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Research Article

Lumbar Microdiscectomy with Preservation of Ligamentum Flavum as A Means of Preventing Epidural Fibrosis

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Abstract

Background: Postoperative scarring stands as the prevailing cause of failure after lumbar microdiscectomies. To avoid the formation of epidural fibrosis, several preventive measures have been recommended, including the application of fat, hemostatic sponges, amniotic membrane, and various anti-scarring barrier materials on the resection window and epidural space, as well as the use of drainage. In terms of surgical tactics, the preservation of the Ligamentum Flavum (LF) during microdiscectomy is recommended to prevent the development of fibrosis.

Objective: The aim of the research was to determine:

a) Would preserving the LF reduce the development of postoperative epidural fibrosis?

b) and whether the results of lumbar microdiscectomies with preserved LF would be improved compared to classic microdiscectomy.

Methods: Overall, 108 patients diagnosed with lumbar discogenic radiculopathy were selected from 2020 to 2022. They were randomly divided into two equal groups. The patients in Group A underwent classic microdiscectomy with preservation of the LF, while the patients in Group B underwent classic microdiscectomy. Patients were assessed with the Visual Analogue Pain Scale (VAPS) and the Oswestry Disability Index (ODI) before the surgery and 12 months after the surgery. The degree of postoperative epidural fibrosis was assessed 12 months after surgery by instrumental studies (MRI).

Results: In both groups, clinical data improved significantly 12 months after the surgery. According to ODI, pre-operative scores in Group A were 87.4 and postoperative scores were 13.2 (P 0.05); VAPS scores before the surgery were 8.4 and 1.7 after the surgery (P 0.05). In Group B, the ODI scores before the surgery were 89.1 and after the surgery were 23.1 (P 0.05); the VAPS scores before the surgery were 8.9 and after the surgery were reduced to 3.4 (P 0.05). The degree of scarring was less in Group A than in Group B.

Conclusion: The clinical results demonstrated in both groups were satisfactory. However, the group where LF was preserved revealed significantly fewer local scarring processes 12 months after surgery. The provided surgical method can be considered tissue sparing, reducing the complications caused by postoperative fibrosis and ultimately leading to a better clinical result after microdiscectomy.

Keywords: Epidural fibrosis; Ligamentum flavum; Microdiscectomy; Tissue-sparing surgery

Introduction

Epidural fibrosis is one of the most common reasons for failed back surgeries (48%), followed by recurrent intervertebral disc herniation (27%), and spinal stenosis (20%). The failure rate varies from 20% to 50%, depending on the evaluation criteria used during assessment. There are many methods to prevent postoperative epidural fibrosis; our method has several advantages: it is literally an organ-sparing surgery; it allows microdiscectomy to be performed in a minimal window; and it prevents the development of epidural fibrosis, which in turn gives us better clinical outcomes than classic microdiscectomy. The frequency of recurrence decreases, and what is more important, in the case of repeated surgery, it is much safer for the surgeon to perform the operation.

Materials and Methods

The study involved 108 patients, who were divided into two groups. They were randomly assigned to groups. Group A included patients who underwent microdiscectomy with LF preservation (51 patients), while in Group B, the classic microdiscectomy was performed (57 patients). Indications for surgical interventions were based on the clinical picture (pain syndrome on the side of the injury lasting from 6 weeks to 3 months); the ineffectiveness of conservative treatment; recurrent symptoms; the presence of clinical signs of radiculopathy; and also, the MRI data, which confirmed intervertebral disc herniation and compression of nerve structures.

The results of surgical interventions were evaluated 12 months after the surgery by means of VAPS and ODI scales and questionnaires, which were compared to the pre-operative data. The MRI scan was also performed 12 months after surgery, and the results were evaluated in a blind fashion by neuroradiologists. The scar formation and its degree were assessed as well. The 12-month postoperative interval was chosen because, as described, scar tissue is very stable 6–12 months after the surgery (5,60).

