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Dura Mater

At the border between the foramen magnum and the spinal column you can distinguish between the two dural layers – one outer periosteal layer and one inner layer, which is the true spinal dura mater. Between those two layers exists an epidural space, which allows the dural sliding movement between the dura and the spinal column. The spinal epidural fatty tissue is only slightly developed in the upper cervical region.

The ultra-structure of the skins around the spinal column is mainly the same as those in the cranium. However the dura and the arachnoid layers in the spinal area are closely connected with each other, so there is no natural subdural space. The dura is made up of an extremely loosely arranged firbroelastic layer, a middle layer which is mainly fibrous and an inner cellular layer. The latter has a lot of interlaced cellular extensions without extracellular collagen and with a clear extracellular space without cell connections.

A longitudinal orientation of the spinal dura mater, i.e. its collagen fibres was detected due to microscopic and electromicroscopic pictures. The lamellae of collagen and elastin have orientated themselves in the longitudinal direction. Longitudinal tensility and tightness are clearly greater than transverse.

Longitudinal tension, which is created by the longitudinal shear of the spinal column during movements, are absorbed mainly by the longitudinally running collagen fibres and are transmitted cranially and caudally into surrounding tissues. There was a marked tensility in the longitudinal and the circular direction noted in the lumbar spine. On the other hand the tissues show a mainly transverse direction the higher the cervical spine.

Elastin fibres have a multidirectional organisation. The amount of elastin in the posterior spinal dura mater is 13.8% and in the anterior region it is 7.1%. The proportion of elastin is highest in the thoracic region.

The spinal dura mater has an average thickness of 0.322 mm. The average thickness anteriorly is 0.353 mm (with no great variations), the average thickness posteriorly is 0.295 (with significant variations). The posterior side is marked thinner below the level of L2. The thickness of the dura mater is strongest developed in the cranio-cervical region and the lumbar spine.

Attachments of the dura:

Investigations with preparations have shown, that the spinal dura mater is only very loosely attached to its cranial and caudal fixations and that there is a sliding of the dura in relation to the spinal column.

The dura mater inserts, as a continuation of the falx cerebelli and the intracranial dura, tightly into the foramen magnum. The dura is especially attached to the following structures:

Ventral:

At the basilar part of the occipital bone (running through the tentorial membrane)
At the transverse Atlantic ligament
At the posterior longitudinal ligament

Dorsal:
At the periosteum of the squamous part of the occiput
At the arches of the atlas and the axis

Lateral:
At the atlantooccipital and the atlantoaxial articulation.

The dura mater is attached to the third cervical vertebra according to Klein and Upledger. We can find some irregular attachments at the third cervical vertebra.

In foeti of approximately 60mm length, the epidural space is filled with connective tissue. This connective tissue reduces to topographic structures as the foetus ages. Then posterior, anterior and lateral ligaments can be localised. Atlantodural and sacral ligaments are continuously present and serve as fixation for the dural bag. These fixations can be responsible for an NRC if they protrude. But most of the dorsal ligaments are reabsorbed during foetal development.

Cranial Ligament of the spinal dura mater:

Lanz calls this attachment at the occipital bone and at the periosteum of the upper cervical vertebrae the "cranial ligament of the spinal dura mater". They are described as the fibrous strings between the dura mater and the posterior edge of the atlantooccipital articulation, one part of the foramen magnum, the posterior arch of the atlas and the arch of the axis.

Relatively broad fibres (9mm) extend from the posterior part of the arch of the atlas. And further fibres run from the lig.flavum between C1/2 and C2/3 and from the arches of C2 and C3 to the dura. There were no further connections detected caudally to C3.

The fibres of the cranial ligament of the dura mater descend caudally for a few mm and form a support structure for the dural bag. Medial fibres of this cranial ligament descent into the deeper part of the ligamentum nuchae.

Rectus Capitis Posterior Minor Muscle:

Only a short while ago it was possible to locate a connective tissue connection between the rectus capitus posterior minor muscle and the posterior part of the dura through the posterior atlantooccipital membrane at the OA joint. An atrophic Rectus Capitis Posterior Minor Muscle could cause a posterior bending of the dura in the direction of the spinal cord when the head of the neck are extended and therefore have a possible compromising effect. Even suboccipital headaches can be explained like that.

Connections to the lig. Nuchae:
It was possible to detect a continuity in the midline between the posterior dura and the ligamentum nuchae at the level of C1 and C2. This connection is especially interesting for the biomechanics of the cervical spine, especially for rotational movements in the saggital and the transverse plains.

