MENINGOVERTEBRAL LIGAMENTS AND THEIR PUTATIVE SIGNIFICANCE IN LOW BACK PAIN

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ABSTRACT

OBJECTIVE: We dissected the lumbar and thoracic spine to determine the presence and morphology of the meningovertebral ligaments (ligaments of Hofmann) and find evidence for their possible contribution to low back pain (LBP).

DESIGN: Sagittal sections including the L5/S1 intervertebral level cephalad to T1 vertebral level were performed on five randomly selected cadaver specimens and several museum specimens at Logan College of Chiropractic anatomy lab. Meningovertebral ligaments were dissected, labeled and documented in both the lumbar and thoracic regions.

RESULTS: Meningovertebral ligaments were found in both the lumbar and thoracic regions of all specimens. These ligaments were much more prevalent in the lumbar spine, but were also present throughout the thoracic spine. The ligaments in the lumbar spine were more numerous as well as heavier in gauge.

CONCLUSION: Dural sac attachments to the posterior aspect of the vertebral bodies and the posterior longitudinal ligament (PLL) could act to fix these structures in the event of nuclear bulge or herniation. The prevalence of the ligaments in the lumbar spine (as well as the increased incidence of herniated nucleus pulposus (HNP) and disc bulges in this region) may compound the effect of disc pathology and result in increased LBP.

KEY TERMS: Meningovertebral ligaments, low back pain, intervertebral disc protrusion.

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INTRODUCTION

Within the epidural space lies a dural attachment complex that has historically received little research. The majority of the information available was conducted in the late nineteenth century by two men, Trolard and Hofmann, from the latter of which these ligaments derived their proper name. The ligaments of Hofmann or meningovertebral ligaments are divided into three subsections(1). One group (midline Hofmann ligaments) attach the anterior dura to the PLL. Another group (lateral Hofmann ligaments) attach the anterolateral dura to the lateral PLL and the vertebral endosteum passing in generally a caudal fashion. A third group extend from the proximal nerve root sheath to the PLL and endosteum of the inferior pedicle and act to limit medial and superior mobility of the nerve root.

The meningovertebral ligaments are located predominantly in the lumbar and lumbosacral area of the spine where the epidural space has its greatest volume. As one looks cephalad from the lumbosacral region, the ligaments become increasingly smaller and are less significant in the thoracic spine apparently due to the natural kyphosis supplying added support to the spinal cord in this region. Again they are found in the cervical spine, however are not as well developed(1).

The ligaments attach to the PLL at the disc levels with greater frequency and in greater numbers than at the vertebral body level. This may be due to the fact that the PLL adheres to the discs and is separated from the mid-portion of the vertebral bodies by vascular and connective tissues. Thus these ligaments share a common anchor to the vertebral column where they act to fix the dura to the column and cause it to move with the axes of vertebral movement(1).

One must be careful not to confuse these ligaments with the denticulate ligaments which are located between the meninges. The meningovertebral ligaments are 100% extradural and there is little mention of them in the majority of anatomical textbooks. Some references do not mention them at all(2,3,4,5,6,7,8) while others refer to them as bands, trabeculae, strands, slips, and fibrous extensions(9,10,11,12,13).

LITERATURE REVIEW

Scapinelli's sagittal sections revealed that the ventral meningovertebral ligaments diverge from the dura in both cranial and caudal fashion to insert on the PLL(1). This contradicts Hofmann's(14) findings but is consistent with the sketching of Trolard(15). This ventral ligament has also been described as a median sagittal septum which inserts in a single or bifurcated strand to the PLL or posterior vertebral body. It stands to reason that the presence of the venous plexuses coupled with the spinal fluid hydrostatic pressure may account for the convergence of fibrous strands to the middle of the anterior epidural space forming these ligaments(1).

