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# A Ligament in the Lumbar Foramina: Inverted Y Ligament

## An Anatomic Report

Y. Şukru Caglar, MD,* Habibullah Dolgun, MD,* Hasan Caglar Ugur, MD,* Gokmen Kahilogullari, MD,* Ibrahim Tekdemir, MD,† and Alaittin Elhan, MD†

**Objectives.** The objective of this study was to investigate the ligaments in the exit zone of lumbar foramen and describe their anatomic relationships with adjacent structures. Few studies have been reported on the ligaments of foramen and the anatomic relationships on the lumbar level. The ligament described in this study is novel since it has not been reported previously.

**Methods.** Ten male and five female cadavers were used to investigate intraforaminal area and ligaments of the lumbar level. The cadavers were filled with colored latex, and the lumbar foramen were examined under operative microscope.

**Results.** A lumbar foramen branched off into two or three main passages, composed of inverted Y ligament form. The medial lower arm of Y ligament was attached to the upper and anterior surface of the superior articular process of the lower corpus vertebra. Its lateral lower arm was attached to the upper surface of the area where the lower corpus vertebra and its pedicle met, and the upper arm was attached to the lower surface of the pedicle of upper vertebra where it met with transverse process. The anatomic properties of vascular and nervous structures in foramen and the relations among them are described.

**Conclusion.** The ligament detected in the study was different from the other reported descriptions of foraminal ligaments. It divided the lumbar foramen into three passages. Because of its relations with adjacent structures, such as nerves and vessels, the inverted Y ligament may be an important structure for lumbar foramen. Thus, it may be an important anatomic landmark.

**Key words:** lumbar foramen, lumbar spine surgery, inverted Y ligament, cadaver, anatomy. **Spine 2004;29: 1504–1507**

Literature reveals few studies on the ligaments of intraforaminal and extraforaminal regions. Therefore, the information on their relations with adjacent anatomic structures is also limited. The dural sleeve of the spinal nerve root was first described by Hoffmann, but ligaments were not consistent at all levels.[1] In another study, Golub and Silverman[2] described five major types of transforaminal ligaments: corporotransverse superior ligament, corporotransverse inferior ligament, superior transforaminal ligament, mid-transforaminal, and inferior transforaminal ligament. Although they could explain the anatomic structure and precise nature of the ligaments, the origin of the ligaments was not clear. Moreover, the clinical significance of these ligaments was not assessed. Spencer *et al*[3] concentrated on Hoffmann's ligaments and described lateral ligament. In the biomechanical studies of Peretti *et al*,[4] only two sites of fixation of the roots were described: the first site of which was the neck of the dural sheath surrounding the root, and the second site was represented by the expansions passing from the spinal nerve to the outer periphery of the foramen. Wiltse *et al*[1] noted that the ligaments tether the circumneural sheath to the bony canal. They observed many vessels that kept the nerve from sliding inside the sheath between the bony canal and nerve; thus, protecting the circulation when operating around these nerves was advised. They further noted that totally stripping the circumneural sheath could theoretically cause pain due to vascular deprivation. Grimes *et al*[5] first described the anatomic configuration as four foraminal ligaments, which were tethering the spinal nerve root within the lumbar foramen.

As for intraforaminal components, many anomalies and morphologic differences were presented to describe lumbar root canal.[6–10] In addition, some recent studies provide details on intraforaminal ligaments through imaging techniques.[11–13]

The diagnoses of lateral or extraforaminal disc herniations have become more common in recent years owing to the developments in diagnostic tools. Thus, foraminal anatomy seems to gain popularity. However, the classic study of Wiltse,[1] which described the foraminal zone and Macnab's description of hidden zone should be reconsidered.[14] The aim of this study is to define a different anatomic structure in lumbar foramen.