Interspinal ligament of the dura mater:

To the sides of the upper cervical spine there is the interspinal ligament of the dura mater, which runs from the spinal column to the dura. Rotation of the cervical spine is herewith directed through those ligaments to the dural tube.

Connections to the ligamentum flavum:

There is connective tissue connection visible in the midline of the epidural space at the level of the lumbar spine, which attaches the dura to the lig. Flavum and narrows the epidural space in the midline. This structure changes from connective tissue fibres to a complete membrane. There are as well existing fibres which come from the lig. Flava of C1/2 and C2/3 and run to the dura; the same is visible at the level of C7/T1. The posterior cervical epidural ligaments connect the posterior dura mater at the level of the cervical spine with the lig.flavum.

Posterior longitudinal ligament:
It is running down on the posterior aspect of the vertebral bodies and connects the discs with each other. Its superficial layer blends with the spinal dura mater. The attachments are irregular and become stronger caudally in form of the anterior sacrodural lig. (Trolard).

Anterior sacrodural ligament:

It is a tight saggital septum with lateral fascial branches.

Hoffmann's ligaments:

These ligaments run between the dura mater and the superficial layers of the PLL. At the level of L5 these lig. can be very small and are sometimes absent at the level of S1. The rule of the thumb is that there is one lig. on each side at each segmental level. In cranial direction these lig.s become wider and reach at the level of L2 the thickness of 1cm. These lig.s have the function to hold the dura caudally during growth in children, and they hold the dura anteriorly against the dura. The Hoffman lig.s and the anterior sacrodural lig.s are also called the meningovertebral lig.s.

Dorsolateral dural ligament (Hoffmann's lateral ligament):

They are lateral ligamentous connection, which are only found in the lower lumbar area. They are the connection between the coating of the spinal nerves and the periosteum of the vertebral bodies.

Trousseaux fibreux de Souile:

They are strong fascial connections which connect the dura with the PLL and the dura with the periosteum.

Meningo-vertebral ligaments:

These are especially developed at the level of the medullary cone and they inherit an anchor function. These ligaments consist of lateral and ventral orientated segmental fibrous bands, which connect the dura to the endosteum of the spinal column. Most obvious is the anterior part which runs from the anterior wall of the dura to the PLL. As well as that some thin collagen ropes from the back of the spinal column radiate to the dura. And there are some fibrous connections to the anterior sacrococcygeus lig.

Opercula of Forestier:
These are found at the level of each intervertebral foramen. These symbolise the connection between the dural coat of each spinal nerve and the periosteum of the related vertebra. These operculae enclose the intervertebral foramina from the inside and the outside; which means that they are lying within and outside of the vertebral column. The intervertebral foramen is not, as discussed so far, closed by a tight membrane, since only perforated extensions fix the nerve root to the foramen.

Transformidal Ligaments:

These stretch round the outside of the intervertebral foramina. Sometimes described as the thicker parts of the operculae or an unfinished opercula or a false lig.

Denticular Ligament:

It runs in between the pia and the dura mater and connects the spinal cord bilaterally to the dura at the levels of the occiput to the L2. It describes a lateral extension of the pia mater. It also symbolises a suspension structure which keeps the spinal cord dangling within its CSF. The connections between the pia and the dura mater are as well as the other attachments of the spinal canal relatively thin..

This lig. is avascular, contains collagen and elastin fibres and is like the pia mater only slightly elastic.

"Rhomboid-shaped hoists":

These connective tissue plates grasp round the inferior medulla oblongata and the superior cord on the anterior side.

It enters the dura together with the upper two peaks of the denticular lig. The inferior peak of this rhomboid usually runs to the area of the anterior median fissure of C4.

Caudally the spinal dura mater is fixed to the back of the second sacral body. Usually the dura fuses with the terminal filum at the level of S2. The final part of the spinal cord comes out of the sacral hiati together with the tight fitting dura and joins at the posterior coccyx with the periosteum.

In the spinal cord the nerves pierce on their way to the periphery or from the periphery the dura mater. At those locations where the nerves leave the spinal cord at the intervertebral foramina they are surrounded and protected by the dura mater for a few mm. The dura then progresses into the epineurium of these nerves.

Experimental results of research give hints of transmission of force from the dura mater spinalis to the dura mater encephali as well as to periorbital structures. The importance of the dura mater spinalis in the osteopathic field could be partly proved through research.

More research is necessary, to do more exact measurements and to clarify certain points.For example, what amount of force of tension is necessary for a transmission of force in the dura mater spinalis to take place? or if the finest rhythmic impulse can be transmitted through the dura mater spinalis in living human beings, like a hypothesis in craniosacral osteopathy, and to clarify the influence of different conservations on the biomechanical behaviour of dura mater.