Computed tomography studies were performed by Scapinelli on autopsied specimens as well as living subjects. In both cases, the ligaments were visualized indicating that these structures are not post-mortem artifacts. While the ligaments density is consistent with that of other spinal canal soft tissue structures, the ability to visualize them depends on the amount of peridural fat present in the anterior epidural space. Myelocomputed tomography assists in the visualization of these structures. The lateral ligaments were not as easily distinguishable apparently due to the decreased amount of peridural fat displaced by the presence of the venous plexuses. He also postulated that the small calcification visible on the posterior vertebral body in many normal CT scans may be due to constant irritation to the insertion of the anterior dural ligament by dilatation of the venous plexuses(1).

Wiltse briefly mentioned Hofmann ligaments in his article on the deep layer of the PLL. They were described as being of considerable variation with usually two at each vertebral level and often having numerous attachments. He reported that the ligaments attach to the PLL then passes cranially to the dura. This is most likely due to the cephalic displacement of the spinal cord as a child develops(16). Wiltse also speculated that the dural ligaments fix the cord to the posterior vertebral bodies and in the event of a midline surgical laminectomy give added protection to the cord(16).

Spencer described the dural ligaments as ranging from trabeculae at some levels to narrow bands and occasional sheets of connective tissue at others. In his study of 36 pairs of nerve roots, six were trabecular, 17 were narrow bands and six others were comprised of lateral sheets of connective tissue. In four specimens, a total of seven levels possessed no attachments with significant tensile strength. He also noted that the ligaments were considerably more developed in the L5/S1 levels(17).

The lateral root ligaments also displayed irregular patterns in each specimen. The lateral bands attach the dura to the lateral PLL and adjacent periosteum of the pedicle of the inferior vertebra. The L5 nerve root attaches to the L4/L5, disc level and the S1 root attaches to the L5/S1 disc level. Development of the ligaments varied from specimen to specimen being symmetrically arranged at any one level. Three specimens in the study showed no fixation at any level. All ligaments fixed the dura and root sleeves anteriorly to the vertebral column and resists posterior and medial displacement of the nerve roots(17).

The intrathecal nerve root cannot undergo any type of fixation since it lies within the dural sac. However once it emerges from this structure, fine arachnoid bands fix the dural sleeve to the nerve root. Within the intervertebral foramen, the epineural sheath becomes adherent to the walls of the foramen. The dural ligament then acts to fix the root to the PLL, vertebral body and the inferior pedicle(17) and in doing so define the pathway of the spinal nerve root or as described by Yeager the spinal nerve root path(18).

Thus, Spencer concluded that a posterior force such as a disc bulge is met by an equal and opposite reaction which is the effect of the dural ligaments and connective tissue at the foraminal exit. This acts to resist posterior displacement of the nerve root and compression against the posterior elements of the intervertebral foramen. Thus the lack of dural attachments at the nerve root level may explain the occurrence of asymptomatic disc protrusion or generalized low back pain(17).

Spencer also suggests that the dural ligament's role in sciatica may be two fold. One, they act to traction a nerve root over a disc protrusion and in doing so result in a pressure-induced neuropathy. Two, they traction the PLL and vertebral periosteum resulting in somatic pain(17).

METHODS

The dissection of five cadavers was performed at Logan College of Chiropractic Anatomy Lab. Transverse sections through the L5 disc and C7 disc were performed separating the thoracic and lumbar spine from the cadaver for further dissection. Additional research is currently underway on the cervical spines of these and other specimens by J. P. Ellis, Director of Anatomy at Logan College.

Then the spinal columns from T1 to L5 were sectioned sagittally to reveal the structures within the neural canal. Numerous examples of meningovertebral ligaments were identified in each cadaver then photographed for documentation. One specimen was sectioned with transverse cuts in order to view the ligaments without disrupting any of their ventral attachments.

The specimens ranged in age from 55 to 85 years. None of the specimens had apparently undergone any type of spinal surgery or died of metastatic disease. One specimen died of sepsis however, there were no noticeable differences between its anatomy and that of the other specimens studied. Three specimens were male and two were female. All specimens showed signs of osteoarthritis of the spine two of which suffered from L5 disc herniation. Four of the specimens were utilized in the study for illustrations. The remaining specimen was less suitable for photography.