Inclusion criteria:

i. Patients with lumbar disc herniation who have an indication for microdiscectomy

ii. Patients aged 16 to 76 years

iii. Patients of both sexes

Exclusion criteria:

i. Patients with recurrent lumbar disc herniation

ii. Polydiscopathy: herniation of more than one intervertebral disc

iii. Extraforaminal hernia

iv. Expressed psychopathology

v. Patients with intervertebral disc herniation status after other surgical interventions on the spine

vi. Patients under 15 and over 76 years old with lumbar intervertebral disc herniation

MRI examination

All patients underwent a contrast-enhanced MRI examination of the lumbar spine, and the contrast material was injected intravenously. A standard T1, T2, and T3 scan was performed before the injection of the contrast material. Each examination detailed epidural fibrosis in five slices on the projection of the operated disc. The degree of epidural fibrosis was graded in four quadrants, with scores ranging from 0 to 4 in each quadrant. According to the method of Ross and co-authors (50, 51), grade 0: absence or trace of fibrosis; grade 1: 25% or less of the quadrant is marked by scars; grade 2: more than 25% up to 50%; grade 3: 50–75% or less; grade 4: more than 75% (Figure 1). A total of 108 patients were evaluated (5 slices, 4 quadrants, 20 evaluations for ach).

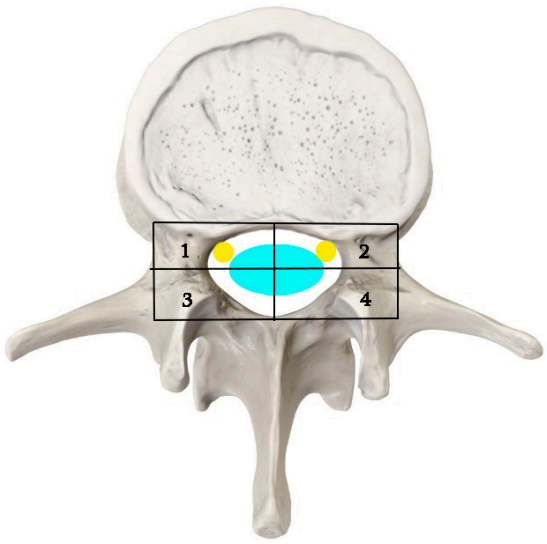

Figure 1: Evaluation of postoperative fibrosis with the Ross method. In 4 quadrants of 5 slices, the degree of fibrosis was evaluated from 0 to 4.

Anatomy of the Ligamentum Flavum and Stages of Surgery

Histologically, the LF differs from other human ligaments in that it consists of very high-quality and dense elastic fibers. The LF is of fibrous structure, and the fibers run along its length. The superior edge of the ligament is attached to the inferior part of the superior vertebral arch, and the inferior edge is attached to the superior part of the inferior vertebral arch. The anterior surface of the LF runs towards the spinal canal, which is separated from the dural sac and the root by epidural fat and the vascular layer. And the posterior surface of the ligament is covered by the anterior surface of the paravertebral muscles. The medial portion of the ligament meets the medial edge of the contralateral LF in the midline and attaches to the base of the spinous process. Part of the lateral edge (the fibrous part) meets the medial edge of the inferior articular process of the superior vertebra (picture). The LF will then pass along the medial part of the articular process and under the plates into the spinal canal. The lateral edge of the LF runs towards and attaches to the fibrous membrane of the facet joint. This part covers the superior and lateral surfaces of the root.

The patient is lying in the prone position on the operating table, and the skin is cut in the middle line in the interspinales area of the corresponding segments lengthwise. The length of the incision is 2-3 cm. After skeletonizing the long back muscle, the interlaminar section is visualized. Mobilization of soft tissues is managed with a Caspar retractor. As soon as LF is visualized, an operating microscope is positioned. In the microscope, the operating field is represented by the superior vertebral arch on the right, the inferior vertebral arch on the left, the spinous process medially, the articular plate laterally, and the interlaminar section. The central part of the incision is represented by LF. The LF is visible in the section where the ligament attaches the articular capsule; in this area, the ligament covers the inferior articular process of the superior vertebra. We must be careful not to damage the articular capsule here. The LF should be carefully dissected with a surgical dissector at the articular capsule lengthwise, in the craniocaudal direction, in accordance with the anatomic orientation of its fibers. The ligament is easily dissected, and the epidural fat tissue and root can be visualized.

