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إيفاءا جزئياً لشرط الحصول على درجة الدكتوراة

في

جراحة المخ والأعصاب

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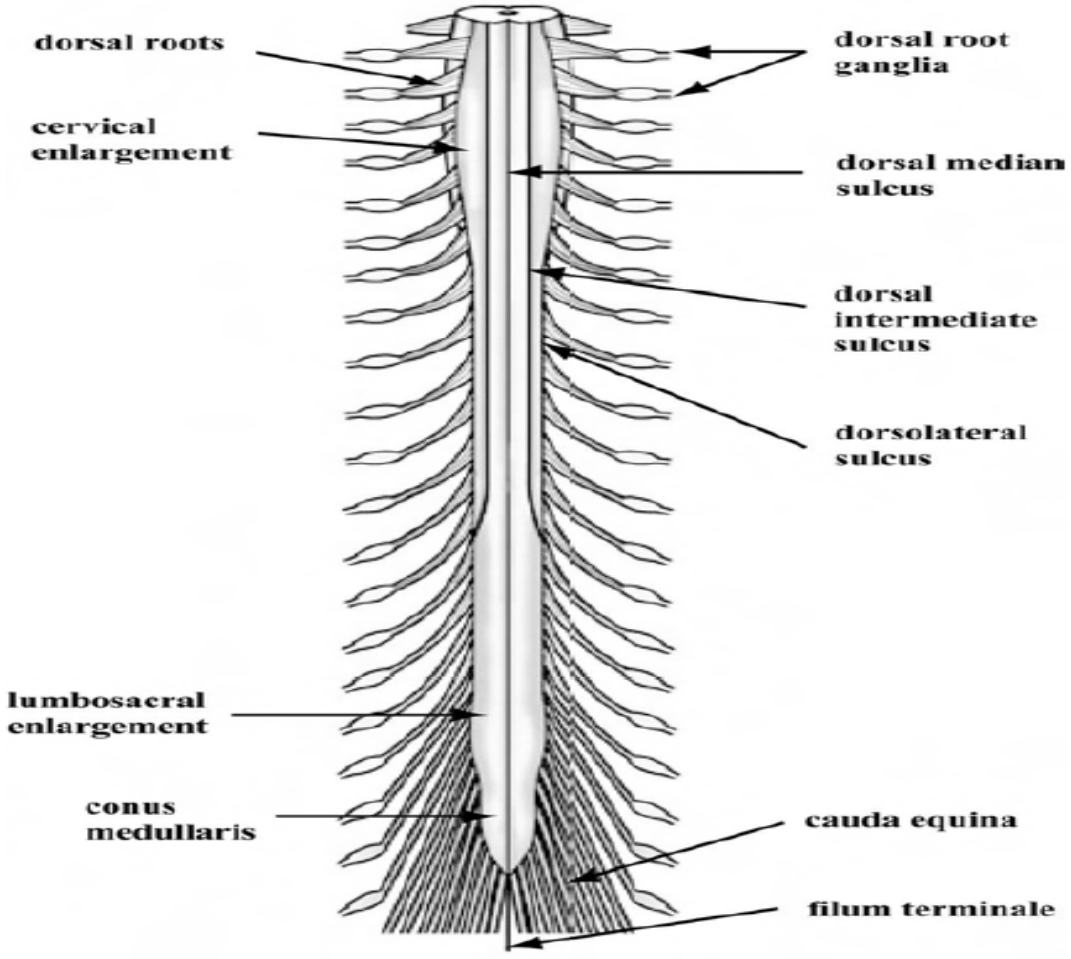
ANATOMY

The spinal cord is the elongated, cylindrical part of the central nervous system, which occupies most of the vertebral canal. Its average length is about 45cm and its weight is about 30gms.It extends from the level of the cranial border of the atlas to the caudal border of the first lumbar vertebra. This level of termination is subjected to variation. The cord's termination may be as high as the lower third of the 12^{th} vertebra or as lower as the disc between the 2^{nd} and the 3^{rd} lumbar vertebra. Continuously cranially with the medulla oblongata, the spinal cord narrows caudally to a sharp tip, the conus medullaris, from the apex of this the filum terminale, a fine connective tissue filament descends to the dorsum of the first coccygeal segment**(Cristante L and Herrmann HD, 1994).**

