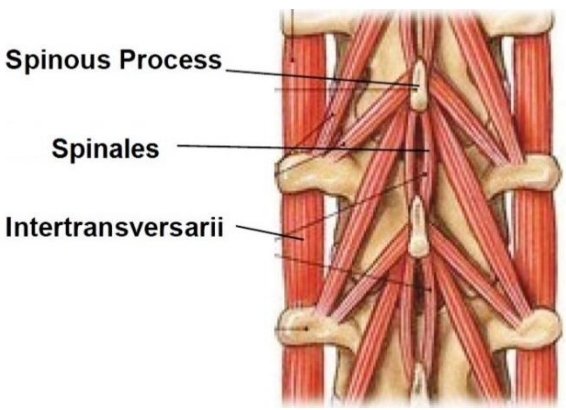


Figure 71 Intertransversarii



Suboccipital Muscles

All the muscles described so far extend the length of the spine, but the majority stop at C2.

All the muscles that attach onto the spine up as far as C2 rotate the spine contralaterally (to the opposite side). All the muscles above C2 and that attach directly onto the occiput rotate the head and neck ipsilaterally (to the same side). These muscles include:

- **The Suboccipital muscles**
- **The Splenius muscles**

The Suboccipital muscles (posterior)

Name	Origin	Insertion	Action	Nerve
Rectus Capitis Posterior Major	Spinous process C2	Lateral end Inferior nuchal line of occiput	Extends and rotates head ipsilaterally	Suboccipital C1
Rectus Capitis Posterior Minor	Posterior arch of C1	Medial end Inferior nuchal line of occiput	Extends head	Suboccipital C1
Obliquus Capitis Inferior	Spinous process of C2	Transverse process of C1	Rotates C1 ipsilaterally	Suboccipital C1
Obliquus Capitis Superior	Transverse process of C1	Between superior and inferior nuchal lines of occiput	Extends and side-bends head	Suboccipital C1

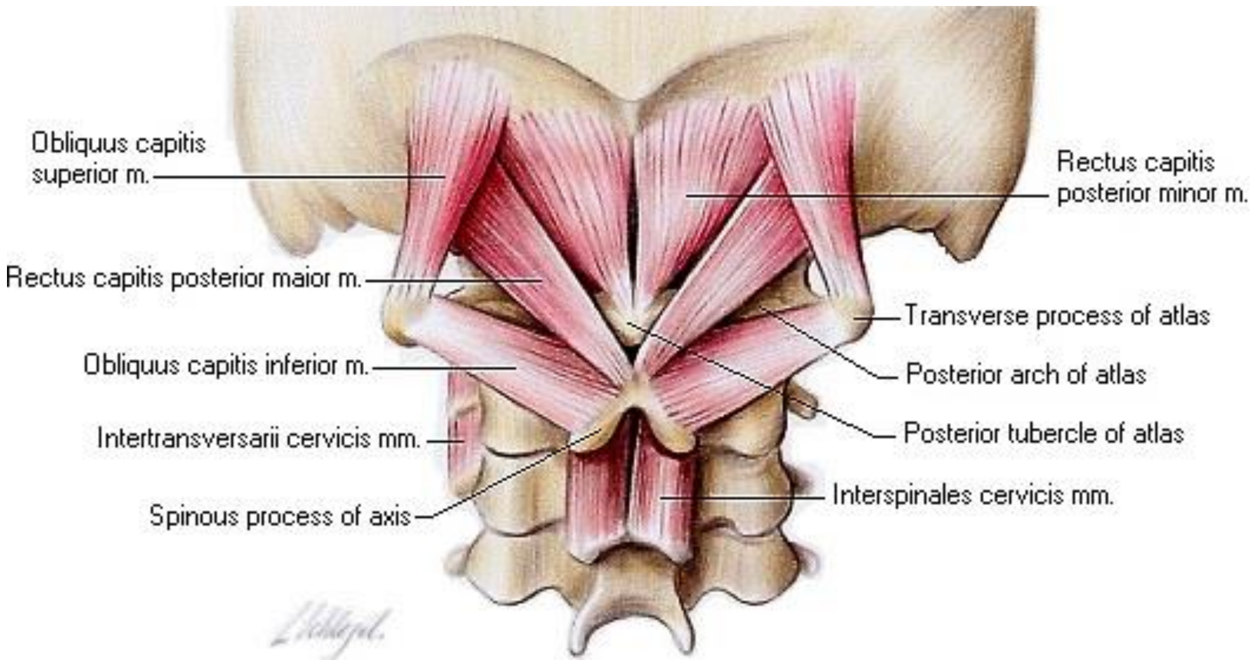


Figure 72 Suboccipital muscles – posterior

The anterior Suboccipital muscles number only two:

- **Rectus Capitis Anterior**
- **Rectus Capitis Lateralis**

Name	Origin	Insertion	Action	Nerve
Rectus Capitis Anterior	Anterior base of transverse processes of C1	Occiput anterior to foramen magnum	Flexes head	C2-3
Rectus Capitis Lateralis	Transverse process of C1	Jugular process of occiput	Side-bends O/A	C2-3

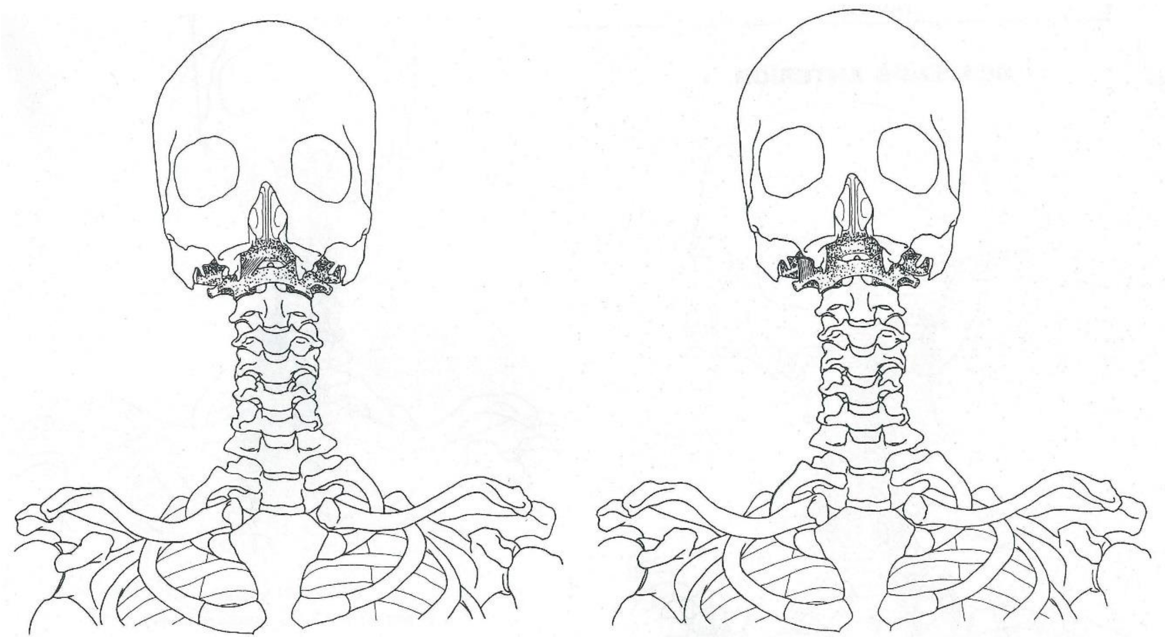


Figure 73 Rectus Capitis Anterior and Rectus Capitis Lateralis

The Splenius Muscles

The word 'splenius' derives from the Greek, meaning 'bandage'. These muscles are therefore seen as the most superficial of the posterior neck muscles.

