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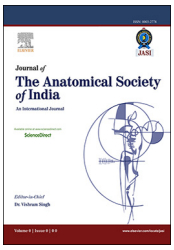

Review Article

Clinical anatomy and significance of the lumbar intervertebral foramen: A review

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ARTICLE INFO

Article history:
Received 8 August 2015
Accepted 26 October 2015
Available online 23 November 2015

Keywords:
Lumbar intervertebral foramen
Anatomy
Clinical
Triangular working zone
Safe zone
Review

ABSTRACT

The objective of this review is to summarize the knowledge about the anatomy of the lumbar intervertebral foramen (IVF) as an anatomic entity. The intervertebral or neural foramen is an orifice located between any two adjacent vertebrae that allows communication between the spinal canal and the extraspinal region. We describe the osseous structure of the lumbar foramen, the adjacent ligaments and its components including the arteries and veins passing through or neighboring it, and the spinal nerves and roots. Although lumbar spine structures are familiar to spinal surgeons and many procedures are performed in the area of the lumbar IVF, yet surprisingly little is known about the precise anatomy of the foramen and the triangular working zone of it.

1. Introduction

Generally, the lumbar spine consists of five moveable vertebrae numbered L1–L5. The lumbar spine is characterized by complex anatomy, which is a remarkable combination of these strong vertebrae, multiple osseous elements linked by joint capsules, and flexible ligaments/tendons, large muscles, and highly sensitive nerves. It also has a complicated innervation and vascular supply as described by Drake et al.[1] It is designed to be incredibly strong, protecting the highly sensitive spinal cord and spinal nerve roots. At the same time, it is highly flexible, providing mobility in many different planes including flexion, extension, side bending, and rotation as mentioned.[2,3]

The intervertebral foramen (IVF), referring to the lumbar IVF also, serves as the path between the spinal canal and periphery, through which canal neurovascular structures pass. This foramen is unique in comparison to other foramens of the body due to its boundaries consisting of two movable joints: the ventral intervertebral joint and the dorsal zygapophysial joint. The proximity of these joints increases susceptibility of

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Abbreviations: IVF, intervertebral foramen; CSF, cerebrospinal fluid; DRG, dorsal root ganglia; TFL, transforaminal ligament; LSTV, lumbosacral transitional vertebra; ED, endoscopic discectomy; MRN, magnetic resonance neurography; PELD, posterolateral endoscopic lumbar discectomy.

http://dx.doi.org/10.1016/j.jasi.2015.10.003

Table 1 – Articles where the anatomy of lumbar IVF is described as a whole.

Level of evidence	Study aim	Date	Authors	Journal
Level IV	Ligament, nerve, and blood vessel anatomy of the lateral zone of the lumbar intervertebral foramina	2015	Yuan SG, Wen YL, Zhang P, Li YK	Int Orthop
Level V	Radiographic anatomy of the intervertebral cervical and lumbar foramina (vessels and variants)	2012	Demondion X, Lefebvre G, Fisch O	Diagn Interv Imaging
Level IV	Anatomy of the intervertebral foramen	2002	Gilchrist RV, Slipman CW, Bhagia SM	Pain Phys
Level IV	Lumbar lateral recess and intervertebral foramen. Radio-anatomical study	2000	Demondion X, Manelfe C, Prere J, Francke JP	J Radiol
Level IV	Chirurgische Anatomie und Pathologie der lumbalen Intervertebralforamina [Surgical anatomy and pathology of lumbar intervertebral foramina]	1994	Steinsiepe KF	Aktuelle Probl Chir Orthop

narrowing from arthritic structural alterations and lesions. Specifically, the lumbar IVF has a critical role in spinal stenosis and other degenerative spine disorders.[4,5]

Although lumbar spine structures are familiar to spinal surgeons, yet surprisingly little is known about the precise anatomy of the IVF as an anatomic entity (as seen in Table 1), particularly the ligamentous structure associated with this canal. Furthermore, only a few studies have described the anatomy of this region but not in depth and not as a whole. Additionally, a lack of schematic depiction of the foraminal components and their anatomical relationships can be observed. To elucidate the clinical significance of the lumbar IVF, we study this foramen as an anatomical entity including spinal nerve roots, vessels, and osseous and ligamentous structures, and we further proceed to their schematic illustration. The following review is a thorough anatomic description of the IVF, with its contents, from L1 to L5 level.

2. The lumbar IVF

2.1. *Anatomical boundaries*

This foramen has two parts: one anterosuperior, made up of the inferior part of the pedicle and the posteroinferior part of the vertebral body (see Fig. 1); the other is inferior and mobile; it is formed by the posterior articular lamina covered by the yellow ligament, in the back, and by the posterolateral aspect of the intervertebral disk in front.[6,7] This second articular part is the one that undergoes motion-related or degenerative changes. At the lumbar spine, the foramen has an oval shape with a large vertical axis. The L5-S1 foramen is the roundest and the smallest of the lumbar intervertebral foramina. The spinal ganglion occupies the largest part of the foramen at this segment.[8,9] In extreme flexion, all the diameters of the IVF are at their maximum; the pedicles move apart from each other, disk convexity is minimal as reported by Revel et al.[10] On the other hand, during extension, all the diameters diminish; the pedicles move closer to each other, reducing the height of the foramen by approximately 20%.[11,12] The collapse of the lumbar IVF equals to the reduction in foraminal height. Thus, as long as the height of the intervertebral space remains satisfactory, the passage of nerve components in the bony upper part of the foramen is protected in a way from disk protrusion, posterior facet joint osteoarthritis, and ascension of the inferior articular process during extension movements.

2.2. *Components*

The vertebral canal contains the spinal cord, its meninges, spinal nerve roots, and blood vessels supplying the cord, vertebrae, joints, muscles, and ligaments. The vertebral bodies and discs compose the anterior border, while the laminae and ligamentum flavum create the posterior border of the canal. Laterally, spinal nerves and vessels travel through the IVF.

Numerous components are together in the IVF: nerve roots and spinal ganglions, foraminal fat, foraminal veins, radicular arterioles, lymph vessels, the meningeal nerve and foraminal ligaments (see Fig. 2). The total area of the neurovascular bundle is estimated at 20–50% of the total foraminal area.[11] The anterior motor root joins the posterior sensory root just after the spinal ganglion in order to form the mixed spinal nerve. The spinal ganglion is located below the pedicle. At the foramen exit, the spinal nerve usually divides into a relatively

Fig. 1 – (1) Vertebral body, (2) Intervertebral disk, (3) Pars interarticularis, (4) Transverse process, (5) Intervertebral foramen, (6) Superior vertebral notch, (7) Inferior vertebral notch, (8) Superior articular process, (9) Inferior articular process, (10) Zygapophysial joint, (11) Lamina, (12) Spinous process, (13) Lumbo-sacral joint, (14) Sacrum.