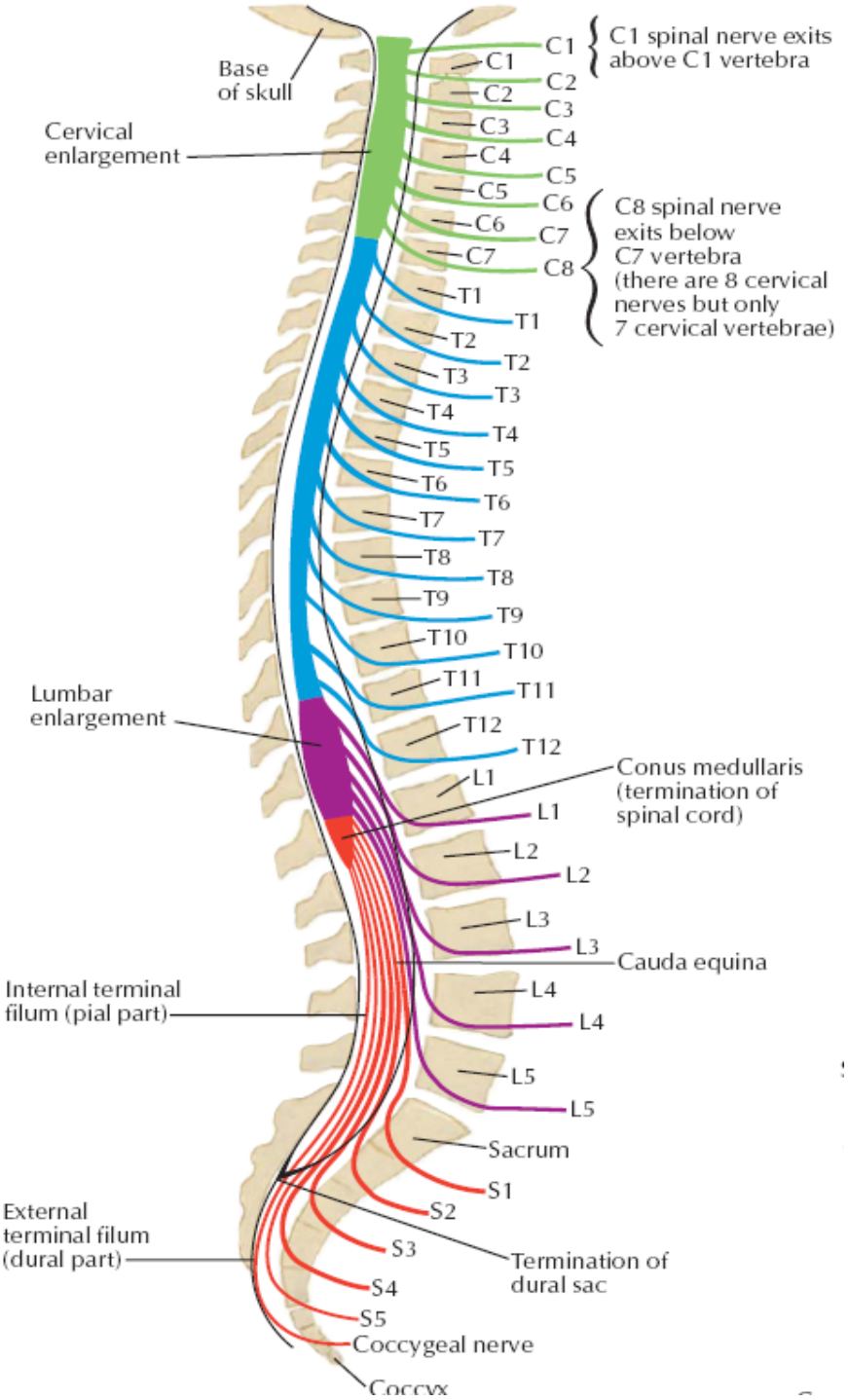
The spinal cord is enlarged at those levels that contribute to the innervations of the upper and lower extremities: the cervical and lumbar enlargements, respectively. Below this level, an extension of the pia mater descends as the filum terminale. At vertebral level S2 (the bottom of the dural sac) the filum terminale is surrounded with dura, and then called the coccygeal ligament, which anchors the cord inferiorly to the coccyx. The spinal cord is anchored laterally by about 20 pairs of denticulate ligaments (Fig. 1), tooth-like connective tissue extensions where the pia pierces the arachnoid to attach to

the dura. They come off the cord horizontally from the midpoint of the lateral funiculus, providing the neurosurgeon with a landmark separating the posterolateral from the anterolateral quadrant (Fig. 1)**(Hoshimaru M et al ,1999).**