## Materials and Methods

This study involved 15 formalin-fixed cadavers with an age range of 28 to 68 years (10 males, 5 females). The area between T12 and S1 was posteriorly and posterolaterally explored. Spinous processes of the vertebrae were removed with a rongeur under Carl-Zeiss surgical microscope. Laminectomy and foraminotomy of all levels were performed to expose detailed anatomy. All the foramen were explored in T12–S1 levels on both sides. Y ligaments were observed at various levels and were scrutinized through microdissection techniques at upper

From the Departments of *Neurosurgery and †Anatomy, University of Ankara, Faculty of Medicine, Ankara, Turkey.
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Address correspondence to Hasan Caglar Ugur, MD, Ankara Universitesi Tip Fakultesi, Norosirurji Anabilim Dali, 06100 Samanpazari, Ankara, Turkey; E-mail: hasanugur2001@hotmail.com

**Table 1. The Forms of Ligaments in the Right L5 Foramen of 15 Cadavers and the Genders and Ages of the Cadavers**

| Case No. | Sex | Ligament | Age (yr) |
|---|---|---|---|
| 1 | Male | Y ligament (3 compartments) | 43 |
| 2 | Male | 2 compartments | 28 |
| 3 | Female | 2 compartments | 33 |
| 4 | Male | Y ligament (3 compartments) | 18 |
| 5 | Male | Y ligament (3 compartments) | 19 |
| 6 | Female | Y ligament (3 compartments) | 66 |
| 7 | Male | 2 compartments | 72 |
| 8 | Female | Y ligament (3 compartments) | 54 |
| 9 | Male | 2 compartments | 55 |
| 10 | Male | Y ligament (3 compartments) | 66 |
| 11 | Male | Y ligament (3 compartments) | 46 |
| 12 | Female | 2 compartments | 81 |
| 13 | Male | 2 compartments | 32 |
| 14 | Female | Y ligament (3 compartments) | 30 |
| 15 | Male | 2 compartments | 48 |

levels. However, they could not be clearly exposed for each foramen because of their fine structure. Only the ligament structures in the right L5 foramen of all cadavers could be clearly exposed. Thus, the Y ligament of the right L5 foramen and its relations were documented (Table 1). The foraminal ligaments and all the ligaments dissected from the right L5 foramen of 15 cadavers were histologically studied.

## ■ Results

Intervertebral lumbar foramen (IVF) is a passage composed of adjacent pedicles. Segmental spinal nerves exit from these openings. Vessels supply the bone and soft tissues and enter through foramen with nerves. The exit zone of IVF was covered by an inverted Y shaped connective tissue in 8 of 15 specimens (Figure 1B). This structure divided the IVF into anterior-medial, medial, and posterolateral compartments, each containing arteries, veins, nerves, and adipose tissue (Figure 1C). In seven cadavers, however, this ligament divided the foramen into two compartments: anterior-medial and posterolateral.

The inverted Y ligament had three arms. The medial lower arm was attached to the upper and anterior surface of the superior articular process of lower corpus vertebra, while the lateral lower arm was attached to the upper surface of the area where lower corpus vertebra and its pedicle met. The upper arm was attached to the lower surface of pedicle of upper vertebra where it met with the transverse process.

The inverted Y shape divided the IVF into three compartments, the smallest of which was located posterolaterally. It was between the anterolateral part of articular process and superior arm of the Y ligament and was 10 × 4.5 mm in size, containing two veins and two arteries. The remaining area was full of adipose tissue. The middle compartment, which lied between the arms of Y ligament, was 10 × 5 mm in size and contained an artery, a vein, and two nerves. The anterior-medial compartment, which contained a nerve, an artery, and a vein and was 20 × 10 mm in size, resembled an egg with wider side up. Considering the nerve, the posterolateral compartment seems to be the safest zone during surgery. Histologic appearance consisted of regular longitudinally extending thick collagen fiber bunches with loose connective tissues (Figure 1A).

## ■ Discussion

The literature presents few ligamentous anatomic attachments of the lumbar region. Some of the ligaments described may be similar to anatomic structures in thoracic or cervical spine.[2,15]

The present study demonstrates a ligament at the exit zone of right L5 foramen, which has not been previously described in the literature. This ligament may be important for operative approaches of intraforaminal pathology and foraminal, extraforaminal, far lateral disc herniations.[16–18] The relation of Y ligament with nerves and vessels of this area carries relative significance in surgical treatments.

