

## Original Article

## Spinal dural attachments to the vertebral column: An anatomic report and review of the literature

Kristopher T. Kimmell, Hayan Dayoub<sup>1</sup>, Hakeem Shakir<sup>2</sup>, Eric H. Sincoff<sup>3</sup>

Department of Neurosurgery, University of Rochester Medical Center, Rochester, NY, <sup>1</sup>Department of Neurosurgery, Thomas Jefferson University Medical Center, Philadelphia, PA, <sup>2</sup>College of Medicine, The University of Oklahoma Health Sciences Center, Oklahoma City, OK, <sup>3</sup>Department of Neurosurgery, SSM St. Clare Health Center, Fenton, MO, USA

E-mail: \*Kristopher T. Kimmell - [kkimmell@gmail.com](mailto:kkimmell@gmail.com); Hayan Dayoub - [hayand@hotmail.com](mailto:hayand@hotmail.com); Hakeem Shakir - [hjshakir@gmail.com](mailto:hjshakir@gmail.com); Eric H. Sincoff - [eric-sincoff@ouhsc.edu](mailto:eric-sincoff@ouhsc.edu)

\*Corresponding author

Received: 28 March 11

Accepted: 13 June 11

Published: 18 July 11

**This article may be cited as:**

Kimmell KT, Dayoub H, Shakir H, Sincoff EH. Spinal dural attachments to the vertebral column: An anatomic report and review of the literature. *Surg Neurol Int* 2011;2:97.

Available FREE in open access from: <http://www.surgicalneurologyint.com/text.asp?2011/2/1/97/82990>

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### Abstract

**Background:** The spinal dura is anchored within the vertebral canal by connective tissue in the epidural space as well as the spinal roots. Inadvertent disruption of these dural attachments may lead to durotomy and cerebrospinal fluid (CSF) leaks. We observed well-developed connective tissue ligaments connecting the lumbar dura to the spinal column and examined these tissues microscopically.

**Methods:** Intraoperative images were obtained during lumbar laminectomy procedures. They demonstrated connective tissue attachments, linking the lumbar dura to the spinal column in the dorsal midline and dorsolaterally. Tissue samples were obtained and examined microscopically. We then conducted a search of the literature to find references to dural attachments to the spinal column.

**Results:** Histological examination of the samples showed minimal cellular fibrous tissue. To date no references to these attachments have been made in neurosurgical literature. Previous studies, including live, cadaveric, and radiographic examinations, have demonstrated a dorsomedian fold of dura attached to the junction of the ligamentum flavum, and dorsolateral ligaments that divide the dorsal epidural space into an anterior and posterior compartment.

**Conclusions:** Epidural fibrous connections or ligaments between the dura and the lumbar spinal column may be of clinical importance to the neurosurgeon. Care should be taken during lumbar procedures not to disrupt or tear these ligaments as this may cause dural tears and CSF leaks. Identifying these ligaments and cutting them sharply may prevent inadvertent durotomies.

**Key Words:** Anatomic study, epidural space, spinal column

**Access this article online****Website:**

[www.surgicalneurologyint.com](http://www.surgicalneurologyint.com)

**DOI:**

10.4103/2152-7806.82990

**Quick Response Code:**

### INTRODUCTION

The epidural space is a frequently encountered area of the spinal anatomy. This potential space is lined by a thin layer of epithelium.<sup>[12,18]</sup> Ventrally, the space is filled

with the vertebral venous plexus. Laterally, the nerve roots leave the intradural space and traverse the epidural space and exit the vertebral column via the intervertebral foramina. Dorsally the epidural space is filled with fat, especially in the lumbar region. The spinal cord and

meninges are thought to be tethered by the nerve roots and relatively immobile within the vertebral column, as they exit through the intervertebral canals. There are well-described, connective tissue bands that run laterally from the dura to the vertebral canal known as Hoffmann's ligaments.<sup>[27]</sup> Dorsal ligaments tethering the dura to the vertebral canal and their clinical importance have not received much attention previously in neurosurgical literature. It is the observation of the authors that there are definite ligaments running dorsolaterally and dorsomedially between the dura and the vertebral canal. We examined these connections further and searched for their mention in literature.

## MATERIALS AND METHODS

Several patients were taken to the operating room for lumbar laminectomy. They had had no previous surgery involving the spinal canal. Upon exposure of the vertebral canal, ligaments in the dorsomedian and dorsolateral planes, linking the posterior elements of the vertebral canal and the dura could be seen. Intraoperative photographs of these ligaments were obtained [Figure 1].