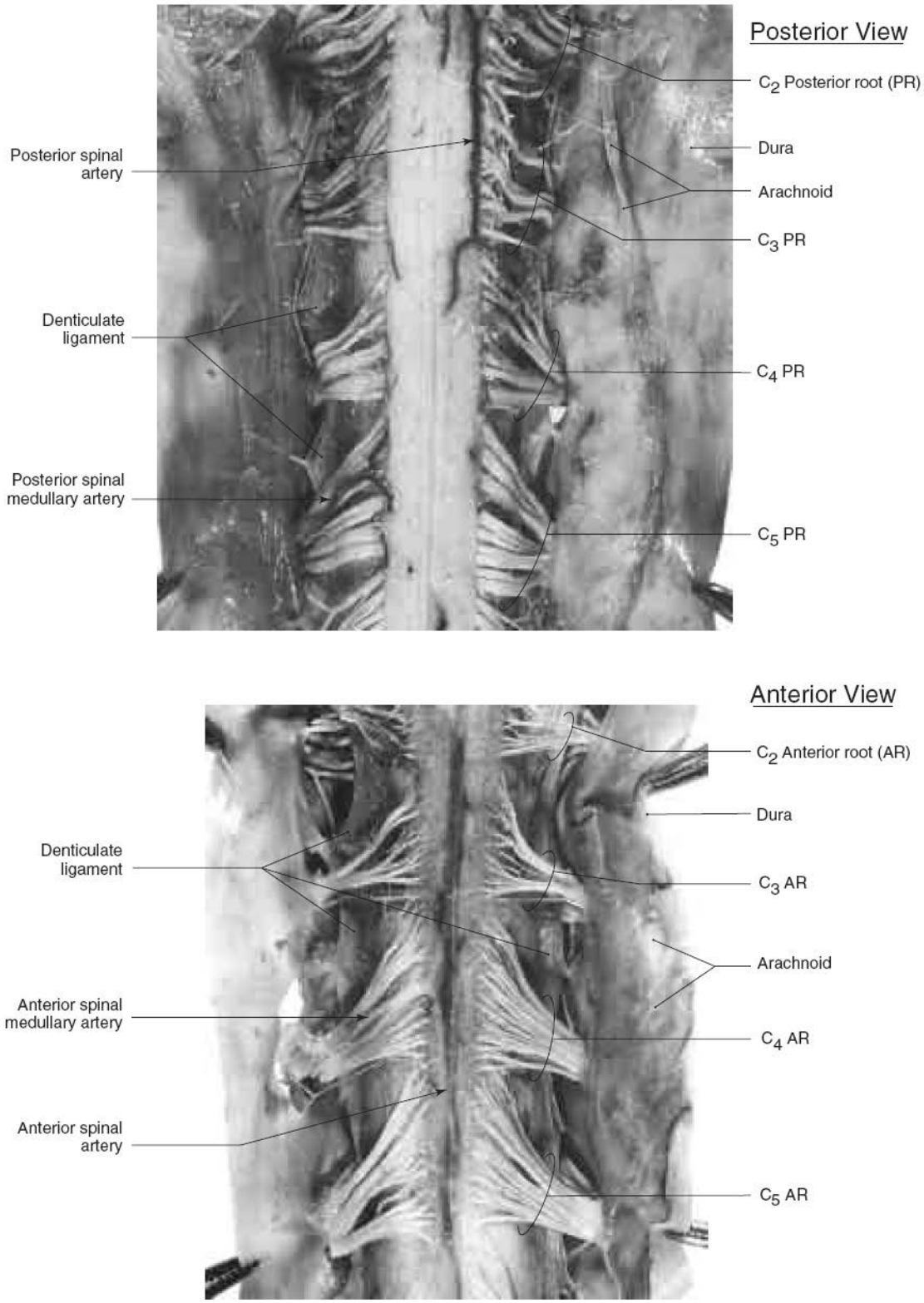
(Fig. 1) Spinal cord; gross anatomy

There are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 Coccygeal. Thirty-one segments of the cord, each segment giving rise to a pair of spinal nerves.The dorsal and ventral roots come together to form the spinal nerve at the level of the intervertebral foramen of exit. Spinal nerves C1 through C7 exit above the vertebra of the same number. C8 exits below vertebra C7. Then spinal nerves T1 through the first coccygeal exit below the vertebrae of the same number.