Golub and Silverman[2] claimed that dissections disclosing intervertebral veins might attain large size and sometimes rivaling the nerve root in dimension. Consequently, they recommended a careful approach in any operation involving this area, which was in conformity with our results. It should be kept in mind that vessels or nerves guide the surgeon who intervenes in these areas.[1] Grimes *et al*[5] described four ligaments in their studies; however, no descriptions of other anatomic structures like vessels or nerves were provided.

CT scan and MRI previously identified corporotransverse and transforaminal ligaments. Thus, CT and MRI may improve the diagnosis of lateral spinosus because of the presumed role of ligaments in the compression of spinal nerves.[2]

CT and MRI technology has provided many new data to the field in the last decade. Through these contributions to intervertebral neuroanatomy and especially to its exit zone, new diagnostic tools have shown us which pathologic conditions can be located in the exit zone of a foramen, and surgical microscope and microtechniques have paved the way to the new approaches concerning the pathologies of neural foramen.[19]

Abdullah *et al*,[20] in 1974, first described the clinical syndrome of extreme (far) lateral disc herniations. According to Young and McCulloch,[21] foraminal and extraforaminal disc herniations make up 5% to 10% of all herniations requiring surgery. Why is the anatomy of this region essential? For years, neurosurgeons have used laminectomy and facetectomy for foraminal and extraforaminal disc herniations, which damage the important articulation of spine. Most surgeons have a fear of sacrificing the facet joints and destroy the instability; thus, the knowledge of the anatomy of this area is going to contribute their ability to handle pathologies, use a different lateral approach, and avoid the sacrifice of facet joint.

Paraspinal posterolateral intertransverse approach has been a choice of preference in recent years because of