Tools utilized in the gross dissection included a cross cut hand saw and electrical band saw as well as two dissecting knives. The fine dissection was performed with surgical scalpels, forceps, and suture needles used to tag exceptional specimens.

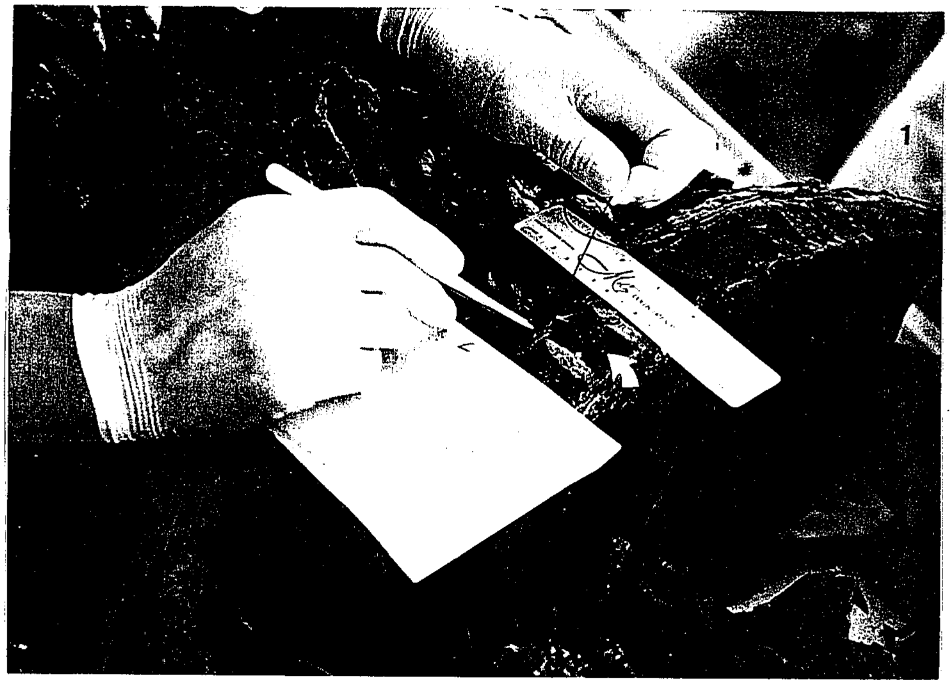
The photography was performed by Nelson Marquina, a student at Logan College and lab technician. The camera used was an SLR Pentax ME super with a Tokina ATX macro 90mm lens. The film used was Kodak Ektachrome ASA 100.

OBSERVATIONS

After the specimens' vertebral columns were sectioned from the cadaver and divided sagittally, the dura mater was meticulously drawn away from the inner walls of the neural canal, allowing us to reveal the presence of ligaments attaching the dura mater to the PLL. While their size varied, their presence was noted at most every level. Some were small slips of connective tissue and others were so large as to occupy a significant portion of the ventral epidural space. The anterior dural ligaments were the largest of the three subgroups and thus the easiest to locate. As one progressed laterally the second group of ligaments became evident. On average they were not as large as the ventral dural ligaments. However, their presence was unquestionable. The third group connecting the root sleeve to the inferior pedicle were the smallest and most difficult to locate, but were present in all of the specimens studied.

In addition to the ventral and lateral dural ligaments, the investigators were able to identify and document ligaments connecting posterior dura to the ligamentum flavum and neural arch. Ellis, the senior author, has noted these structures in most all of the specimens he has studied.

The ligaments were differentiated from epidural fat and areolar tissue by placing mild to moderate traction on the structures and noting their adherence to the dura as well as the spinal attachments. The structures displayed resilience to traction that could only be provided by a tissue which is fibrous in nature.