(Fig.2) Spinal nerves

The spinal nerves in the cervical region exit nearly horizontally through intervertebral foramina at about the same level, but beginning in the thoracic region the dorsal and ventral roots descend to their foramina of exit. Since the spinal cord ends at vertebral level L2, dorsal and ventral roots from lower levels are significantly lengthened to reach their level of exit, forming an aggregation of rootlets that resembles a horse's tail, the cauda equine (Fig. 2).



(Fig.3) Posterior and anterior views of cervical spinal cord between C2-C5

Posterior view of Spinal cervical cord at the level between C2-C5.The dura and arachnoid are reflected,and the pia is intimately adherent to the spinal cord and rootlets. The posterior spinal artery is found medial to the entering posterior rootlets (and the dorsolateral sulcus), while the anterior spinal artery is in the anterior median fissure(Fig3) (Rhoton ,2002) .

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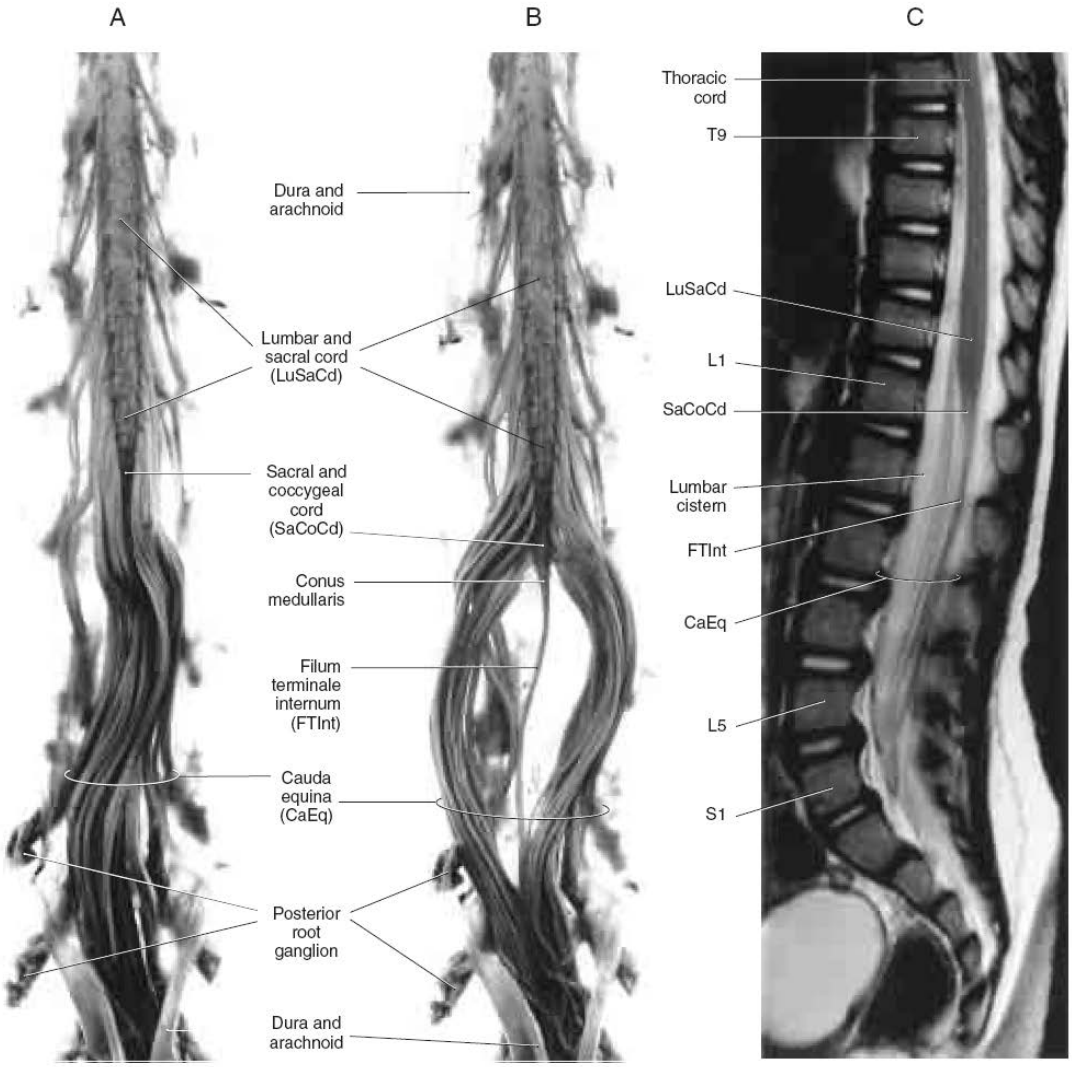