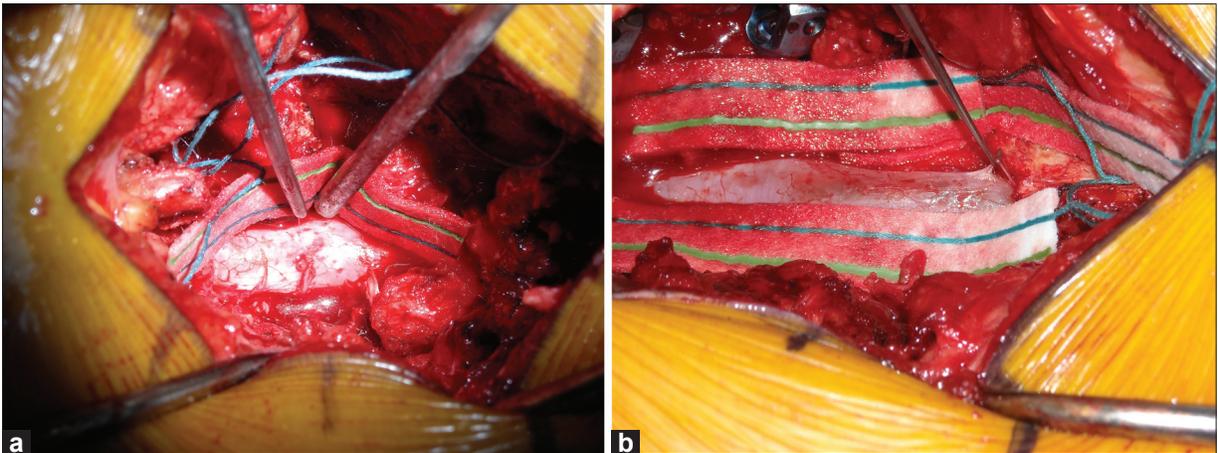
A sample of these ligaments was removed and sent to the Pathology Department for examination.

Grossly the ligaments were white-to-pale pink-tan tissue rods, approximately 1.0 cm in length, and 0.1 cm in diameter. On histological preparation with H and E staining, the fibrous bands were examined under low, medium, and high power [Figure 2]. Microscopic examination revealed a minimal, cellular fibrous connective tissue.

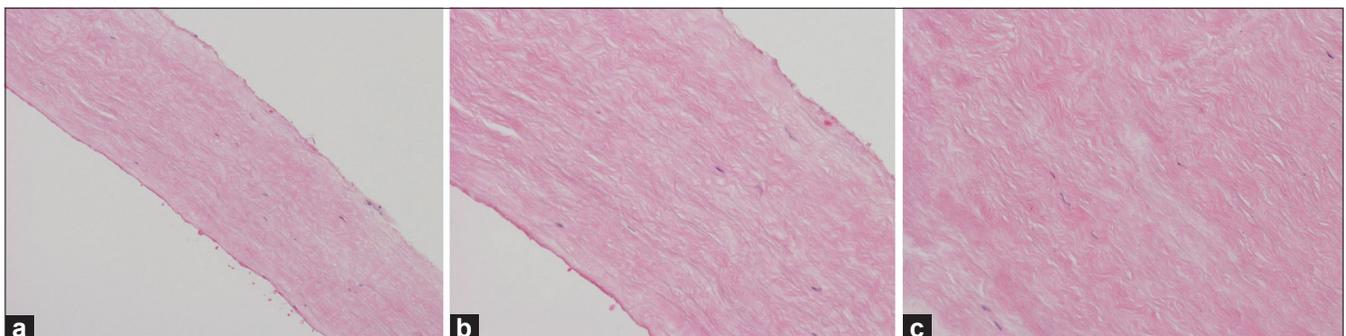
A search of the literature using PubMed was conducted, to search for connective tissue in the epidural space. Search terms included epidural ligaments, epidural space, epidural space connective tissue, epidural membranes, and peridural membranes.