There are two:

- Splenius Capitis
- Splenius Cervicis

Name	Origin	Insertion	Action	Nerve
Splenius Capitis	Lower end ligamentum nuchae Spinous process of C7, T1-4	Mastoid Process of temporal Lateral end superior nuchal line	Extends and ipsilaterally rotates head	Lateral branches of dorsal primary rami C3-4
Splenius Cervicis	Spinous process of T3-6	Transverse processes of C1-3	Extends and ipsilaterally rotates head	Lateral branches of dorsal primary rami of middle and lower cervical nerves

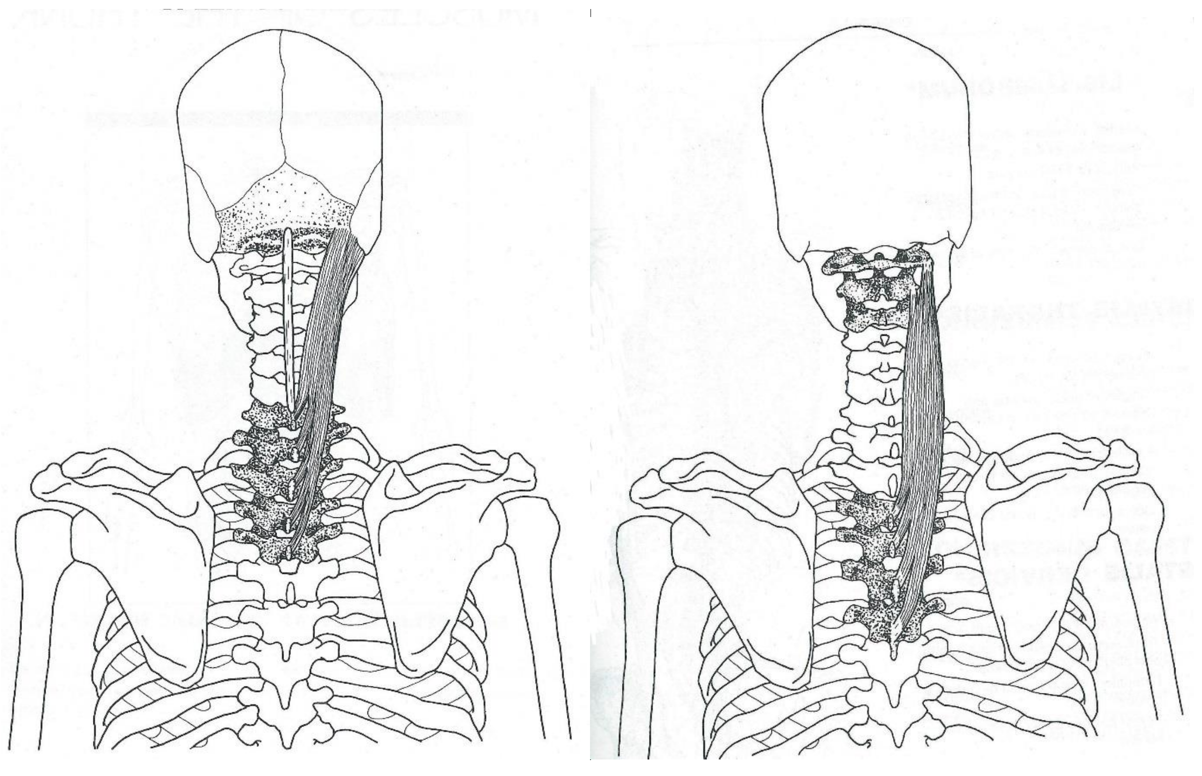
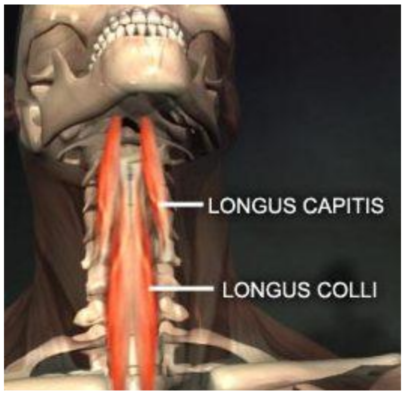


Figure 74 Splenius Capitis and Splenius Cervicis

Anterior and lateral neck muscles

Most muscles charts only show the superficial muscles of the spine, rarely the lateral and never the muscles on the anterior aspect of the cervical spine.



Anterior Cervical Muscles

There are two key ones here:

- Longus Capitis
- Longus Colli
    - This is seen as one muscle, but is subdivided into three parts

Name	Origin	Insertion	Action	Nerve
Longus Capitis	Transverse processes C3-6	Occiput anterior to foramen magnum	Flexes head	C1-3
Longus Colli				
Superior oblique part	Transverse processes of C3-5	Anterior arch of C1	Flexes cervical spine	C2-7
Inferior oblique part	Anterior surfaces of C1-3	Transverse processes of C5-6		
Vertical part	Anterior surfaces of bodies of C1-3 and C5-7	Anterior surfaces of C2-4		

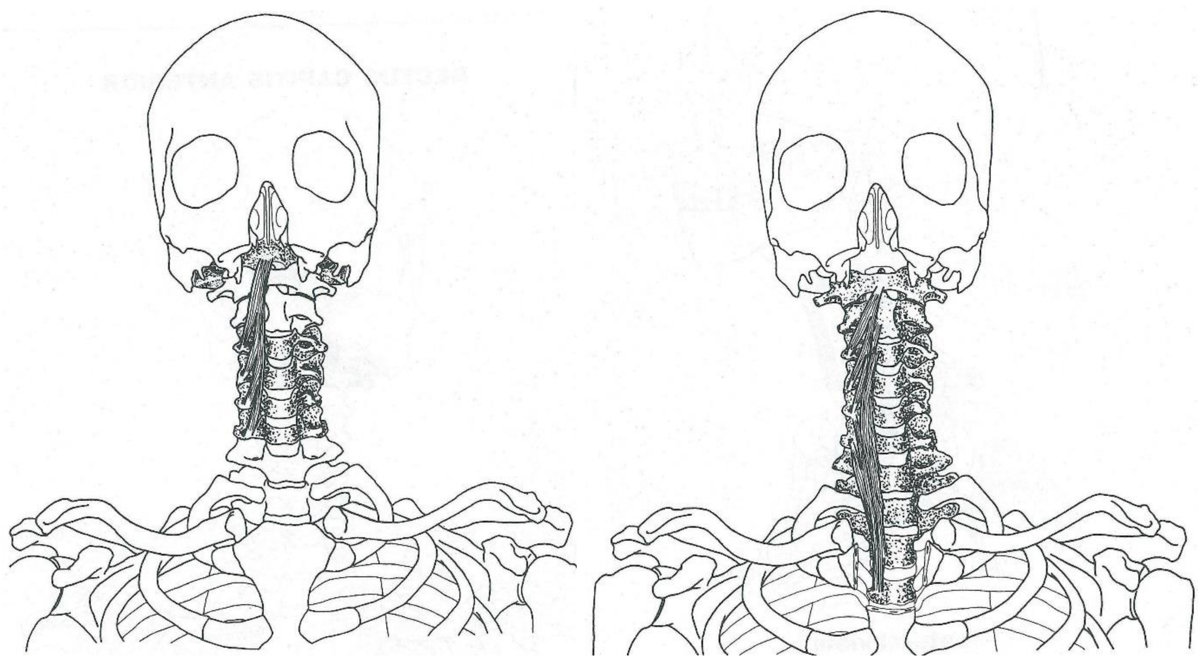


Figure 75 Longus Capitis and Longus Colli

The Scalene Muscles

The Scalenes are a group of muscles that pass between the side of the cervical spine and the upper two ribs. There are three:

- **Anterior scalene**
- **Medial scalene**
- **Posterior scalene**

Name	Origin	Insertion	Action	Nerve
Anterior Scalene	Transverse processes of C3-6	Inner border of Rib 1 (scalene tubercle)	Elevates Rib 1 (inspiration) Flexes and rotates neck contralaterally	Ventral rami of cervical nerves
Medial Scalene	Transverse processes C2-7	Upper surface of rib 1	Elevates rib 1 (inspiration) Flexes and rotates neck contralaterally	Ventral rami of cervical nerves
Posterior scalene	Transverse processes of C5-7	Outer surface of Rib 2	Elevates rib 2 (inspiration) Flexes and rotates neck contralaterally	Ventral rami of lower cervical nerves