Due to its elasticity, the ligament can be stretched and mobilized, making it easier to access the intraspinal structures.

The lateral part of the ligament covers the root, and the medial part covers the dural sac. At this point, it is preferable to perform hemostasis with bandages rather than using bipolar electrocoagulation. It must be noted that if the mobile operating window of the ligament is not enough to safely perform the operation, you can perform the resection of the arch with a drill to create more space. If this approach is also ineffective, it is better to continue the operation with the classic method. After discectomy, the edges of the LF are easily attached to each other, leaving no defect and requiring no additional barrier applicator, including hemostatic sponge or fat grafting (Figures 2-4).

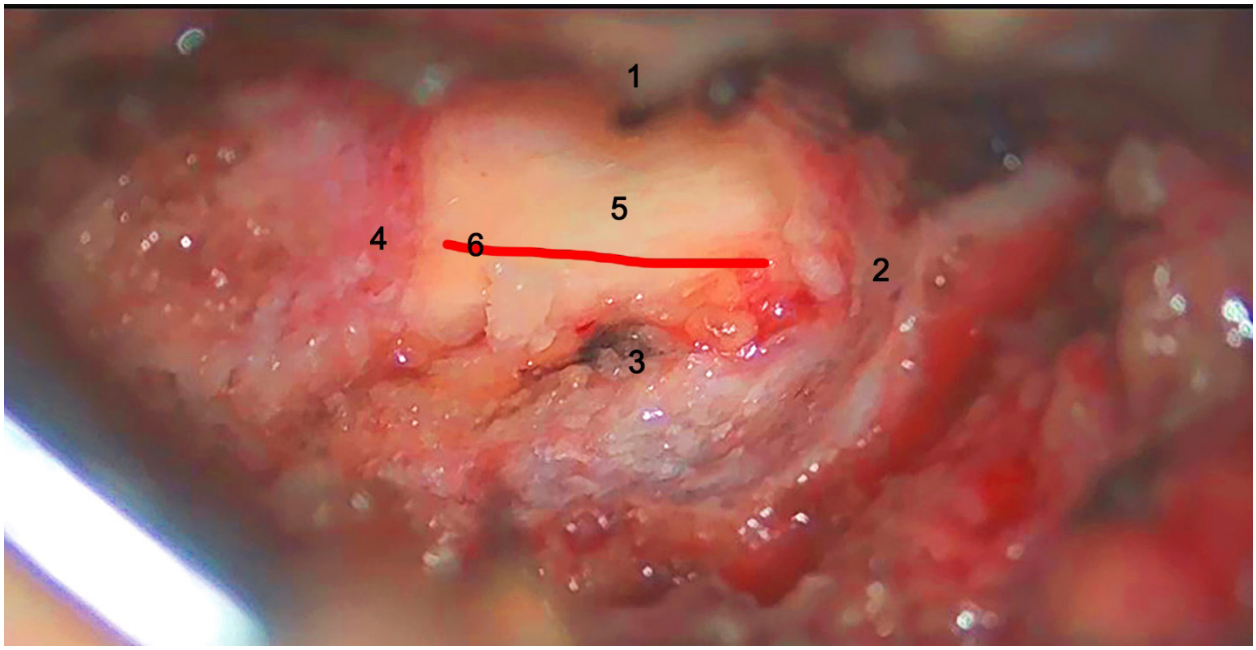

Figure 2: 1– spinous process; 2 – inferior edge of the L4 vertebral arch; 3 – the contact of the LF with the facet; 4 - the superior edge of the L5 vertebral arch; 5- Ligamentum flavum; 6 - Line of dissection LF;