(Fig.4) A and B; cauda equine. C; MRI T2WI lower portion of the cord and filum terminal internum

Overall posterior (A, B) and sagittal (MRI) T2-wieghted views the lower thoracic, lumbar, sacral and coccygeal spinal cord segments and (C)the cauda equina. The dura and arachnoid are retracted in A and B. The cauda equina is showen in situ in A but in B the nerve roots of cauda equina have

been spread laterally to expose the conus medullaris and fillum terminale internum. This latter structure is also called the pial part of the filum terminale.

In (C), the lower portion of the cord, the filum terminale internum, and cauda equina are clearly seen. In addition, the intervertebral discs and the bodies of vertebrae are clear. The lumbar cistern is an enlarged part of the subarachnoid space**(Rhoton ,2002).**

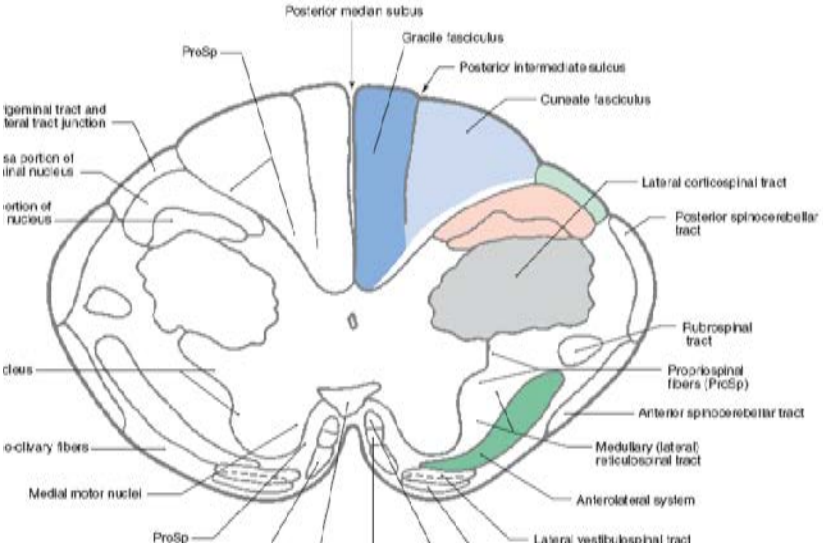
CERVICAL SPINAL CORD

In cross section the cervical spinal cord is ovoid and has the largest amount of white matter; the dorsal, lateral, and ventral funiculi. The dorsal median sulcus, extending into the cord as the dorsal median septum, divides the two dorsal funiculi (dorsal columns). In the cervical and upper thoracic region, the dorsal funiculus is divided by the dorsal intermediate sulcus into two major tracts: fasciculus gracilis and cuneatus. The dorsal roots emerge from the dorsolateral sulcus, whereas the ventral roots emerge from the ventrolateral sulcus. The deep ventral median fissure contains the anterior spinal artery (Fig. 5).

(Fig.5) Cervical spinal cord cross section.

The dorsal horn, intermediate zone, and ventral horn of the spinal cord gray matter are enlarged because of the increased number of neurons involved with the innervation of the upper extremity.

5-5 Transverse section of the spinal cord at the C1 level. Lateral corticospinal fibers are now located medially toward the decussation of the corticospinal fibers, also called the motor decussation or pyramidal decussation (see also Figure 5-8, page 98). At this level, fibers of the spinal trigeminal tract are interdigitated with those of the dorsolateral tract. The spinal cord at C_1 and C_2 levels appear round in CT myelogram when compared to low cervical levels (see Figure 5-4).



