Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/zz7e4b38

# BEYOND THE MYTH: HIGH MIGRATED LUMBAR DISCS EFFECTIVELY TREATED WITH ENDOSCOPIC SURGERY: A TWO YEAR PROSPECTIVE STUDY

**Muhammad Farooq[1*], Naeem Ul Haq[2], Tabrez Wali Shah[3], Shahid Nawaz[4], Mumtaz Ali[5], Naveed Noor[6], Abdul Haseeb Sahibzada[7]**

[1*]Consultant Neurosurgeon, Farooq Endocopic spine clinic, Peshawar General Hospital, Peshawar, Pakistan
[2]Consultant Neurosurgeon, Neurosurgery Department Mardan Medical Complex, Mardan, Pakistan
[3]Senior Registrar, Neurosurgery Department, Peshawar General Hospital, Peshawar, Pakistan
[4]Associate Professor Neurosurgery, Gomal Medical College, D.I Khan, Pakistan
[5]Professor, Neurosurgery Department, Irfan General Hospital,Peshawar, Pakistan
[6]Naveed Noor, Medical Officer, Rehman Medical Institute, Peshawar, Pakistan
[7]Research Officer, Farooq Endocopic spine clinic, Peshawar General Hospital, Peshawar, Pakistan

***Corresponding Author:** Muhammad Farooq
*Consultant Neurosurgeon, Farooq Endocopic spine clinic, Peshawar, Pakistan
Email: farooqendospine33@gmail.com

**Abstract:**

**Introduction:** Even though Full Endoscopic Lumber Discectomy outcomes are now better than those of traditional open surgery due to advancements in technology and different approaches, however, managing high-grade migrating discs is still challenging.

**Objective:** This study aimed to determine the outcomes of FELD for patients with high-grade migratory disc herniation.

**Material and Methods:** This prospective two years observational study included patients operated by full endoscopic spine surgery using interlaminar approach with symptomatic high-grade migrating lumbar disc herniation at different disc levels.Zones 1 and 4 migration were regarded as high-grade migration and were included in the study. A full-endoscopic interlaminar approach was carried out. The improvement in functional outcomes, as measured by the Visual Analog Scale (VAS) for pain and the Oswestry Disability Index (ODI), was the main outcome measure. The modified Mac Nab criteria were used to evaluate spinal surgery outcomes.

**Results:** A total of 442 endoscopic lumbar surgeries were performed out of which, 47 (11%) procedures were carried out to treat highly migratory disc herniations. 14 (30%) of these highly migratory disc herniations were upward, while 33 (70%) migrated downward. The mean preoperative back pain VAS score was 7.8 ± 1.2. which was dropped to 3.2 ± 1.0 ($p < 0.001$) at the 6-month follow-up and a further 2.5 ± 0.9 ($p < 0.001$) at the 1-year follow-up. 92 (76.7%) patients reported excellent outcomes using the modified MacNab criteria.

**Conclusion:** Full endoscopic spine surgery is an effective management strategy for high migrating lumbar disc herniations, with good results in terms of pain reduction and functional recovery. This method provides a less invasive option that leads to fewer surgical problems and faster recovery.

**Keywords:** Endoscopic spine surgery, high migrated lumbar discs, lumbar disc herniation, prospective study, surgical outcomes.

## Introduction:

Migrated disc is a clinical entity characterized by lumbar disc herniation (LDH), which extends beyond the inferior or superior margin of the intervertebral disc in an upward or downward orientation. (1,2) A downward low-grade migrated disc accounts for 30.9% of all cases of migrated discs, which have an incidence of about 35–72%. On the other hand, high-grade migrating discs—which have a 34% incidence—are more common. (3,4) The type and severity of migrating disc herniation were categorized by Lee et al. who initially proposed the migrating disc herniation grading system for PELD, while Kim et al. later on made modifications. (5,6) Three forms of migratory disc herniation can be distinguished based on prior studies: low-, high-, and extremely high-grade migration. "High-grade" disc migration was described by Lee et al. and Choi et al. as migration that was larger than the posterior marginal disc space's observed height. A "very high-grade" migrated disc herniation was defined by Kim et al as disc migration that goes over or below the inferior pedicle margin. (7)