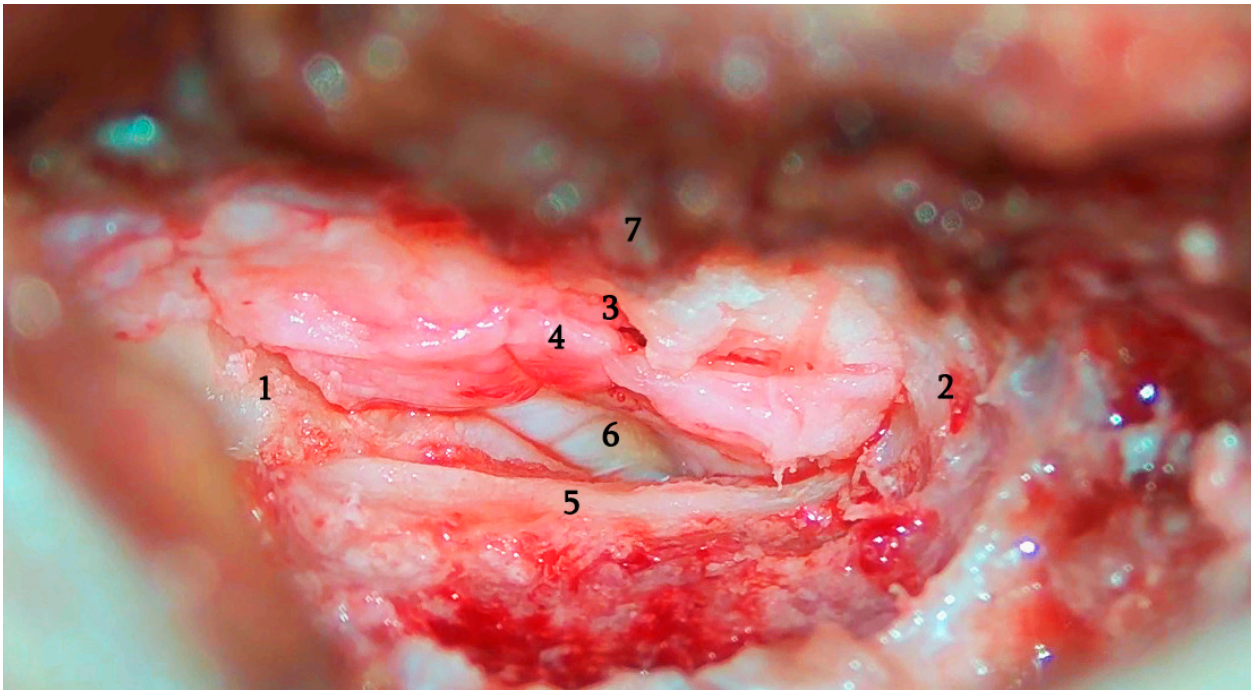

Figure 3: 1– the superior edge of the L5 vertebral arch; 2 – inferior edge of the L4 vertebral arch; 3 - the lateral edge of the longitudinally disconnected LF; 4 - the medial edge of the LF; 5- facet; the contact of the LF with the facet; 7 – spinous process.