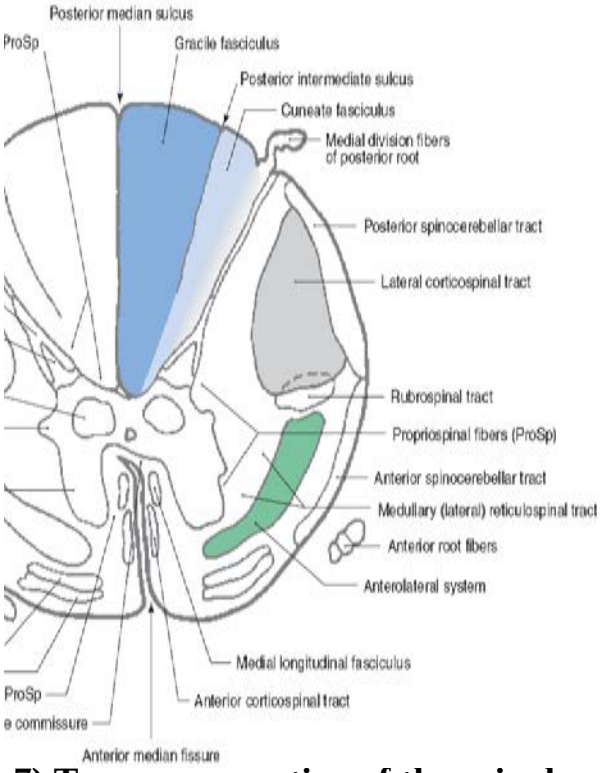
(Fig.6) Transverse section of spinal cord at the level of C1 (Rhoton ,2002) Lateral corticospinal fibers located medially toward the decussation of the corticospinal fibers, also called the motor decussation or pyramidal decussation. At this level, fibers of the trigeminal tract are interdigitated with those of the dorsolateral tract.

THORACIC SPINAL CORD

In cross section, the thoracic spinal cord is round and has the smallest amount of gray matter, which has an H-shaped configuration. In the upper thoracic cord the dorsal funiculus is divided by the dorsal intermediate sulcus into two tracts, but in the lower thoracic cord the sulcus is not present and the dorsal funiculus only contains the fasciculus gracilis.

The lateral horn of the spinal cord gray matter is only present from T1 to L2 and thus is a prominent characteristic of the thoracic cord. It contains the intermedio-lateral nucleus (pre-ganglionic sympathetic neurons)(Fig 7).

thoracic spinal cord appears round in CT myelogram.



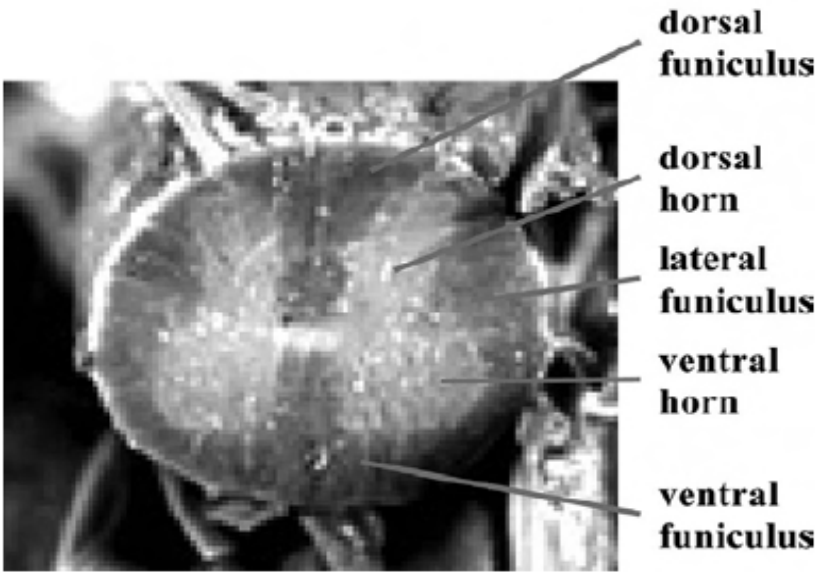
(Fig. 7) Transverse section of the spinal cord at the level of T4 The white matter appears large in relation to the rather diminutive amount of the gray matter. Posterior and anterior horns are small, especially when compared to the lower cervical levels and to lumbar levels.The overall shape of the cord is round. (Rhoton ,2002)

