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Posterolateral musculofascial approach to intervertebral discs of the lumbar spine: anatomic and topographic study

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Abstract:
Objective: assessment of the anatomical and topographical parameters of the wound channel formed in the course of the posterolateral musculofascial approach with the purpose of identifying the possibility of its clinical use in decompressive and stabilizing surgical interventions.
Materials and Methods: a posterolateral musculofascial approach to the lumbar spine was modeled using material from 20 male and female cadavers 54 – 76 years of age (median 67.5 years) who died from diseases not associated with the pathology of the spine. The study examined wound length, depth, wound depth index, and wound access zone, as well as the angle of intersection of the wound edges with the surface of surgical instruments.
Results: the mean length of the surgical wound when performing the lateral musculofascial approach was 149.75±6.35 mm. The mean depth of the wound was 116.75±8.85 mm. The mean value of the surgical wound depth index with interfascial approach was 77.96±5.04. The mean area of the intervertebral disc available for removal was 71.2±2.8%. The length of the aperture in the annulus fibrosus was on average 15.8±0.78 mm. The mean angle of the intersection of the wound edge by the trajectory of transpedicular screw implantation was 3.15±1.25°.
Conclusion:the assessment of the anatomical and topographical parameters of the wound channel formed during the posterolateral musculofascial approach allowed concluding that such surgical approach could be used to improve the functional outcomes of decompressive and stabilizing interventions on the lumbar spine.

Keywords: lumbar spinal stenosis, minimally invasive approach, transpedicular fixation, surgical technologies.

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Introduction

According to various authors, the prevalence of symptomatic spinal stenosis at the level of the lumbar spine in the adult population ranges from 5 to 11% exhibiting an ongoing increase due to constantly increasing life expectancy [1, 2]. The persistent increase in the number of patients requiring decompression and stabilization interventions, along with their growing mean age, increase the demands on surgical technology. One of the current relevant vectors for the development of contemporary spine surgery is to reduce the traumatic consequences of performed operations. The goal of reducing perioperative damage is achieved through the introduction of novel surgical techniques characterized by minimally open or percutaneous option of standard approaches to the area of surgical interest [3]. The combination of such technology with surgical navigation essentialfor providing the patient safety significantly raises the cost of treatment [4]. Limited healthcare resources, combined with an increase in the number of patients in need of decompressive and stabilizing interventions on the spine, substantiate the need for the development and employment of hybrid approaches that combine accessibility to the main anatomical landmarks and low trauma.

To reduce the damaging effect of surgical approach to the lumbar region soft tissues in the treatment of degenerative stenoses and instability, we have developed a modified posterolateral musculofascial approach to the intervertebral discs of the lumbar spine [5].

Objective –to assess the anatomical and topographical parameters of the wound channel formed during the posterolateral musculofascial approach in order to determine the possibility of its clinical use when performing decompressive and stabilizing surgical interventions.

Materials and Methods

Based on the material of 20 corpses of both sexes with different body mass index (average 25.1±2.9) aged from 54 to 76 years (median 67.5 years) who died from diseases not related to spinal pathology, we modeled the posterolateral musculofascial approach to the lumbar spine (*Table*).

Using the studied approach performed through standard median and paramedian incisions [6], we conducted discectomy and implanted transpedicular screws and intervertebralcagesdesigned to stabilizethe spine. This study examined standard parameters of a surgical wound: length, depth, wound depth index, and wound access zone, as well as the angle of intersection of the wound edge with the surface of surgical instruments. The length of the wound was measured as the distance between the most distant points located on the longitudinal axis of the wound. The depth of the wound was determined as a segment of the axis of the surgical intervention corresponding to the distance from the annulus fibrosus to the plane of the upper aperture of the wound. The wound depth index was calculated as the ratio of the wound depth to the size of the upper aperture multiplied by 100, using the formula:

$$V = (D/L) \times 100,$$

where V is the wound depth index, D is a wound depth, and L is a wound length.

The wound access zone in this study reflects the width of the opening in the annulus fibrosus in the course of discectomy. The area of the intervertebral disc available for removal was determined as well. After discectomy, dye (brilliant green) was poured into the interbody space through a unilateral approach. The remains of the disc were removed en bloc, along with the endplates, and dissected along the plane of the disc. The stained area of the resected disc was assessed in photographs using AutoCAD 2011 as a percentage of the total disc area.