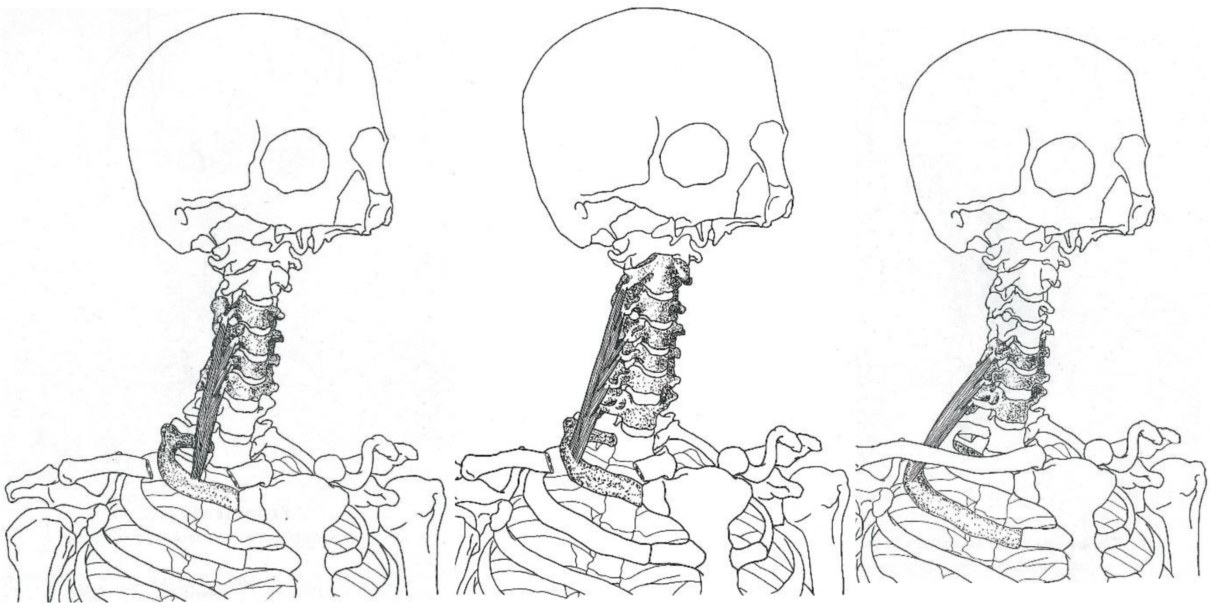


Figure 76 Scalenes: Anterior Medial and Posterior

Other muscles that attach onto ribs. These include the primary and secondary muscles of respiration.

Primary muscles of respiration:

- **Diaphragm**
- **External Intercostal Muscles**
- **Internal Intercostal Muscles**
- **Transversus Abdomis**

Diaphragm

Name	Origin	Insertion	Action	Nerve
Diaphragm				
Sternal	Inner part of xiphoid process	Central tendon	Draws tendon down, increasing volume of thoracic cavity	Phrenic nerve C3-5
Costal	Inner surfaces of lower 6 ribs and costal cartilages			
Lumbar (crura)	L1-3 lumbar vertebrae and medial lumbocostal arches			

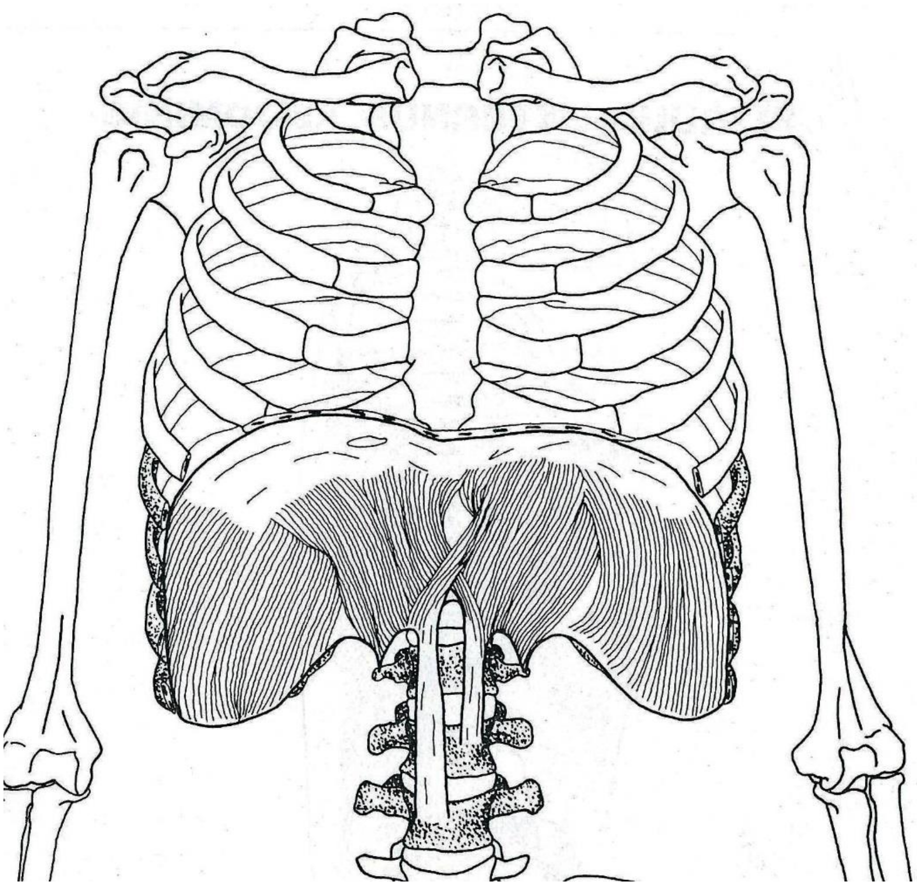


Figure 77 Diaphragm

Intercostals

Name	Origin	Insertion	Action	Nerve
External intercostal	Lower margin of upper eleven ribs *Fibres run down and forwards*	Superior border of rib below	Elevates anterior part of ribs Increases chest volume - inhalation	Intercostal nerve

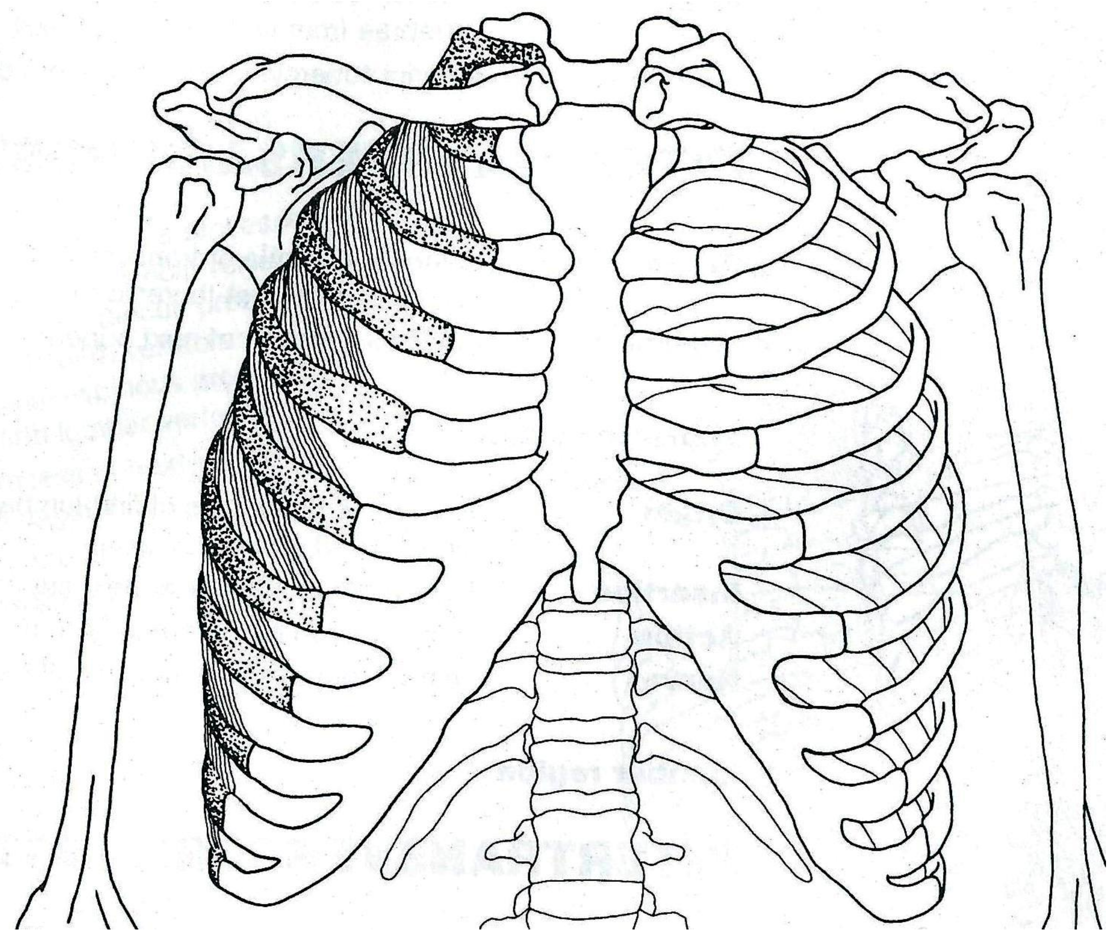


Figure 78 External intercostals

Intercostals

Name	Origin	Insertion	Action	Nerve
Internal intercostal	From cartilages to angles of upper eleven ribs *Fibres run up and forwards*	Superior border of rib below	Pulls anterior part of ribs down Decreases volume of chest cavity - exhalation	Intercostal nerve