LUMBAR AND SACRAL SPINAL CORD

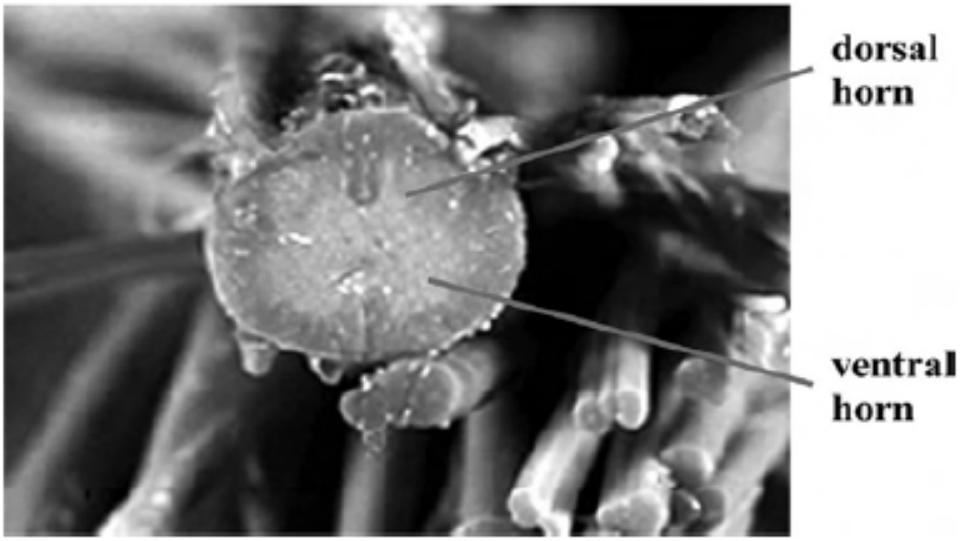
In cross section, the lumbar spinal cord is round but larger in diameter than the thoracic cord because the lumbo-sacral enlargement is related to the innervation of the lower extremity. The ventral horns are enlarged because they contain motor neurons to muscles of the leg. The amount of white matter is proportionately smaller than in higher regions of the cord because the sensory and motor tracts are diminished in size (Fig. 8).

In cross section, the sacral spinal cord (S1–S3) still contributes to the

lumbosacral plexus and the innervation of the lower extremity and therefore has a significant amount of gray matter (Fig. 9&10).



(1Figure 3.9*b* Lumbar spinal cord cross section. 02).



(Fig.9) Sacral cord cross section.

(Fig10) Transverse section of the spinal cord at the level of the L4.
Posterior and anterior horns are large in relation to the modest amount of white matter, and the general shape of the cord is round. Fibers of the medial division of the posterior root directly enter the gracile fasciculus. The roots of upper portions of the cauda equine surround the lower levels of the lumbar spinal cord.

Meningeal relationships

The spinal meninges differ from those of the brain due to the presence of a thicker pia mater attached to the inner dural surface by the dentate ligaments, and the presence of an intermediate leptomeningeal layer and fatty extradural space. The meninges are thus adapted to mobile vertebral column, with the spinal cord suspended and centered within the subarachnoid space. The subarachnoid space contained, in turn, within a non-elastic dural sac that

adapts perfectly to the movements of the spinal column.