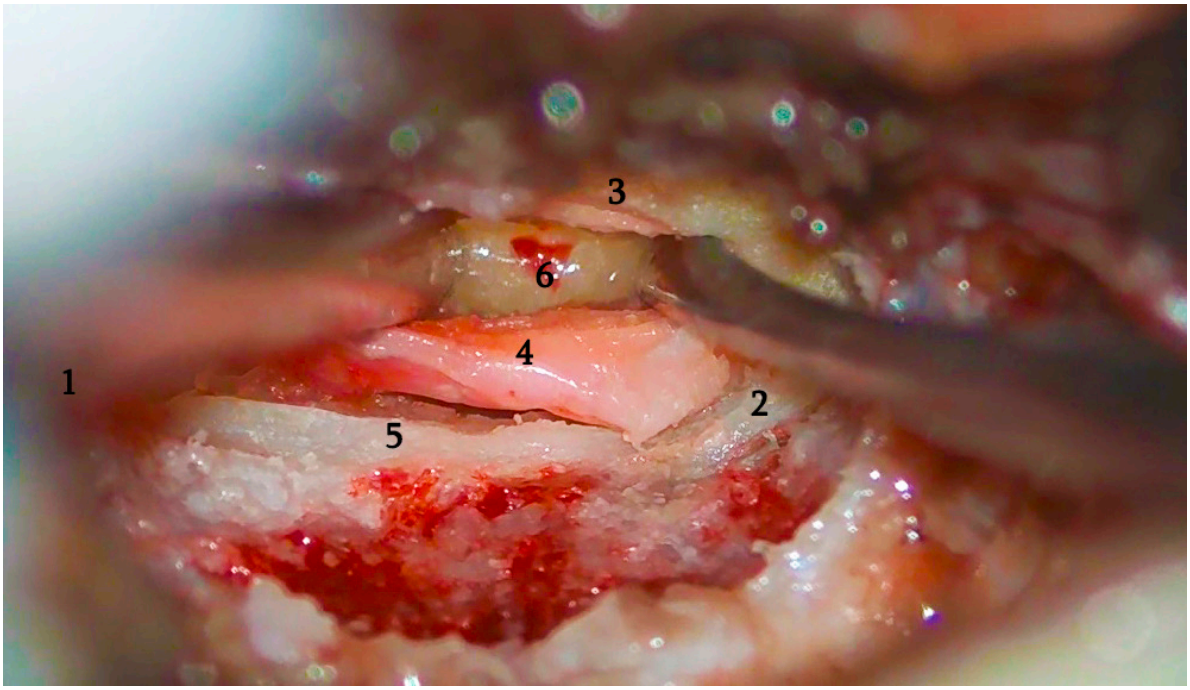

Figure 4: 1 – the superior edge of the L5 vertebral arch; 2 – the inferior edge of the L4 vertebral arch; 3 – the medial edge of the longitudinally disconnected LF; 4 - the lateral edge of the LF; 5- facet; 6 - epidural fat tissue.

Results

The surgeries of all 108 patients were performed without complications. The observation period was 12 months. No patient required reoperation due to recurrent intervertebral disc herniations. The VAPS and ODI scores improved significantly in both groups on the second day after the surgery, but 12 months after the surgery, the difference between the groups according to the VAPS (Table 4) and ODI (Table 5) was noticeable; the patients in Group A demonstrated better results (P 0.005). Moreover, 12 months after the surgery, the difference was observed in terms of developing epidural fibrosis as well; the results were better in group A than in group B (Tables 1-5, Figures 5&6).