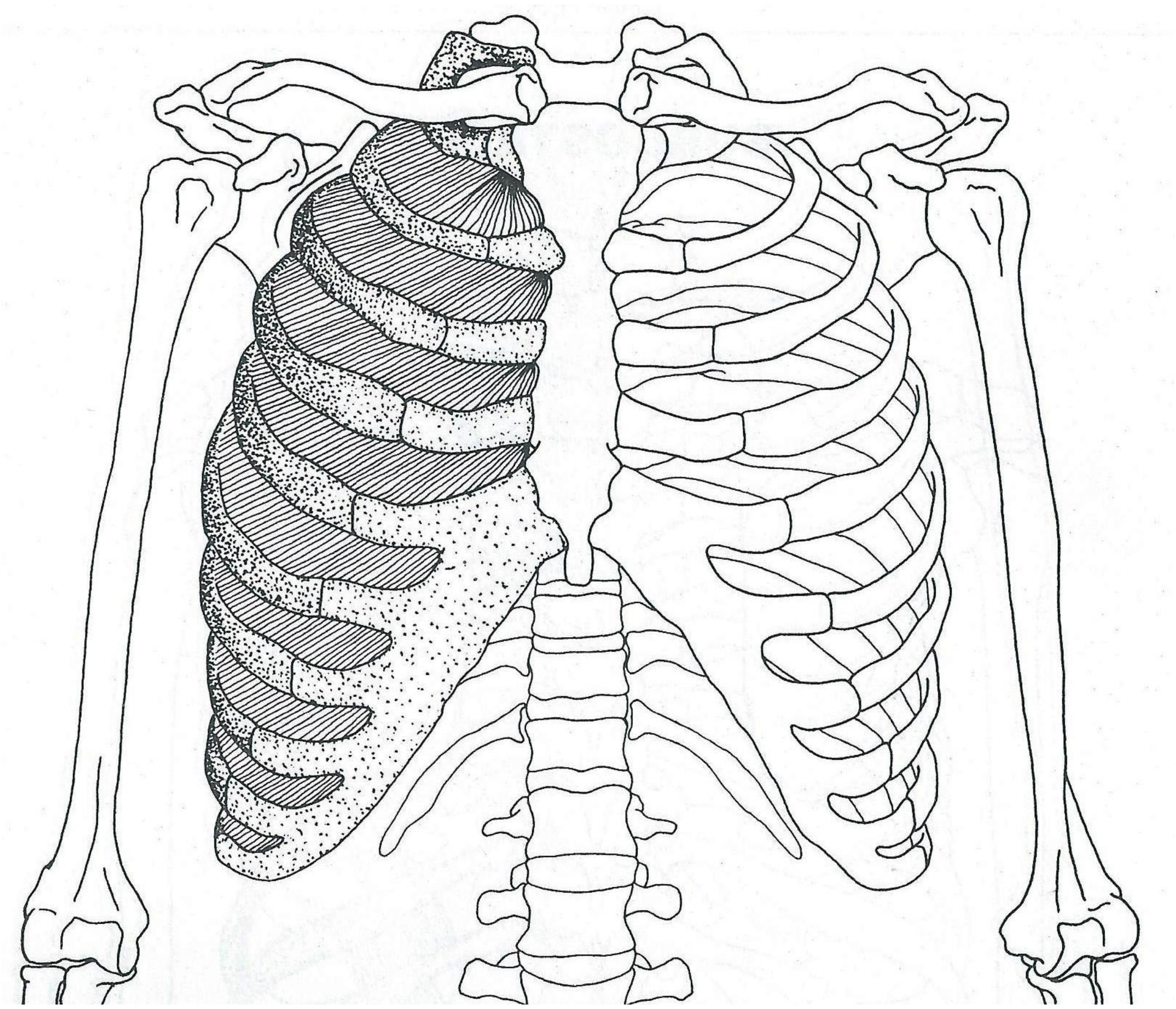


Figure 79 Internal Intercostals

Accessory Muscles of Respiration

Any muscle that attaches onto a rib potentially becomes a muscle of respiration, so this section cannot be complete without the others.

Subcostales

Name	Origin	Insertion	Action	Nerve
Subcostales	Inner surface of each rib at its angle *Fibres pass down and medially*	Inners surface of rib one or two below	Draws anterior part of rib down Decreases chest volume (exhalation)	Intercostal

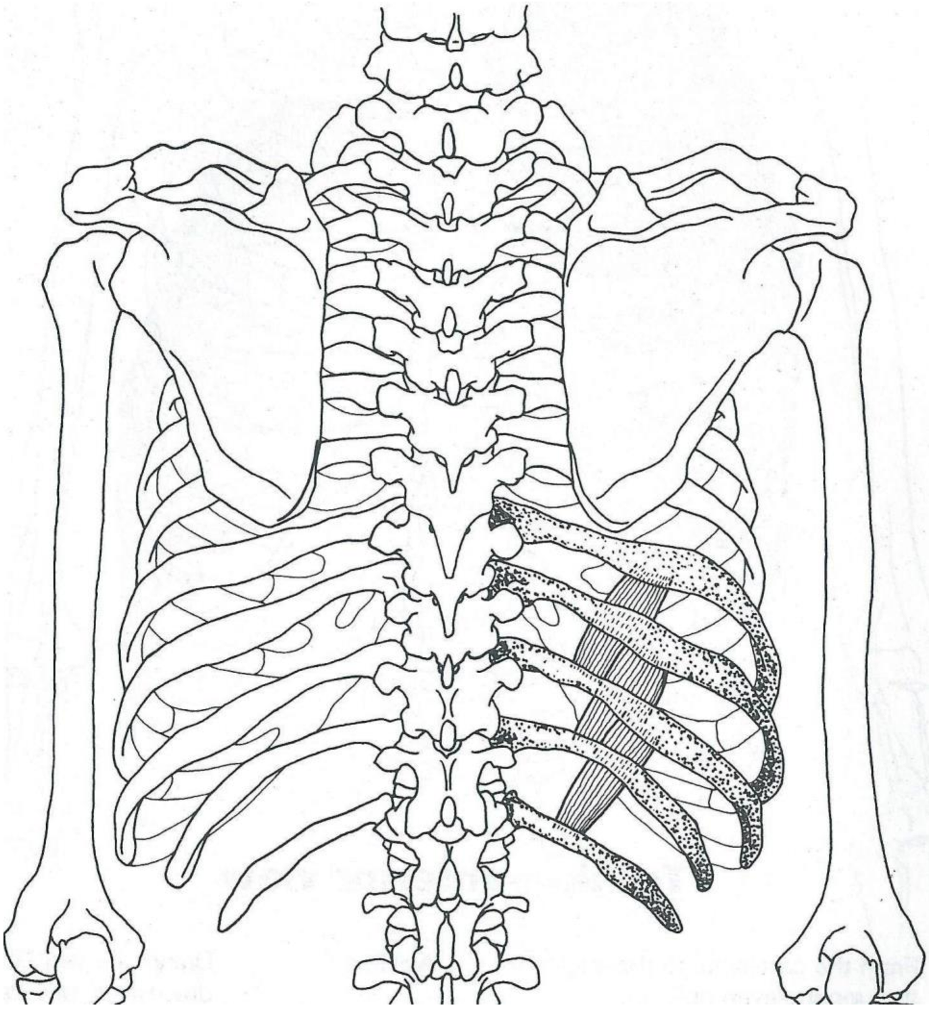


Figure 80 Subcostales

Transversus Thoracis

Name	Origin	Insertion	Action	Nerve
Transversus Thoracis	Inner surface of lower end sternum and adjacent costal cartilages	Inner surface of costal cartilages of ribs 2-6	Pulls down anterior end ribs, reducing chest volume exhalation	Intercostal