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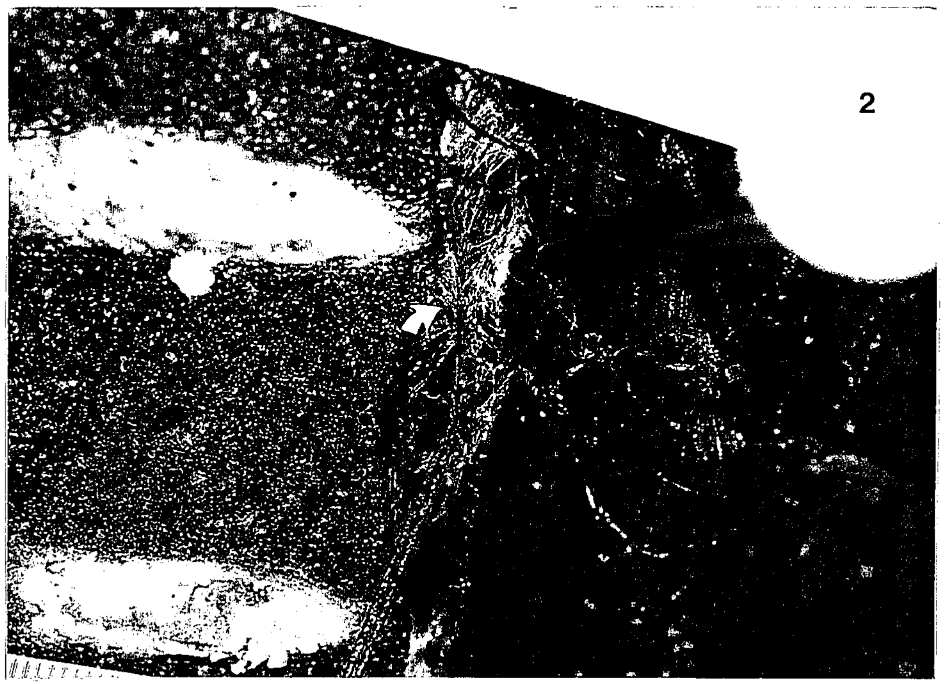

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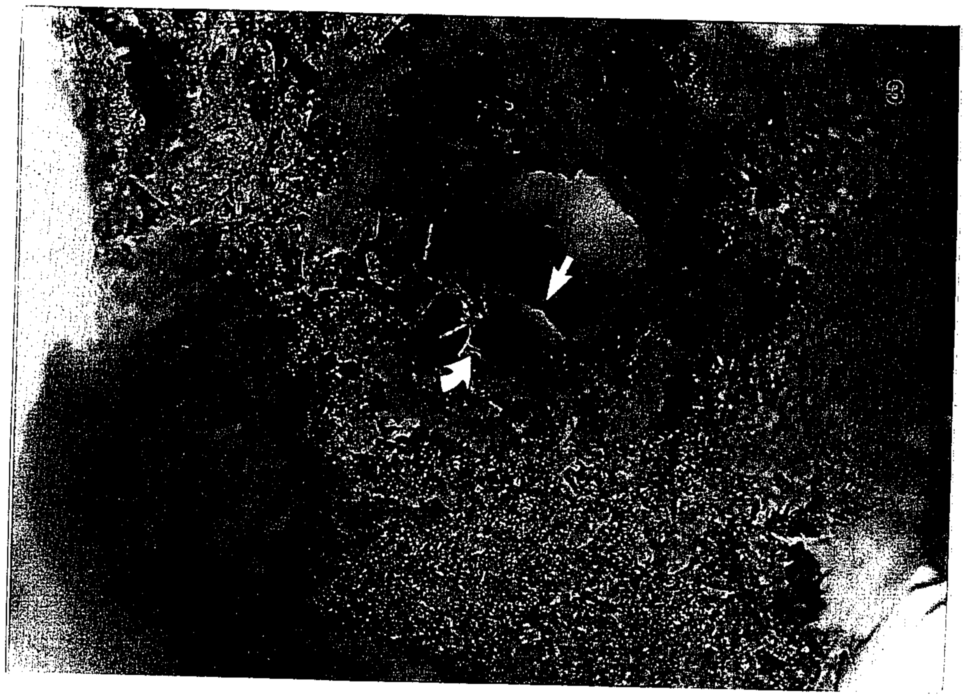