As an indicator of the chosen surgical approach trauma, we employed the angle of intersection of the tool trajectory with the edges of the wound. These angles were determined relative to the sagittal plane. For this purpose, steel wires marked at 1 cm intervals were used;they passed through the spinous process (corresponding to the sagittal plane), the medial and lateral edges of the wound, the channel formed for implanting the transpedicular screw, and the trajectory of the instrument during the discectomy process. The distance between the wires was identified at a level of 20 cm from the spinal canal. The angle of the spoke deflection was determined by the following formula:

$$AIWE = AII - WAA,$$

where AIWE is the angle of intersection of the wound edge and the instrument;AII is the angle of instrumentinclination; and WAA is the wound aperture angle.

The topography of the spinal nerves, their relationship to the instrument for intervertebral implantation, and the possibility of damage to the thecal sac and spinal nerve roots during surgical procedures were also assessed.

We subjected the resulting digital material to statistical processing using the methodsof descriptive statistics. To process the research data, Microsoft Excel 2010 and STATISTICA 13.3 software were employed. We assessed quantitative indicators for compliance with normal distribution using the Shapiro–Wilk test, and indicators of asymmetry and kurtosis were analyzed as well. Our data are presented as minimum and maximum values, arithmetic mean (M) and standard deviation (σ).

Results

The minimum (min) length of the surgical wound duringthe posterolateral musculofascial approach to intervertebral discs of the lumbar spinewas 132 mm, the maximum (max) length was 161 mm, the meanwas 149.75±6.35 mm. The minimum, maximum and mean values of the wound depth were 98 mm, 136 mm, and 116.75 ± 8.85 mm, respectively. The mean of the surgical wound depth index in interfascial approach was 77.96±5.04 (min of 67.5, max of 90.5). When assessing the area of the intervertebral disc available for removal, the mean was 71.2±2.8% (min of 66%, max of 76%). The length of the aperture in the annulus fibrosusduring discectomy from the lateral intermuscular approach was on average 15.8±0.78 mm with a minimum value of 14 mm and a maximum value of 17 mm. The mean of the intersectionangle of the wound edge with the trajectory of transpedicular screw implantation was 3.15±1.25° (min of 1°, max of 5°).

Discussion

The surgical wound performed through a lateral interfascial approach meets the criteria for qualitative assessment of surgical approach developed by A.Yu. Sozon-Yaroshevich [7]: specifically, it ensures the correct direction of the axis of the surgical intervention, its angle, as well as the optimal depth of the wound and the wound access zone for surgical techniques, while minimizing surgical trauma due to excessive traction of the wound edges when implanting transpedicular screws and performing discectomy.

The incision of the skin and subcutaneous tissue is performed in two ways. In a bilateral approach: along the midline with subsequent mobilization of the tissue to the lateral edge of the erector spinae muscle and with a unilateral access option (along the vertebral line with subsequent exposure of the lateral edge of the long extensor of the back). Both incision options eliminate the resistance of the skin part of the wound to the medial displacement of the longissimus dorsi muscle and facilitate a significant increase in the angle of the surgical action without additional trauma. In order to prevent damage to the ventral branches of the lumbar vessels, the deep layer of the thoracolumbar fascia was not opened to the base of the transverse processes.

Table. Distribution of cadaveric material by gender and age sensu the World Health Organization classification

Gender	Age, years			Total
	45-59	60-74	75-89	
Male	4	5	1	10
Female	2	5	3	10
Total	6	10	4	20

The approach to the intervertebral disc is provided through the intertransverse fascia. The safest zone in terms of possible damage to the dorsal branches of the lumbar arteries, along with muscle and articular branches of the lumbar nerves, is the so-called Kambin's Triangle(a space restricted below by the upper edge of the transverse process, medially by the inferior articular process, and laterally by the spinal nerve) [8-11]. The intertransverse part of the deep layer of the thoracolumbar fascia is cut away from the superior edge of the underlying transverse process and joint capsule, which allows reasonable visualization of the intervertebral disc and the corresponding spinal nerve without resection of the transverse process (*Figure 1*).