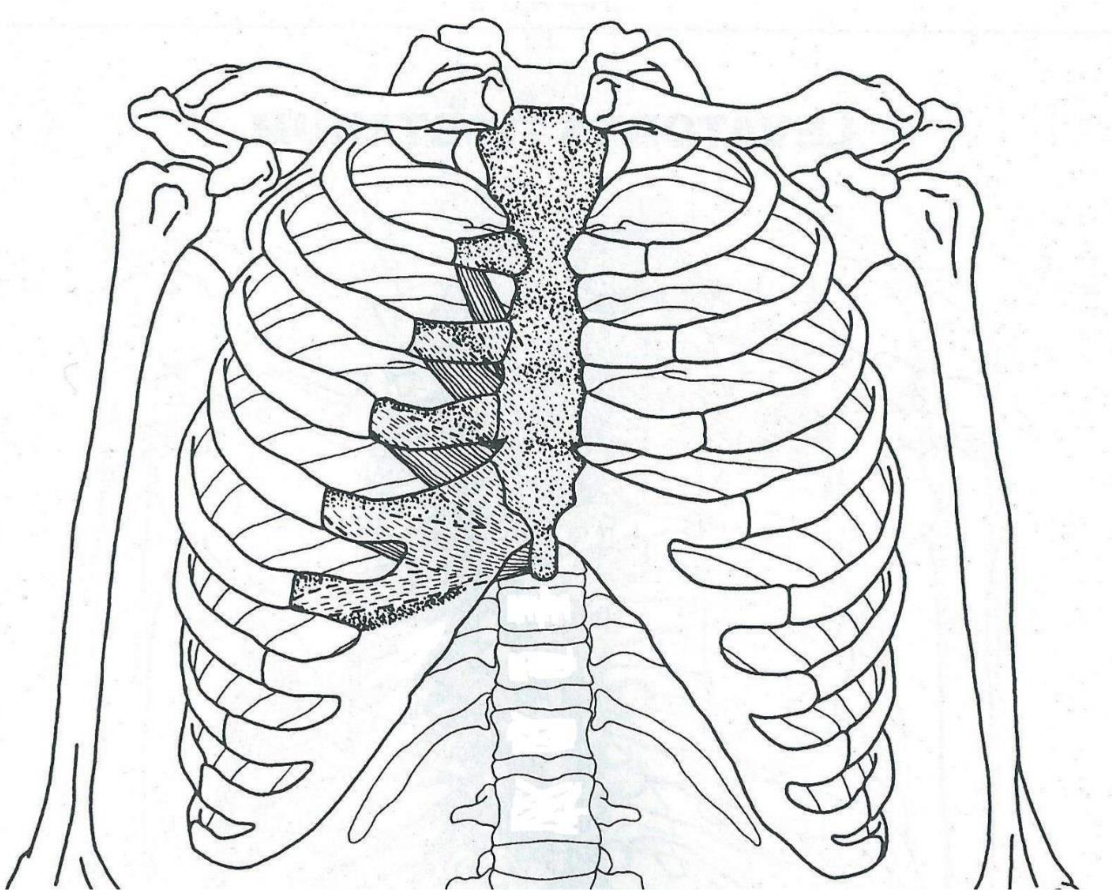


Figure 81 Transversus Thoracis

Levator Costae

Name	Origin	Insertion	Action	Nerve
Levator Costae	Transverse processes of C7 – T11 *Fibres pass down and laterally*	Outer surface of next lower rib	Elevates ribs Extends, Side-bends and contralaterally rotates spine	Intercostal

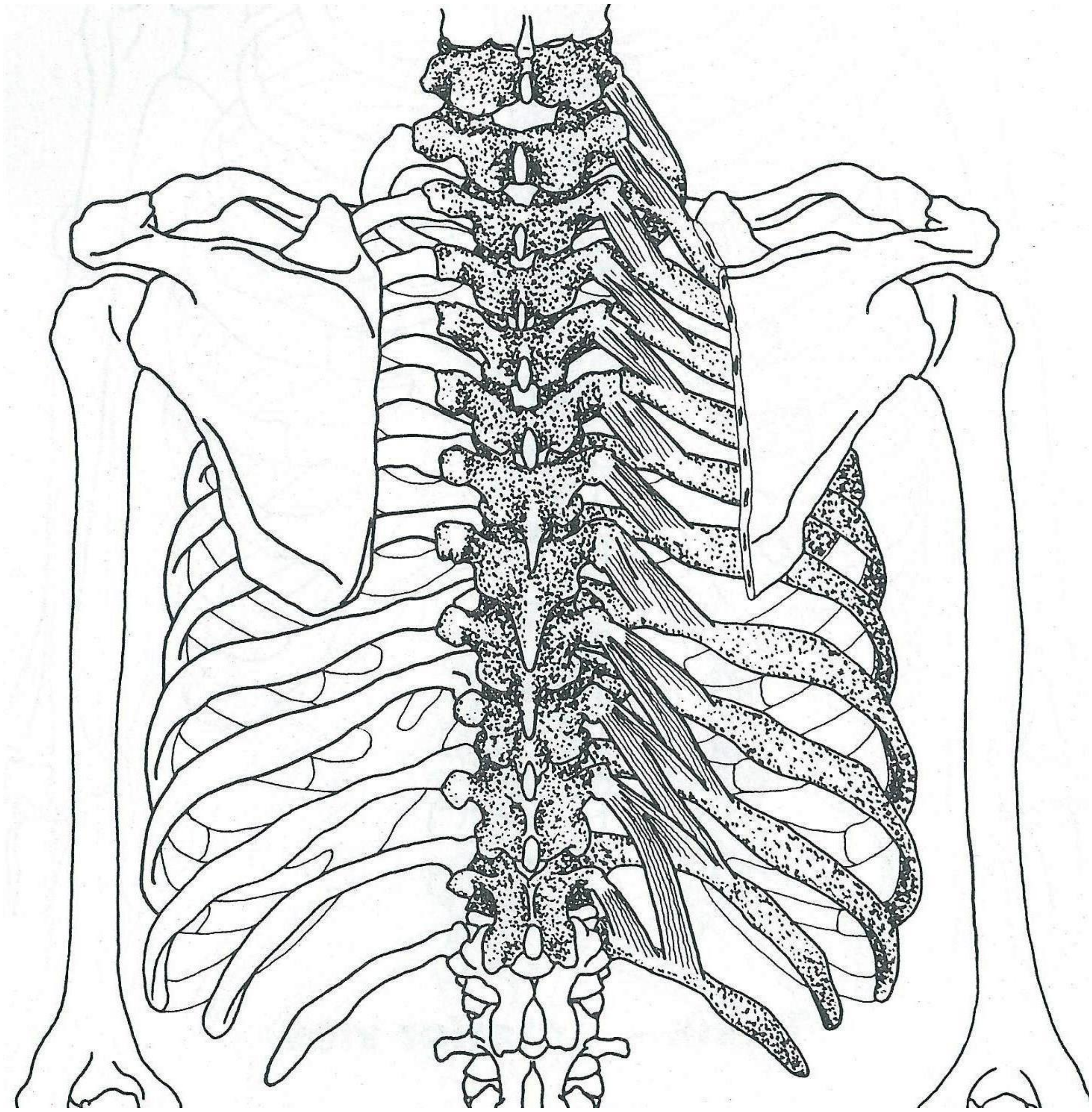


Figure 82 Levator Costae

Serratus Posterior Superior

Name	Origin	Insertion	Action	Nerve
Serratus Posterior Inferior	Ligamentum nuchae Spinous processes of C7 and T1-3	Upper borders of upper edges of ribs 2-5 Lateral to angles	Raises ribs in inspiration	T1-4