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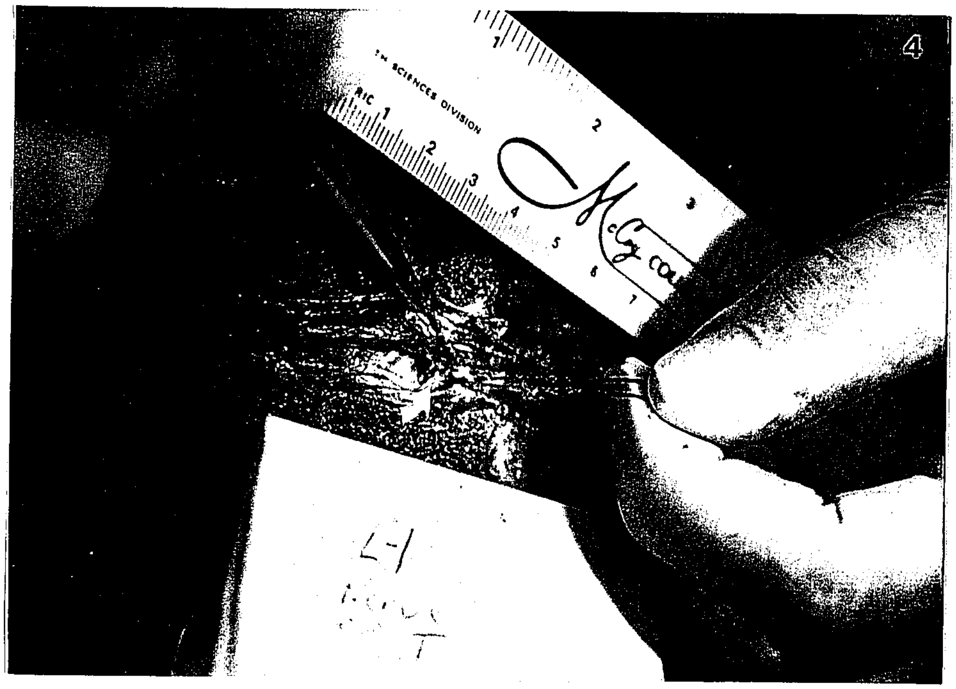

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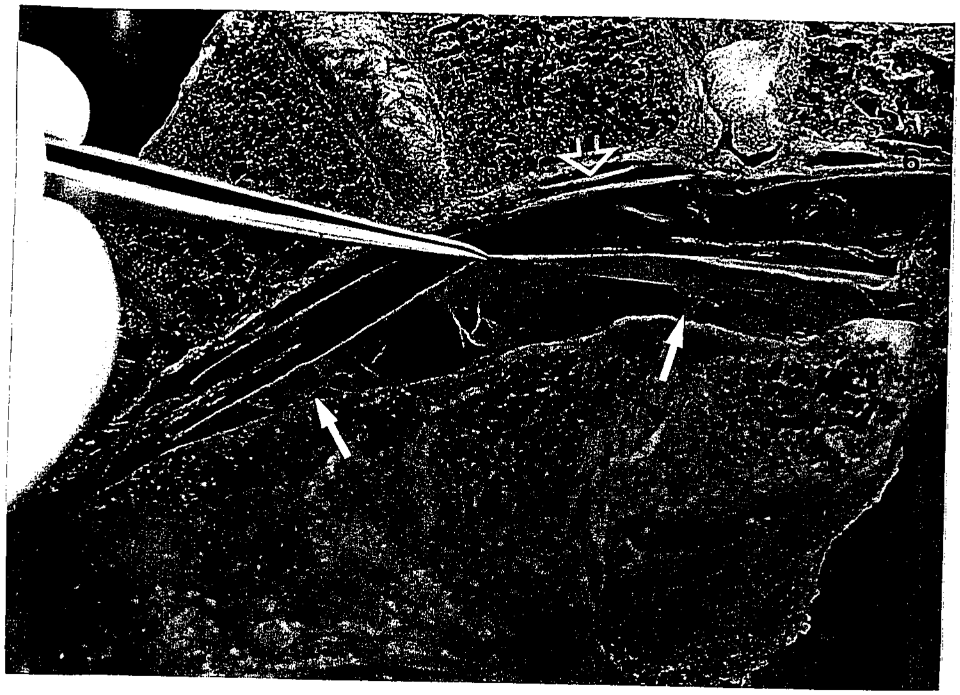