Pia Mater:-

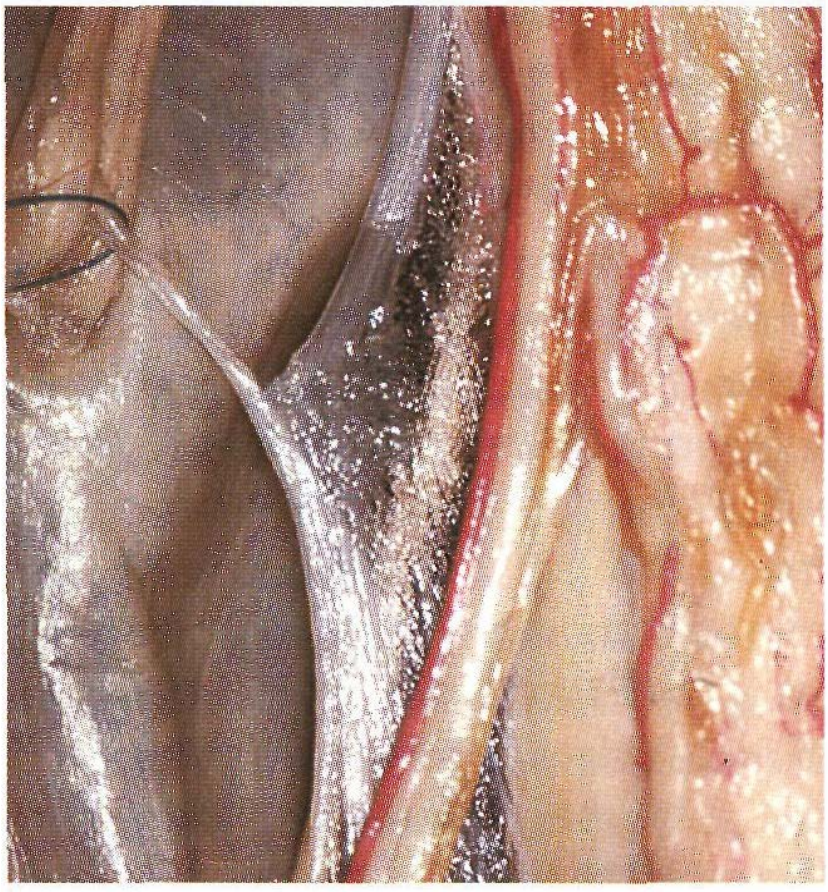
The spinal pia mater is mechanically stronger than the pia mater of the brain. It consisted of loose connective tissue made of elastic collagen fibres and reticulin containing-mesothelial cells. It is fused with the surface of spinal cord, and consists of circular fibres in two layers: A deep one, which called pia intima and superfacial part, called epipia.

The pia lines the ventral median fissure, forms the dorsal median septum and terminates at the junction of the spinal and nerve root. Only the superficial layer, consisting of longitudinal fibres, surrounds the roots, giving them a white hue. Fissures between these two layers allow communication with subarachnoid space. The ventral longitudinal vessels course between the two layers, and are covered with a pial condensation the linea splendens, a structure 1 mm thickness that has no attachment to the dura or the arachnoid. The pial sheath covers the vessels as far as the end capillaries, and separates the subarachnoid space from privascular spaces. The pial mater is a single continuous layer of cells, separated from nervous tissue by a thick sub-pial collagenous layer extending laterally to the dentate ligament.

Dentate ligament:-

Thick at their rostral ends, the dentate ligaments attach the lateral surface of the spinal cord to the dura transversely. The medial border of each, thinner

than the lateral border, is adherent to the lateral anterior column (corticospinal tract) and ventrolateral column (anterolateral tract). The lateral border of each ligament is free, with the exception of the areas adjacent to the roots. These are thick serrations whose apices are attached to the dura between the overlaying root sheaths, although they are closer to the latter. This arrangement results in a pattern of arcades located in front of emerging nerve roots. At the cervical level, the ligament is located anterior to the spinal accessory nerve(Fig11)(Sgouros S et al, 1996).



(Fig.11) Posterior view of the thoracic spinal cord.
A nerv root artery can be seen behind the dentate ligament.

Arachnoid:- The subarachnoid space, which will later contains the cereberospinal fluid, initially develops on the ventral aspect of the spinal cord, and then on its dorsal aspect. Consisting of a dense, impermeable, superficial layer adherent to the dura, the arachnoid may contain calcifications. It has processes by which it is attached to the pial surface of the spinal cord and to the inner layer of the dura, from which it may easily be detached.

Laterally,the pia and arachnoid taper off at the point of contact between the spinal nerves and the dura, the latter becoming continous with the epineurium. At this level, the arachnoid has intradural and transdural processes, as well as transverse processes, similar to the pacchionian granulations found intracranially, which may be involved in the cereberospinal fluid resorption. In the subarachnoid space, several types of septae have been described **(Brotchi et al., 1996)**

The median dorsal septum is fenestrated, and runs from the superficial layer of the arachnoid to the dorsal aspect of the spinal cord along the dorsal median vien, whose winding course determines the shape of the septum. This septum, of which, there are sometimes two, extends from the middle part of the cervical cord to the upper part of the lumbar cord, rarly as far as the filum terminale.