Access to the intervertebral discs L3-L4, L4-L5 and L5-S1 is performed via resection of the extraforaminal part of the annulus fibrosus. A feature of the posterolateral musculofascial approach is that discectomy is performed bypassing the spinal canal (*Figure 2*). This approach also allows performing the decompression stage.

Indirect decompression is performed by segmental distraction [12]. Direct decompression in the intervertebral foramina and spinal canal can be conductedin the scope of lumbar facetectomy with ligamentum flavum removal and foraminotomy with ligamentum flavum removal [13, 14].With the posterolateral musculofascial approach, the trajectory of transpedicular screw implantation runs parallel to the edge of the wound, which does not complicate its installation and substantially simplifies the stage of mounting the rods on the screws (*Figure 3*).

Figure 1. Surgical wound. In the intertransverse spaces, the nerves L4 and L5 are highlighted, and the intervertebral discs L4-L5, and L5-S1 are visible. The dorsal branches of the lumbar arteries are preserved. The Kambin'sTriangle is highlighted. This article uses original images (Figures 1-3), which are the intellectual property of the authors

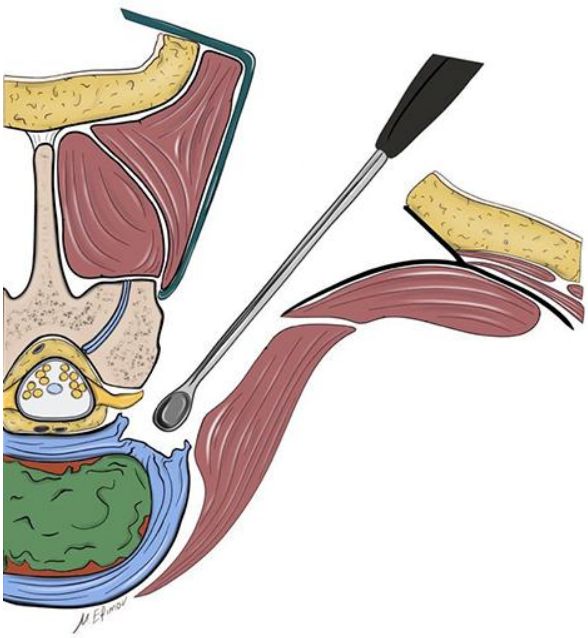

Figure 2. Performing a discectomy. The area of intervertebral disc available for removal is markedin brilliant green

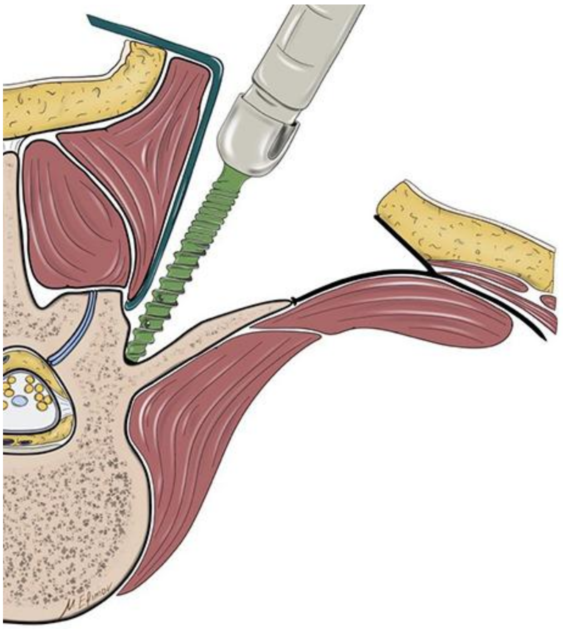

Figure 3. Trajectory of transpedicular screw implantation

Hence, the developed modified posterolateral musculofascial approach allows performing transpedicular fixation at the L3-L4-L5-S1 level, thereby providing the possibility to perform decompression of neural structures in the radicular and spinal canals at the L3-L4, L4-L5, L5-S1 levels. The studied approachalso allows performing discectomy and implantation of supporting stabilizing structures into the intervertebral spaces L3-L4, L4-L5, L5-S1. The proposed approach ensures the safety of the ligaments of the posterior supporting complex of the spine, does not involve the need to cut off the deep muscles of the back from their normal places of attachment to the spine, and does not include damage to the dorsal branches of the lumbar arteries and the posterior branches of the spinal nerves. The anatomical features of this surgical approach provide the prerequisites for reducing the invasiveness of the intervention, which, however, requires further study.