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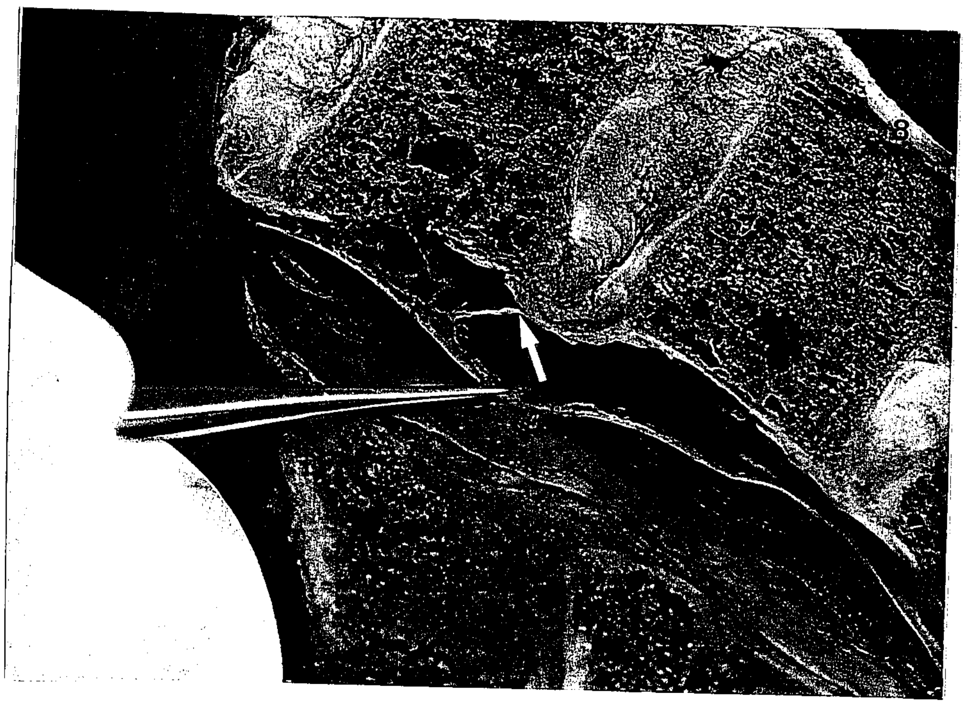

Figure 8.

DISCUSSION

Meningovertebral ligaments are predominantly found in the anterior epidural space in the lumbar and lumbosacral regions of the neural canal. Thus the spinal cord in this region is functionally fixed to the PLL and posterior vertebral bodies more so than any other region of the spine. This may be due to the fact that the anterior epidural space in this region is of greater volume and is able to accommodate a larger number of ligaments with greater size.

The highest incidence of disc bulges and nuclear herniation occur at the L5/S1 disc level. This, coupled with the increased density of ligamentous tissue fixing the dural sac and nerve roots, may compound the pathological effects of a disc bulge or herniation.

This raises the question of what happens to the spinal cord in the case of a spondylolisthesis. If the dural sac is adherent to the PLL, it stands to reason that the cord and the nerve roots will be tractioned anteriorly with the slipping of a vertebral body.

Calcification of meningovertebral ligaments has been described and documented through the use of computed tomography(19), however, their anatomical and pathological significance were not considered. It can be hypothesized that calcification of these ligamentous structures could result in mechanical irritation to the thecal sac and nerve roots. It has been postulated that the small cap of bone which is often visible on the posterior vertebral bodies with the use of CT scans may be the result of traction on these meningovertebral ligaments resulting in a type of "traction spur"(1).