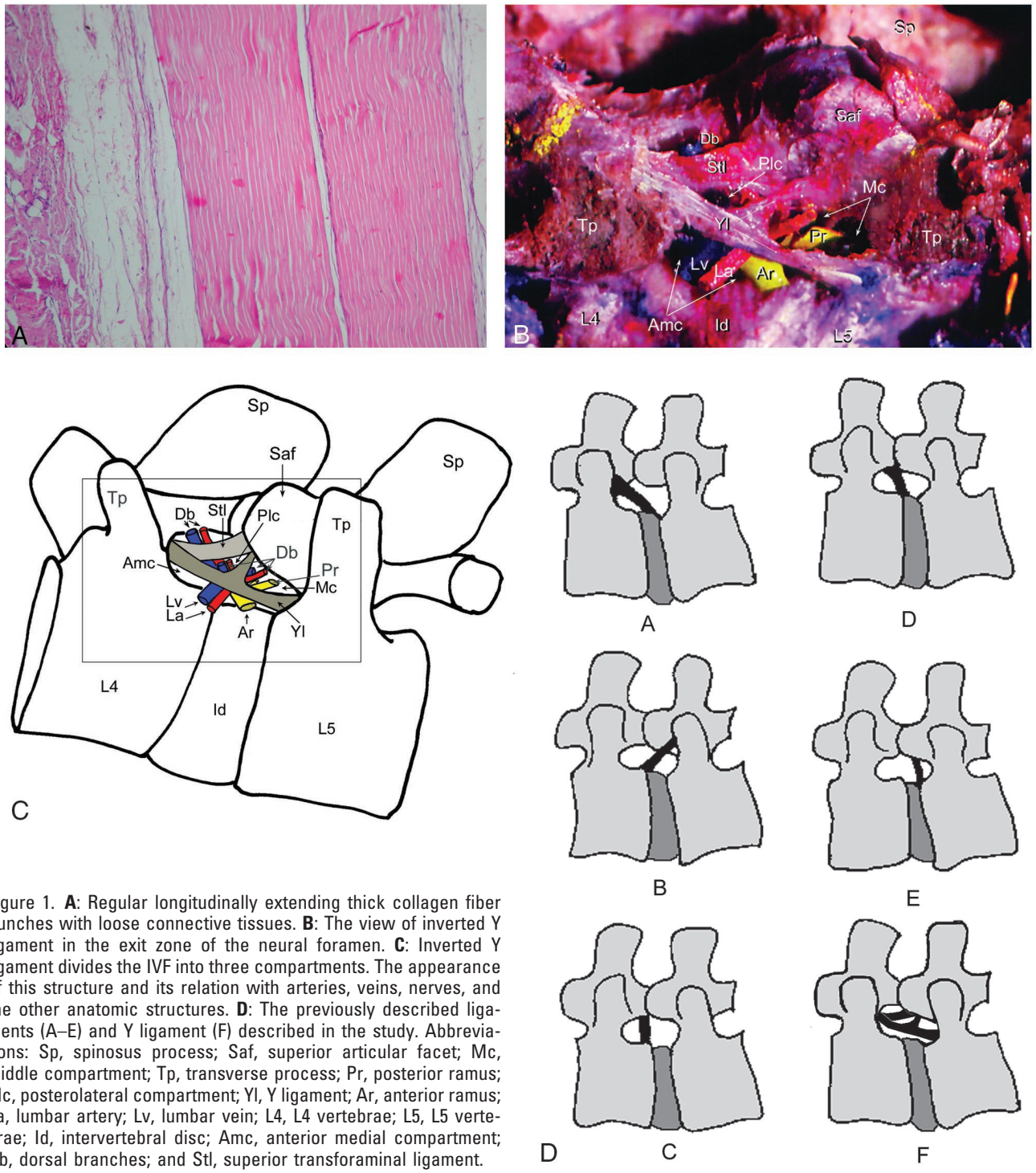


Figure 1. **A**: Regular longitudinally extending thick collagen fiber bunches with loose connective tissues. **B**: The view of inverted Y ligament in the exit zone of the neural foramen. **C**: Inverted Y ligament divides the IVF into three compartments. The appearance of this structure and its relation with arteries, veins, nerves, and the other anatomic structures. **D**: The previously described ligaments (A–E) and Y ligament (F) described in the study. Abbreviations: Sp, spinosus process; Saf, superior articular facet; Mc, middle compartment; Tp, transverse process; Pr, posterior ramus; Plc, posterolateral compartment; Yl, Y ligament; Ar, anterior ramus; La, lumbar artery; Lv, lumbar vein; L4, L4 vertebrae; L5, L5 vertebrae; Id, intervertebral disc; Amc, anterior medial compartment; Db, dorsal branches; and Stl, superior transforaminal ligament.

its efficiency and safety when the surgeon has a comprehensive grasp of the anatomy of foraminal region. This study may further aid in the improvement of this approach. In the paraspinal intertransverse approach, the pedicles and isthmus are the landmarks in bone instructions. For safe access to the pathologic zone, the intertransverse ligament may be a guide.[21] Young and McCulloch propose taking the intertransverse ligaments as a flap based laterally and detached medially to avoid the posterior branch of radicular artery.[21] The next step is to remove the tip of superior facet and the shoulder of inferior facet. The method described above protects the nerve root. The findings of this study may help after these steps and show that the compartments divided by Y ligaments are either in two or three parts. The posterolateral compartment always seems to be the safest zone because it does not contain nerve roots. The results of this study are parallel to the technique of Young and McCulloch[21] in their large series, which proposes a safe approach to the nerve roots.

The structures of the other compartments are also important. If surgery is not performed with extreme caution, the hemorrhage of arterial or venous structures involved in them may cause severe epidural complications, which may soon cause postoperative pain. Despite the pronounced importance of all structures, damaged nerve roots may lead to dramatic neurologic deficits. Thus, this study may contribute into recent literature on surgical techniques concerning this area.

### ■ Key Points

- Inverted Y ligament, detected in the study, was different from the other reported descriptions of foraminal ligaments.
- The inverted Y ligament divided the lumbar foramen into three passages.
- Because of its relations with adjacent structures, like nerves and vessels, inverted Y ligament may be an important structure for lumbar foramina.

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