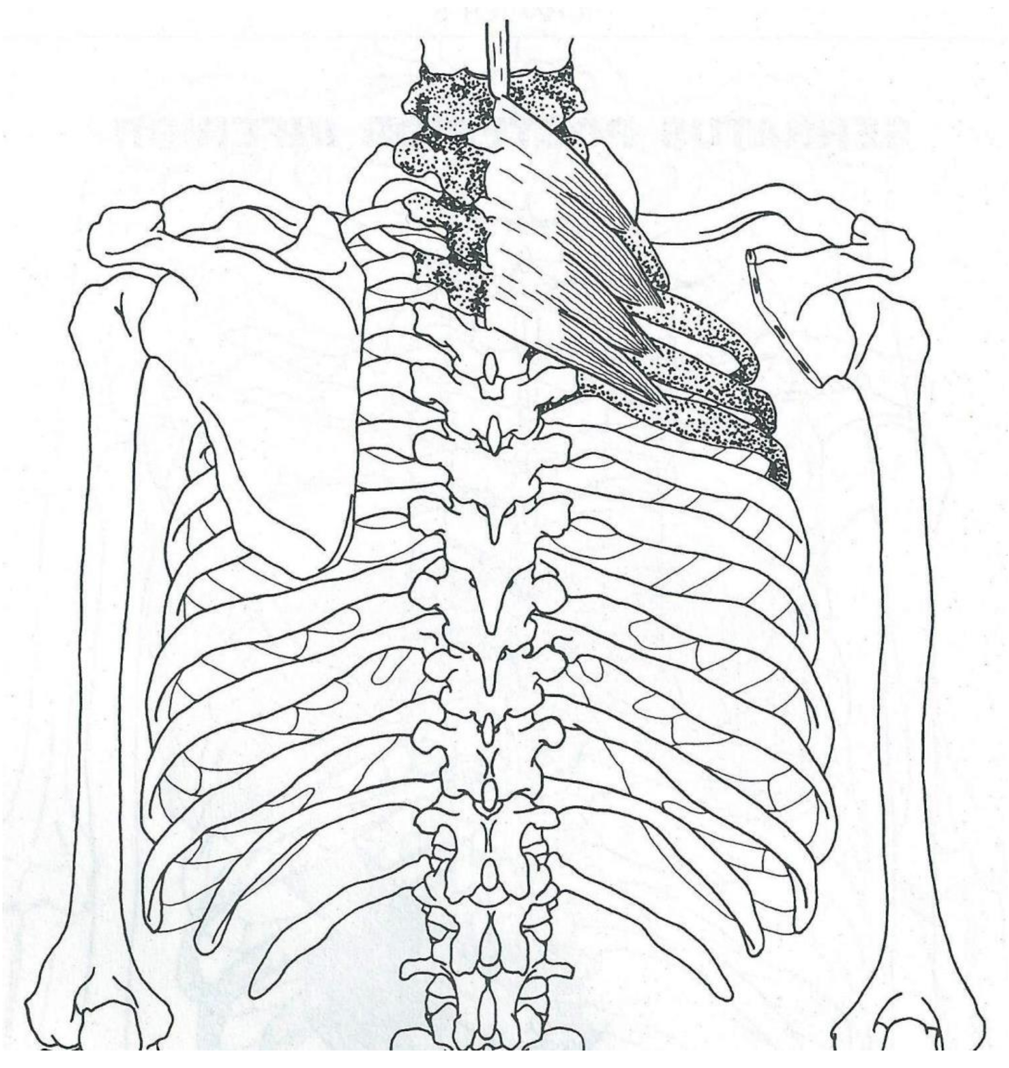


Figure 83 Serratus Posterior Inferior

Serratus Posterior Inferior

Name	Origin	Insertion	Action	Nerve
Serratus Posterior Inferior	Spinous processes of T11-12, L1-3	Lower borders of Ribs 9-12	Pulls ribs down, resisting pull of diaphragm	T9-12

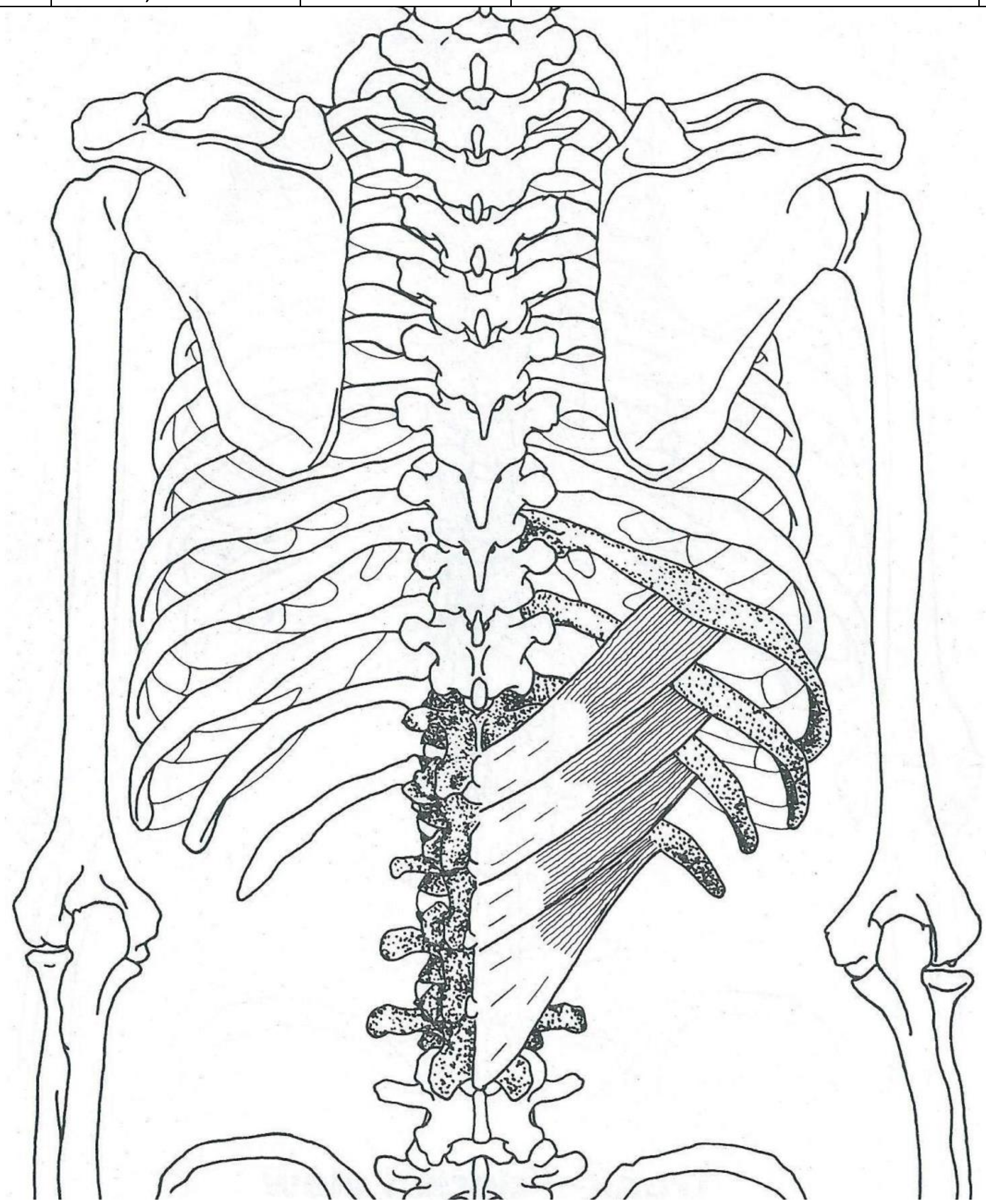


Figure 84 Serratus Posterior Inferior

Pectoralis Minor

Pectoralis minor is actually a muscle of the shoulder. It is included here as a muscle of respiration

Name	Origin	Insertion	Action	Nerve
Pectoralis Minor	Outer surfaces of Ribs 3-5	Coracoid process of scapula	Draws scapula forward and down (depresses shoulder) Raises ribs in forced inspiration	Medial pectoral nerve C8, T1