In accordance with Spencer's(17) hypothesis that the lack of dural attachments may result in asymptomatic disc protrusion, we suggest chiropractic adjustments may affect the meningovertebral ligaments in some patients with disc lesions. The manner in which the ligaments are affected may however be somewhat debatable. One may construct an argument that the tension put on these ligaments by a disc may be alleviated by disrupting tension in the ligaments during a high velocity low amplitude thrust (HVLA). This argument could be supported by the fact that an MRI prior to chiropractic management of the disc bulge will be identical to an MRI taken after the patient has attained a symptom free status through the use of Chiropractic treatment. However, chiropractic practitioners who use low velocity techniques (Logan Basic, Toftness, Activator Methods etc..) experience the same level of success with their treatment(20,21,22). Therefore, it is unlikely that the dural ligaments are actually disrupted as a result of chiropractic treatments. However, we believe they are affected in some manner by the adjustment. This is most likely accomplished by alleviating tension placed on these ligaments by the disc bulge. The manner in which this is accomplished is unknown, however, we may postulate that a vertebral subluxation brought on by a disc bulge may place tension on the dural ligaments. Thus, a reduction of the subluxation will alleviate this tension and in doing so reduce or abolish the pain.

CONCLUSION

This study has confirmed and illustrated further the existence of meningovertebral ligaments, significance of which has notably been neglected, even though their presence in the human body has been documented for over one hundred years.

While a limited number of specimens were utilized in this research, the results were consistent with those found in the literature review, and in numerous specimens dissected and studied by Ellis. The number and size of the ligaments varied from specimen to specimen, however the L5/S1 region possessed the largest and most well developed ligaments.

Two of the specimens had suffered L5/S1 disc herniation. The extruded nuclear material was kept from expanding by the presence of the anterior meningovertebral ligament. This configuration of the meningovertebral ligaments has been referred to as the median sagittal septum in some of the literature(17). Dural ligaments' significance in human anatomy as well as their contribution to the pathological effects of disc protrusion has been understated in the literature to date. These anatomical structures, found in all Homo sapiens at most every level of the lumbar and lumbosacral regions, deserve to be documented further. Of equal importance, their putative role in low back pain cannot be ignored and will require more in-depth investigations to thoroughly understand possible mechanisms.

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ILLUSTRATION LEGENDS

Figure 1: Representative specimen (cadaver #1) dissected to reveal the contents of the neural canal in sagittal section. Meningovertebral ligaments are tractioned by the string. Curved arrow indicates body of L1 vertebra.

Figure 2: Specimen #1 demonstrating anterior meningovertebral ligaments the largest of which is labeled with a green string, exposed by retracting dura mater posteriorly with forceps at the level of the L1/L2 disc. Note trabeculae surrounding the ligament.

Figure 3: Transverse section of the T5 vertebra. The straight arrow demonstrates the dura mater tractioned posteriorly to allow the anterior and lateral meningovertebral ligaments to be viewed.

Figure 4: The dura mater is tractioned with forceps while the meningovertebral ligament is labeled with a string. Note its attachment to the L1 nerve root as it enters the intervertebral foramen.

Figure 5: Sagittal section of L4/L5 and L5/S1 discs and the sacrum. Note the disc herniation at the L4/L5 disc level. The open arrow displays the deep layer of the PLL. The short arrow indicates the PLL's attachment at the disc. The meningovertebral ligaments are marked with the long arrow.

Figure 6: Same views as figure five. Again the open arrow identifies the deep layer of the PLL while the solid arrows denote the dorsal meningovertebral ligaments. Forceps tractioning the dura mater anteriorly.

Figure 7: Again the dorsal meningovertebral ligaments are displayed at the S1 vertebral level (solid arrow).

Figure 8: Anterior dura mater is tractioned posteriorly at the L4/L5 disc level to reveal an excellent example of the anterior meningovertebral ligament.