## RESULTS

One report from the neurosurgical literature discussed anterior connective tissue and its association with the posterior longitudinal ligament (PLL).<sup>[2]</sup> Our search found no reference to dorsal connective tissue or ligaments in the epidural space in the neurosurgical



**Figure 1:** (a) Intraoperative photographs demonstrating the dorsal fibrous attachments of the dura to the spinal column (b) Intraoperative photographs demonstrating the dorsal fibrous attachments of the dura to the spinal



**Figure 2:** (a) H and E stained slides at (a) low, (b) medium, and (c) high powers, demonstrating the fibrous tissue with low cellularity

literature. Several anatomic reports were found in other disciplines.<sup>[1-9,10-13,15-16,19,21-24,26-28]</sup> The anesthesia literature had examined the dorsomedian attachments of the dura to the vertebral column.<sup>[1,4,5,8,10-13,23]</sup> Several reports had examined cadaveric spinal columns in humans and animals.<sup>[3,4,7,10,11,13,15,16, 21,27,28]</sup> The radiological literature has highlighted these dorsal connections of the dura to the vertebral column.<sup>[3,7,9,14,17,24,28]</sup>

The fibrous tissues connecting the dura to the spinal cord have long been alluded to in anatomic texts. Hoffman was the first to formally describe them, as a medical student in 1895, and since that time the ventrolateral connections have borne his name.<sup>[18]</sup> The ventromedian ligaments associated with the posterior longitudinal ligament (PLL) are sometimes called Trolard's ligaments.<sup>[2]</sup> However, the dorsal connections have been less formally described. Von Ludinghausen described a dorsomedian fold that he observed at the time of laminectomies,<sup>[16]</sup> which was also reported by Juan Sanchez around the same time.<sup>[22]</sup> Radiographic studies performed by Luyendijk seemed to confirm the presence of this dorsomedian fold.<sup>[17]</sup>

In addition to radiographic reports, there have been studies of cadaveric and live subjects that demonstrate these connective tissues. Several cadaveric studies, beginning with Husemeyer and White,<sup>[13]</sup> seemed to confirm the presence of the dorsomedian fold of the dura. Blomberg, after his cadaveric study,<sup>[12]</sup> sought to examine the epidural space in live subjects by performing epiduroscopy in 10 patients.<sup>[5]</sup> He observed definite connective tissue attachments dorsomedially and dorsolaterally. Several other studies in the anesthesia literature confirmed Blomberg's findings of ligaments tethering the dura to the spinal column, anteriorly, dorsomedially, and dorsolaterally.<sup>[8,10-12]</sup>

## DISCUSSION

A brief review of the embryology of the spinal cord and dura is beneficial to understand the epidural ligaments attaching the dura to the vertebral column. There are reports that have examined the development of the spinal canal at various stages of fetal growth.<sup>[7,26]</sup> In the early embryological stages, the epidural space is filled with a continuum of various connective tissue progenitors, including adipocytes and fibrocytes. As the embryo grows, these cells differentiate into several layers, including the precursor of the dura mater, which is thought to derive from the mesenchyme as well as the neural crest cells. At the embryologic stage, these layers completely surround the spinal cord. As the vertebral bodies lengthen, these connective tissue layers become discontinuous. These discontinuous connections become the epidural ligaments, and are found to be focally and anteriomedially associated with the PLL (Trolard's ligaments), laterally associated with the intervertebral

foramina (Hoffman's ligaments), and dorsolaterally and dorsomedially (the posterior epidural ligaments) associated with the vertebral laminae and ligamentum flavum.

Histologically, these connective tissues are fibrous, which suggests that the epidural ligaments in the spinal canal are the analogs of the outer fibrous layer of the cranial dura that is associated with the internal periosteal layer of the cranium. Furthermore these fibrous ligaments may function in stabilizing the structures within the vertebral canal. Yong-Hing *et al.*, examined the histological makeup of the connective tissues of the posterior vertebral column, highlighting the difference between the more elastic nature of the ligamentum flavum, which suggests a function in mobility, and the other connective tissues, including the epidural ligaments, which are more fibrous, lending to a function in stabilization and immobility.<sup>[29]</sup>

Although the focus of this study is on the lumbar epidural ligaments, their existence in the cervical region has been demonstrated in other studies.<sup>[6,25]</sup> On account of their close relationship to the dura and their frequent encounter during the spinal procedures, it is important for the neurosurgeon to be aware of these ligaments during spinal procedures. Failure to identify these ligaments and carefully dissect them may lead to inadvertent durotomies and unwanted CSF leaks.

## CONCLUSION

The epidural ligaments that link the dura and the lumbar spinal column are of clinical importance to the neurosurgeon. Care should be taken during spinal procedures not to tear these ligaments as this may cause dural tears and CSF leaks. Identifying these ligaments and cutting them sharply may prevent inadvertent durotomies.

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