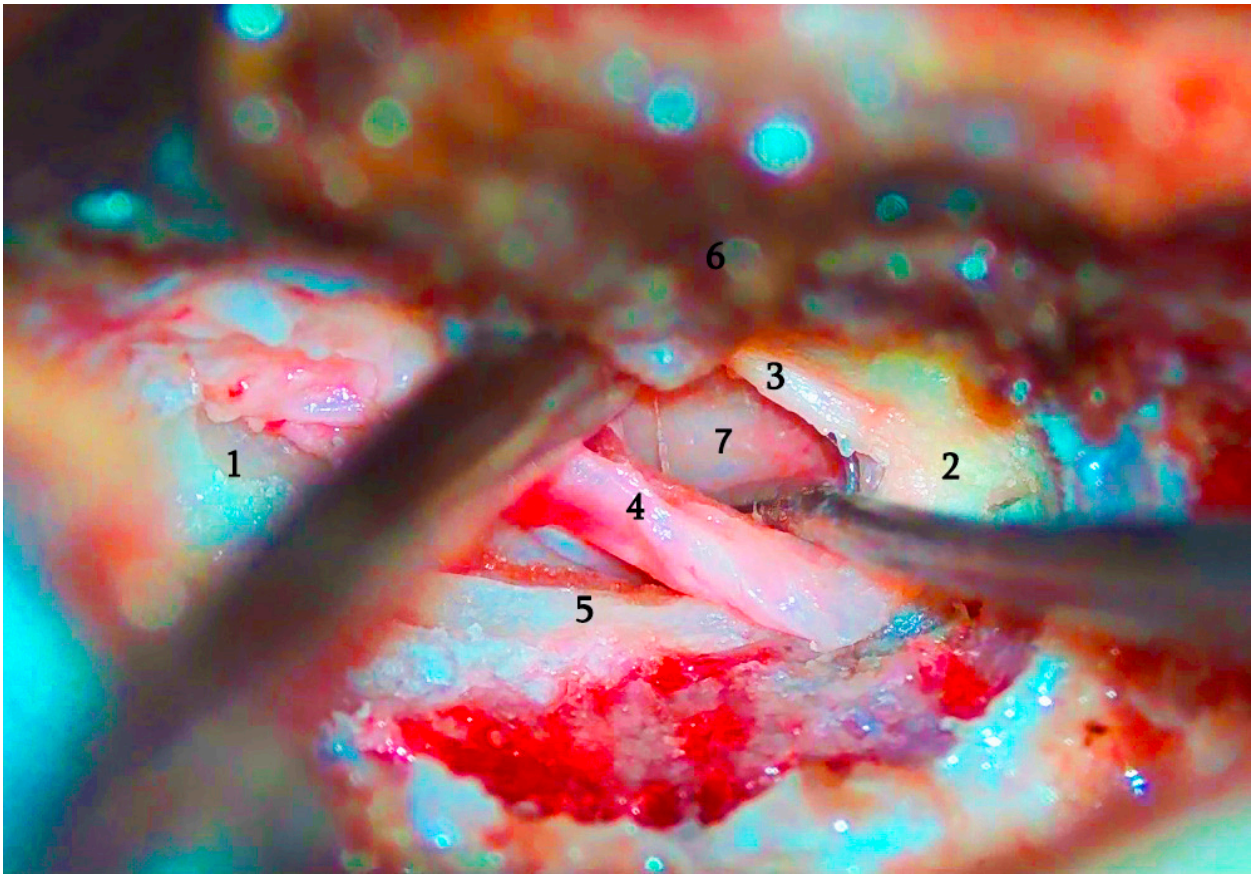

Figure 5: 1 – the superior edge of the L5 vertebral arch; 2 – the inferior edge of the L4 vertebral arch; 3 – the medial edge of the longitudinally disconnected LF; 4 – the lateral edge of the LF; 5 – facet; 6 – spinous process; 7 – L5 root.

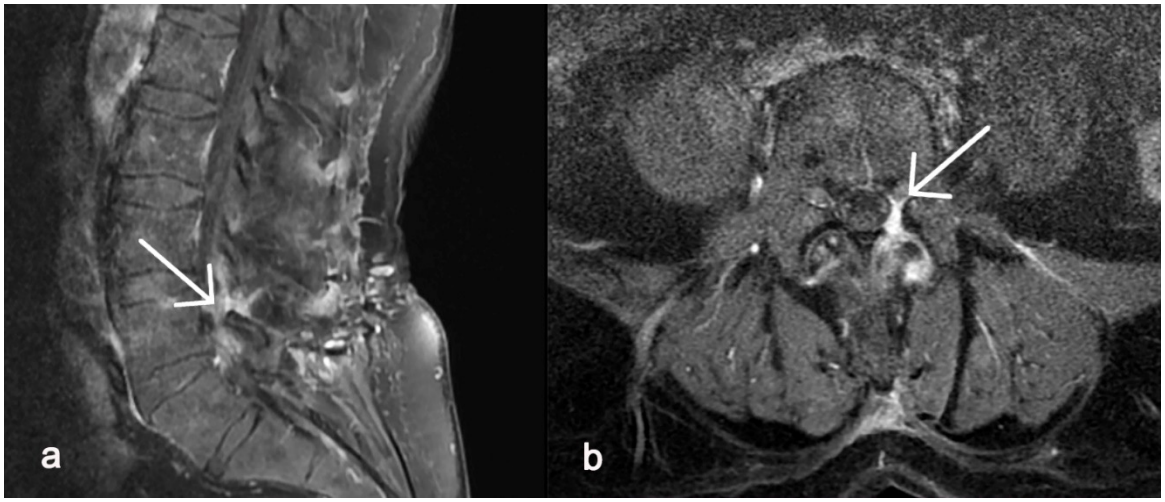

Figure 6: Contrast-enhanced MRI scan 12 months after classic L4/L5 left–sided microdiscectomy, reveals extensive epidural fibrosis with homogenous enhancement (arrow)(Grade 3, according to Ross). T1 – FS sagittal (a) and axial (b).

Table 1: Gender Ratio in Groups.

Group	Microdiscectomy with preservation of LF Group A	Classic Microdiscectomy Group B	Total
Women	31 (28,7%)	30 (27,8%)	61
Men	20 (18.5%)	27 (25%)	47
Total	51	57	108

Table 2: Distribution of Operated Patients by Age.