Conclusion

Based on the assessment of the topographical and anatomical parameters of the surgical wound formed during the posterolateral musculofascial approach, we concluded that the use of the lateral musculofascial approach allows performing decompressive and stabilizing interventions on the lumbar spine in patients with different bodymass index values, while minimizing surgical trauma resulting from prolonged compression of muscles by retractors, as well as traction of the wound edges by instruments used for implantation of transpedicular screws and discectomy. Hence, the proposed surgical approach can be used to improve the functional outcomes of surgical treatment in patients with dorsopathies.

Author contributions: all authors contributed equally to the preparation of the manuscript.

Conflict of interest: the authors declare no conflicts of interest.

References

1. Otani K, Kikuchi S, Yabuki S, et al. Lumbar spinal stenosis has a negative impact on quality of life compared with other comorbidities: An epidemiological cross-sectional study of 1862 community-dwelling individuals. *Scientific World Journal* 2013; (2013):590652. https://www.doi.org/10.1155/2013/590652
2. Katz JN, Zimmerman ZE, Mass H, Makhni MC. Diagnosis and management of lumbar spinal stenosis: A review. *JAMA* 2022; 327(17): 1688-99. https://www.doi.org/10.1001/jama.2022.5921
3. Allain J, Dufour T. Anterior lumbar fusion techniques: ALIF, OLIF, DLIF, LLIF, IXLIF Traumatol *Surg Res*. 2020; 106(1S): S149-57. https://www.doi.org/10.1016/j.otsr.2019.05.024
4. Foley KT, Holly LT, Schwender JD. Minimally invasive lumbar fusion. *Spine* 2003; 28(15 Suppl): S26-35. https://www.doi.org/10.1097/01.BRS.0000076895.52418.5E
5. Godanyuk DS, Gulyaev DA, Kondyukov DA, Alugishvili ZZ. Method of surgical approach to the intervertebral disc in the treatment of degenerative instability of the lumbar spine. Patent for inventionRU 2644922, 2018. (In Russ.).
6. Kim DH, Vaccaro AR, Dickman CA. Surgical Anatomy and Techniques to the Spine.2 nd Ed. *Elsevier Health Sciences* 2013: 382-8.
7. Sozon-Yaroshevich AYu. Anatomical and Clinical Substantiations of Surgical Approaches to Internal Organs. Moscow 1954; 180 p.(In Russ.).
8. Kambin P, Casey K, O'Brien E, et al. Arthroscopic microdiscectomy: Comparison of preoperative and postoperative imaging studies. *Arthroscopy*. 1997; 13(4):438-45. https://www.doi.org/10.1016/s0749-8063(97)90121-3
9. Maher CO, Henderson FC. Lateral exit-zone stenosis and lumbar radiculopathy. *J Neurosurg*. 1999; 90(1 Suppl): 52-8. https://www.doi.org/ 10.3171/spi.1999.90.1.0052
10. Ahn Y, Lee SH, Park WM, Lee HY. Posterolateral percutaneous endoscopic lumbar foraminotomy for L5-S1 foraminal or lateral exit zone stenosis. *Technical note J Neurosurg*. 2003; 99(3 Suppl): 320-3. https://www.doi.org/10.3171/spi.2003.99.3.0320
11. Park J W, Nam H S, Cho S K. Kambin's triangle approach of lumbar transforaminal epidural injection with spinal stenosis. *Ann Rehabil Med*. 2011; 35(6): 833–843. https://www.doi.org/10.5535/arm.2011.35.6.833
12. Mobbs RJ, Phan K, Malham G. Lumbar interbody fusion: Techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. *J Spine Surg*. 2015; 1(1): 2-18. https://www.doi.org/10.3978/j.issn.2414-469X.2015.10.05
13. Christie SD, Song JK. Minimally invasive lumbar discectomy and foraminotomy Neurosurg Clin N Am. 2006; 17(4): 459-66. https://www.doi.org/10.1016/j.nec.2006.06.001
14. Kang K, Rodriguez-Olaverri JC, Schwab F. Partial facetectomy for lumbar foraminal stenosis. *Adv Orthop*.2014; 2014: 534658. https://www.doi.org/10.1155/2014/534658

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