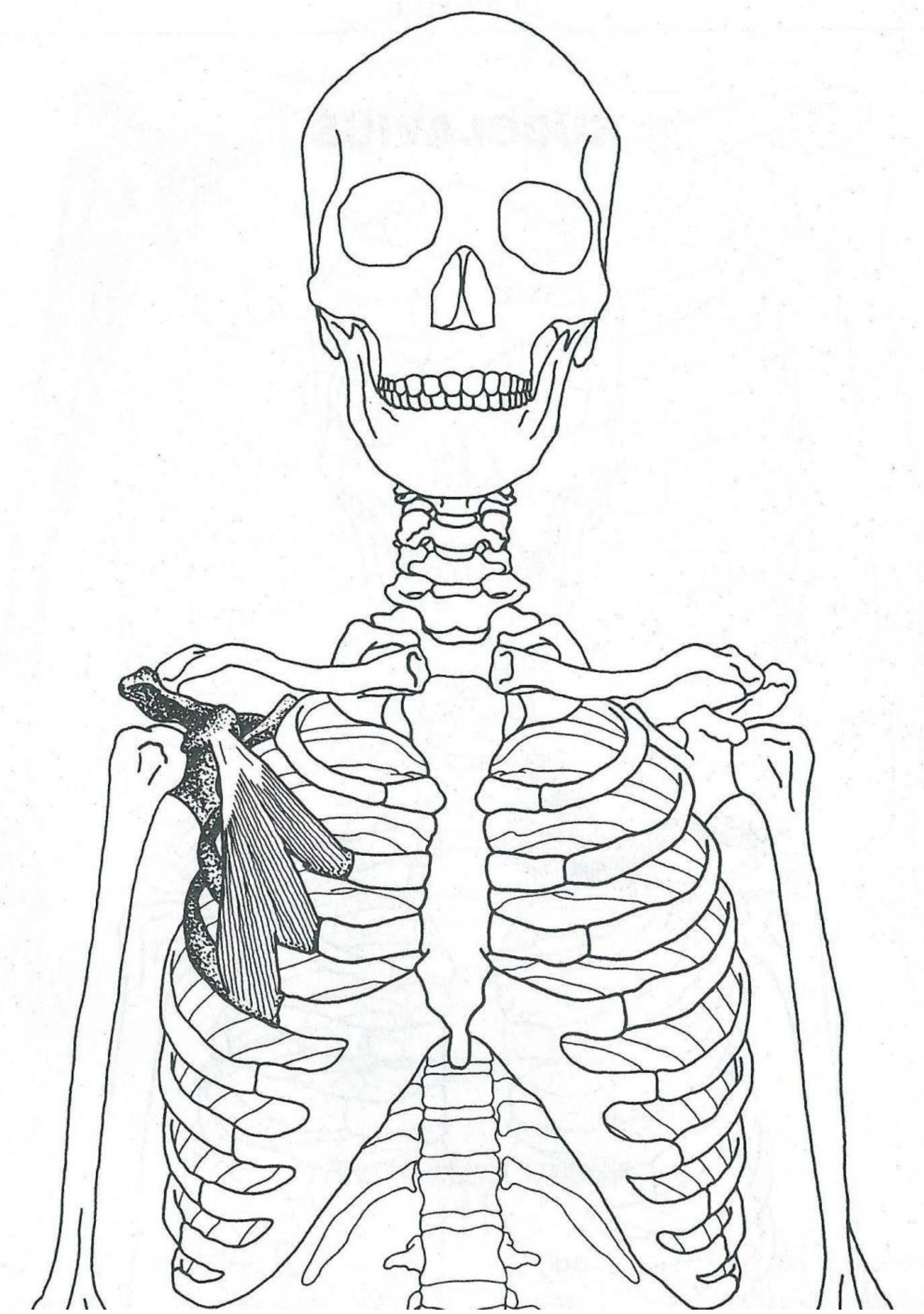


Figure 85 Pectoralis Minor

Quadratus Lumborum

Quadratus is really a muscle of the low back, but it also can function as a muscle of respiration

Name	Origin	Insertion	Action	Nerve
Quadratus Lumborum	Iliolumbar ligament Iliac crest	Rib 12 Transverse processes of L1-4	Side-bends lumbar spine Fixes ribs for forced expiration	T12, L1

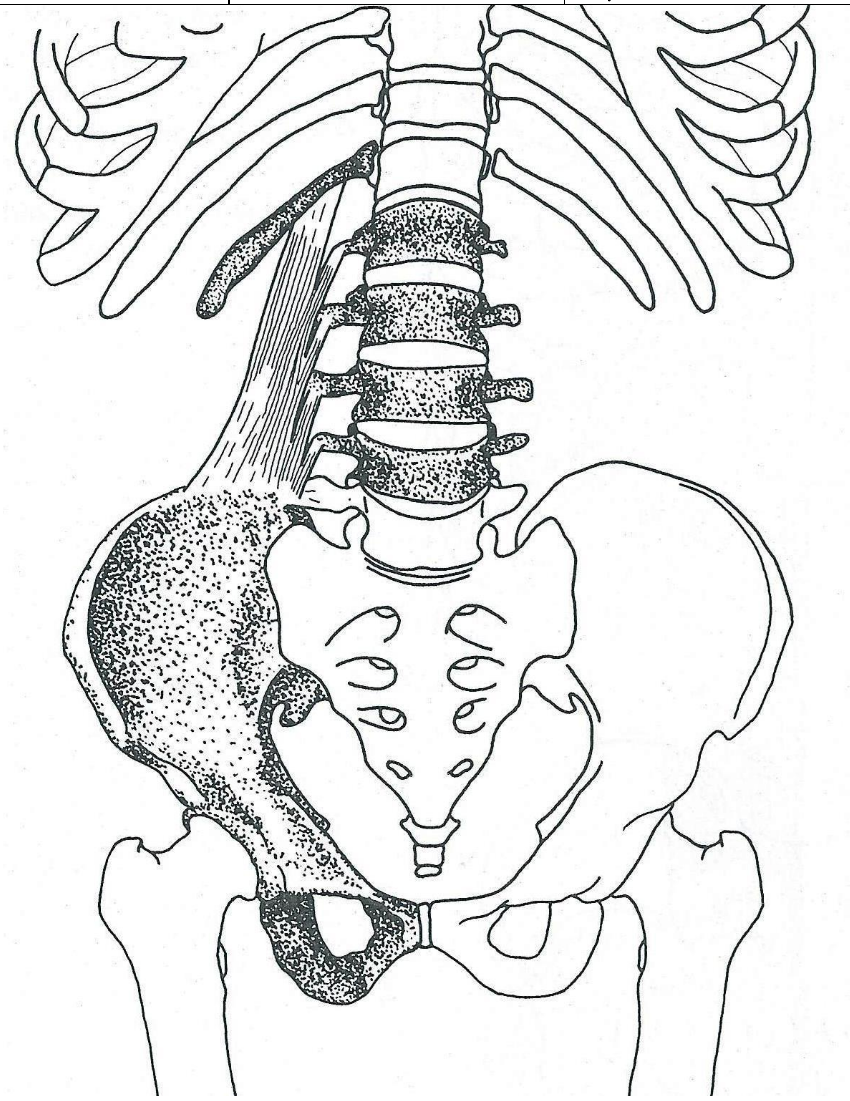


Figure 86 Quadratus Lumborum

Abdominal Muscles

The primary function of these is to hold and compress the abdominal contents, but as they also attach onto ribs, they can also function as accessory muscles of respiration

Name	Origin	Insertion	Action	Nerve
Rectus Abdomis	Crest of pubis Symphysis pubis	Cartilages of ribs 5-7 Xiphoid process	Flexes vertebral column Compresses abdominal contents Forces expiration	7-12 intercostal nerves