Age group	Group A	Group B	Total
16-36	7	11	18
36-56	19	24	43
56-76	25	22	47
N	51	57	108

Table 3: Clinical Evaluation of Patients before the Surgery with VAPS and ODI scales.

Clinical Evaluation method	A 51	B 57	P Value
ODI	87,4	89,1	P>0,005
VAPS	8,4	8,9	P>0,005

Table 4: Distribution of Operated Patients after Classic Microdiscectomy according to VAPS and ODI Scales.

Clinical evaluation method	Group A with preserved LF	Group B with classic microdiscectomy
VAPS	1,7	3,4
ODI after surgery	13,0	23,1

Radiological Assessment of Groups A and B, Degree of Epidural Fibrosis after Surgery.

Table 5: Evaluation of MRI results.

Degree of Fibrosis	Ligament-sparing A (n) test 51	%	Microdiscectomy B (n) control 57	%
Not developed		25		18.6
0% - 25%		50.5		18.8
25% - 50%		10.5		28.4
50% - 75%		8		19.5
75% - 100%		6		14.7
Average score				

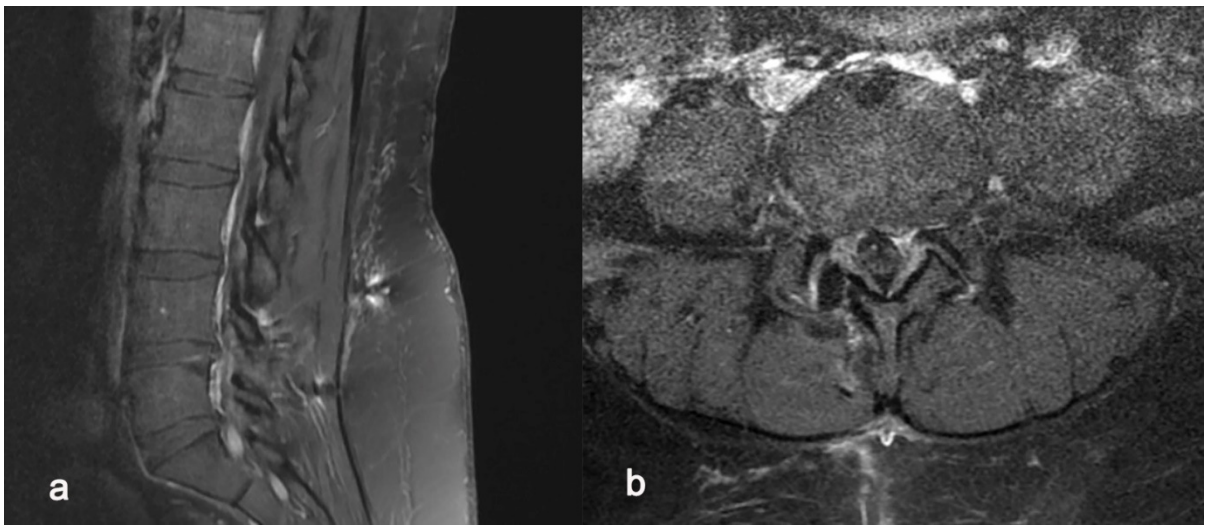

Figure 7: L4/L5 right-sided ligament-sparing microdiscectomy, contrast-enhanced MRI scan 12 months after the surgery no reveals epidural fibrosis, (Grade 0, according to Ross) T1 – FS sagittal (a) and axial (b).