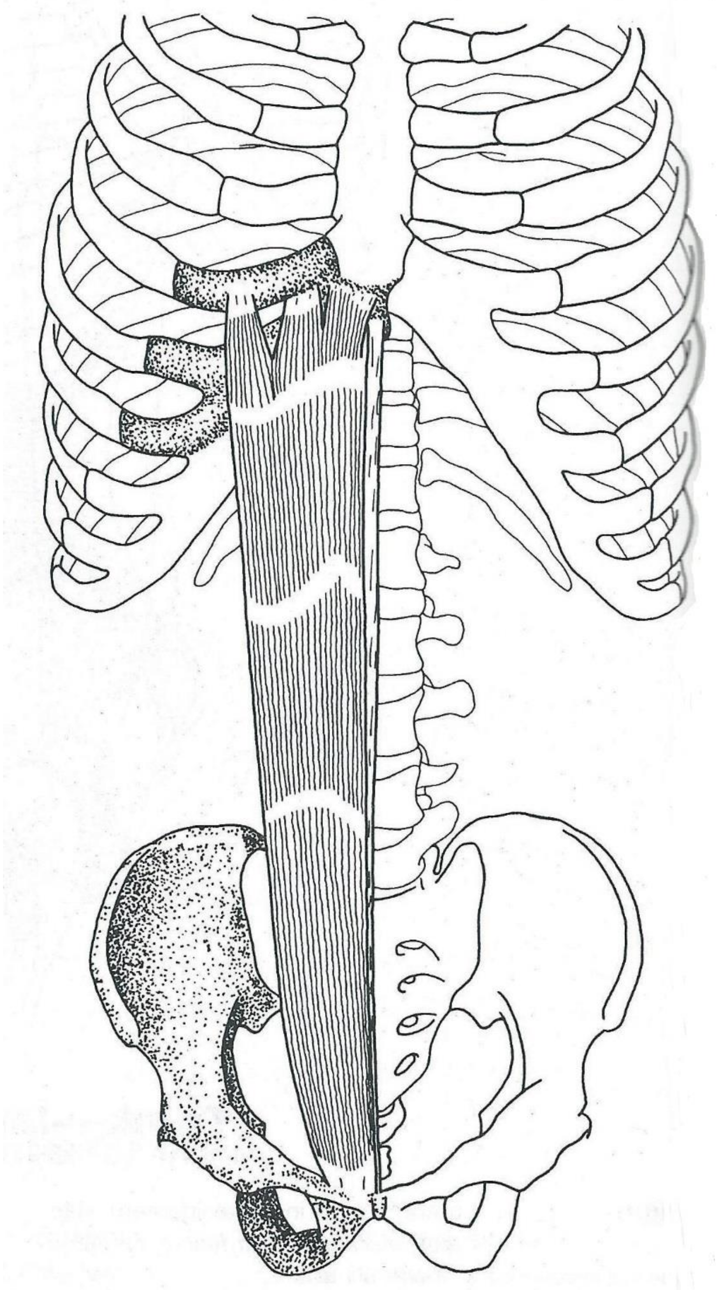


Figure 87 Rectus Abdominis

External Obliques

Name	Origin	Insertion	Action	Nerve
External Obliques	Lower 8 ribs	Anterior part of iliac crest Abdominal aponeurosis to linea alba	Compresses abdominal contents. Side-bends ipsilaterally Rotates contralaterally	Intercostals 8-12 Iliohypogastric Ilioinguinal
Internal Obliques	Lateral half inguinal ligament; iliac crest, thoracolumbar fascia	Cartilage of ribs 9-12, abdominal aponeurosis to linea alba	Compresses abdominal contents; ipsilaterally side-bends and rotates spine	Intercostals 8-12 Iliohypogastric Ilioinguinal
Transversus Abdomis	Lateral part inguinal ligament; iliac crest; thoracolumbar fascia; cartilage ribs 6-12	Abdominal aponeurosis to linea alba	Compresses abdomen	Intercostals 7-12 Iliohypogastric Ilioinguinal

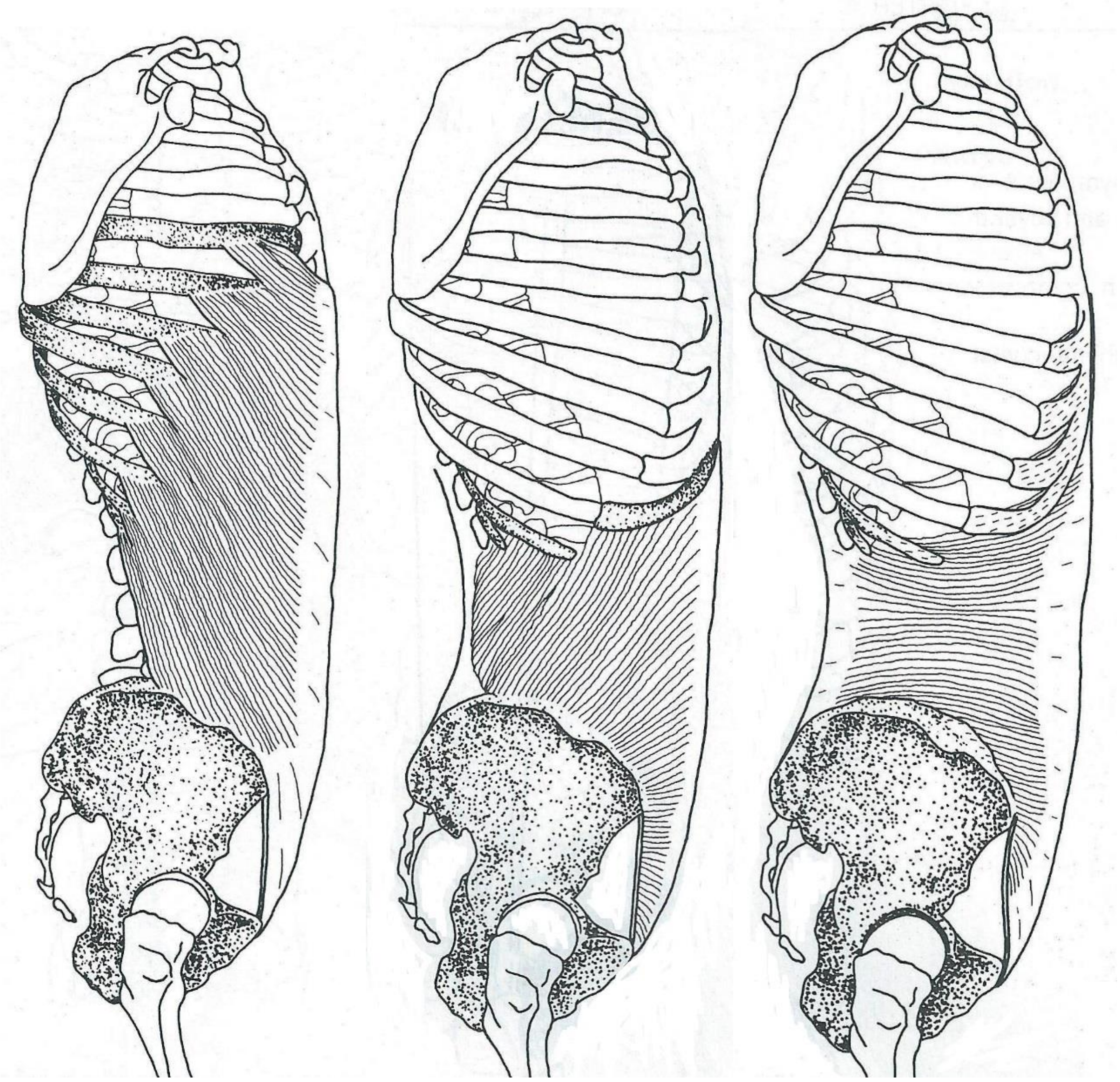


Figure 88 External Oblique, Internal Oblique, Transversus Abdominis

Hip and Low Back Flexors

Name	Origin	Insertion	Action	Nerve
Psoas Major	Bases of transverse processes of all lumbar vertebrae	Lesser trochanter of femur	Flexes hip and lumber spine	Branches of lumbar plexus L2-3 (and L1-4)
Psoas Minor	Sides of T12 and L1	Arcuate line to iliopectineal eminence	Flexes lumbar spine	First lumbar nerve from Lumbar plexus
Iliacus	Upper 2/3 of iliac fossa; ala of sacrum and adjacent ligaments; anterior inferior iliac spine	Onto tendon of psoas major	Flexes hip	Femoral nerve L2-3

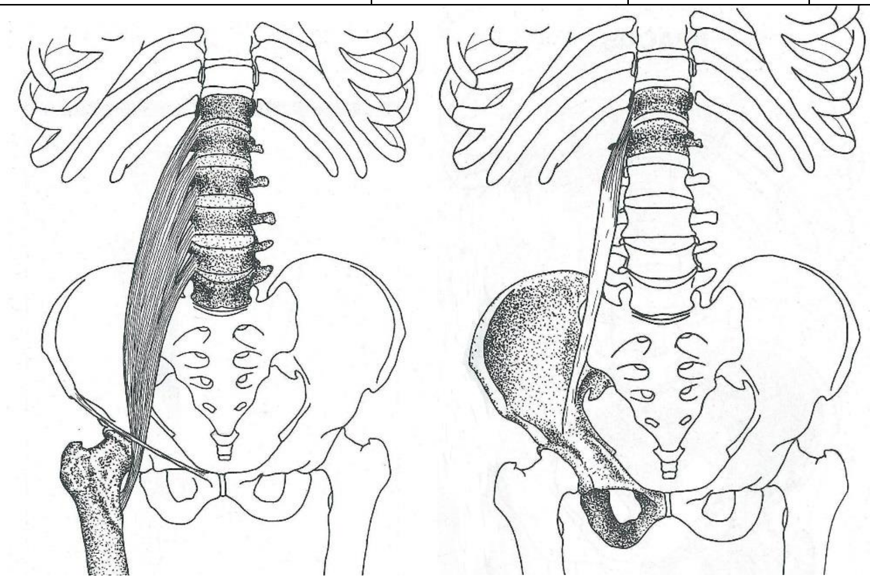


Figure 89 Psoas Major and Minor

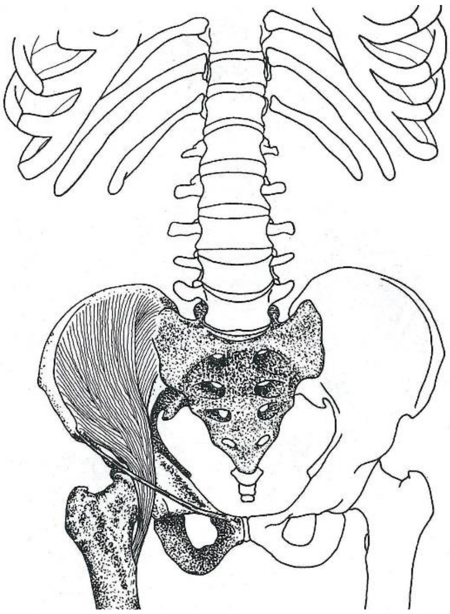


Figure 90 Iliacus