Discussion

Based on the obtained data, we can say that both groups, with the ligament-sparing as well as the classic microdiscectomy, showed improvements 24 hours after the surgery, and no significant differences were observed during this time, according to VAS and ODI data. The evaluation conducted 12 months after the operation proved that the VAS and ODI data were better in the group where the LF was preserved, which was also confirmed by the MRI scans evaluating the degree of epidural fibrosis. The failure of back surgery has been studied by many authors and is believed to be a global issue in contemporary spinal neurosurgery [1]. Postoperative complications are quite common after lumbar discectomy, including epidural fibrosis, spinal stenosis, recurrent intervertebral disc herniation, discitis, instability of the operated segment, and others that often require repeated operations [2]. Each of them can be the subject of different studies, but epidural fibrosis remains one of the most common postoperative complications [3]. Since fibrosis is a physiological response to injury, the deeper mechanisms of its development have also been studied. It has been proven that TGF- plays a key role in the scar formation process. Histological studies have shown that the elements of the intervertebral disc can trigger the inflammatory process, which leads to the formation of fibrosis [4]. Contemporary studies have also proved that the presence of blood in the spinal canal contributes to the development of epidural fibrosis (H. LaRocca and I. Macnab [5]). The presence of blood in the epidural space causes aseptic inflammation, which eventually leads to fibrosis and scar formation [6].

There are many methods to prevent the development of the Failed Back Surgery Syndrome (FBSS), including: minimizing the hematoma in the epidural space by using different types of drains [7]; using a strong hemostatic agent like a barrier membrane, TachoComb, was recommended in this regard [8]; various artificial [9] and natural anti-scarring barriers have been recommended, including the amniotic membrane [10]. Fat grafting was often used as a method to prevent epidural fibrosis [11]. The preventive methods listed above did not imply revision of surgical nuances until a tissue-sparing method such as microdiscectomy with preservation of the ligamentum flavum was introduced. There are studies conducted by different authors where they describe the dissection of the ligament, formation of a flap from it, microdiscectomy, and reattachment of the flap with or without suturing it; some of them applied the rule of minimal resection. All methods were aimed at preserving this anatomical structure, leaving it in its place, and maintaining its biomechanical, elastic, and barrier functions [12].

One of the most comprehensive studies was conducted by Yunus Aydn [13] and the authors. 1500 patients participated in the study, which lasted for several years. Unlike our method, the study involved the formation of a tricuspid flap, which was reattached to its original place after the discectomy. The study by Jigang Li [14] should also be noted in this regard. It also involved the ligament-sparing method, where the researcher performed the resection of the lateral part of the ligament, forming a small resection window sufficient for microdiscectomy. Zahid Askar [15], similar to Aydin, focused on the formation of a flap from the ligament, but with different modifications: the ligament was removed and dissected from the lateral edge, and the flap was moved medially. After the discectomy, the flap was reattached to the ligament. If the ligament could not completely cover the dural sac, fat grafting was applied.

Overall, both studies had similarities and differences, including in terms of the surgery duration, the incision sizes, the volume of blood loss, the degree of arch resection, the tactics of preserving the lateral pocket, as well as the methods of ligament separation and resection, its dissection, and flap formation. Some authors sutured the ligament, while others reattached it without suturing. They also used different materials to cover the defect; some used fat grafting, while others used hemostatic sponge. Different methods were used to evaluate the clinical picture, both pre-operatively and post-operatively [16]. There were differences in clinical assessment scales and neuroimaging methods [17]. The main difference in our study was that no flap was formed from the ligament during the surgery; it was dissected lengthwise along the longitudinal arrangement of its fibers, and after that, the discectomy was performed. The edges of the ligament reattached to each other due to its elasticity, leaving no defect and no need to apply additional artificial barriers or biological material.

Our method allows microdiscectomy to be performed in a minimal operating window to avoid the formation of a flap and resection of the LF. It is possible to get access to the root without exposing the dural sac, which protects it from damage and liquefaction in the postoperative period. After discectomy, contact is restored as soon as its edges are reattached. This method of ligament sparing makes it relatively safe to perform repeated surgery in cases of recurrent herniation. The results of the study showed that the opinion that preserving the ligament reduces epidural fibrosis and improves the clinical picture proved to be true. The limitation of the method involves sequestered and migrated hernias, as they require a larger operating visualization window, due to which the ligament needs a larger dissection or resection for a safe discectomy. Also, unlike classic microdiscectomy, this method is more time-consuming.

Conclusion

Studies have proved that recurrent postoperative pain is mainly associated with epidural fibrosis, and the ligament-sparing microdiscectomy reduces the development of epidural fibrosis, which proves the advantage of this method in the prevention of fibrosis.

Acknowledgement

None.

Conflict of interest

None.

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