Percutaneous endoscopic lumbar discectomy (PELD) has become an increasingly common surgical procedure for treating lumbar disc herniation with an effective rate of 90%, since Kambin introduced the idea of the Kambin triangle and subsequently performed the first PELD in 1973.(8,9) FELD is indicated mostly in individuals with non-migrated or low-grade migrated disc herniation, despite its many benefits.Open surgery is typically recommended for high-grade migrated disc herniations due to the high failure rate of FELD. Additionally, FELD is typically challenging due to anatomical hurdles encountered during high-grade migrated disc removal, which might lead to the inadequate removal of the disc material. (10) It has been observed that in these patients, failure rates with typical FELD techniques (either transforaminal or interlaminar) can reach up to 20 percent. The primary cause of this elevated risk of surgical failure is the extremely difficult and time-consuming debris removal procedure, particularly in instances of high-grade migration. Even for skilled endoscopic spine surgeons, it might be difficult to treat highly migrated lumbar disk herniation (LDH). (11)

Using the advancement of tools and methods, high-grade migrating lumbar discs can now be corrected using FELD. Many spine surgeons have created innovative methods for treating high-grade migrated lumbar disc herniation with FELD. These methods include using the foraminoplastic technique (12,13,14), trans-facet process and pedicle-complex approach (15), two-level TELD (10), contralateral TELD (16), suprapedicular approach (17), and transpedicular approach. (18)

Even though FELD outcomes are now better than those of traditional open surgery due to advancements in technology and different approaches, however, managing high-grade migrating discs is still challenging.Therefore,this study aimed to determine the outcomes of FELD for patients with high-grade migratory disc herniation.

## Material and Methods:

### Study design/setting/duration:

This prospective two years observational study was conducted at Afridi Medical Complex,Peshawar from January 2020 to January 2022 with one year follow up period.Ethical approval was obtained from the institutional review board and informed consent was taken from the participants.

### Patient Selection:

### Inclusion Criteria:

The study included patients operated by full endoscopic spine surgery using interlaminar approach with symptomatic high-grade migrating lumbar disc herniation at different disc levels, ages 18–75. MRI, CT, and clinical examinations all confirming the diagnosis. The radiological categorization of migrating disc herniations supplied by Lee et al. was used to categorize herniated discs.

Four migration zones are described based on this classification. Zone 1 (high-grade) denotes cranial migration that extends past the neighboring vertebral body's inferior margin. Cranial migration within the height of the neighboring vertebral body is indicated by Zone 2. Caudal migration within the height of the neighboring vertebral body is indicated by Zone 3. Caudal migration that extends past the superior edge of the neighboring vertebral body is represented by zone 4 (high-grade).
Zones 1 and 4 migration is regarded as high-grade migration and were included in the study.

**Exclusion Criteria:**
Patients who showed signs of segmental instability, had spinal stenosis confirmed by CT or MRI, or had other pathological disorders such acute inflammation, infection, fractures, or malignancies were not included in the study. They were also eliminated if they were lost to follow-up within two years.

**Surgical Procedure:**
A single, skilled neurosurgeon with expertise in endoscopic spine surgery carried out each procedure. A full-endoscopic interlaminar approach was selected according to the location and degree of the disc herniation. In order to increase working space and decrease lordosis for easier access to the spine, patients were put in a prone posture on a radiolucent table. A dilator was passed after making a little skin incision (about 8 mm) under general anaesthesia. Then, an endoscope was implanted that has a built-in functioning channel. With the help of RF probe, the soft tissues were cauterized to confirm the anatomical landmarks.Using the endoscopic camera, the ligamentum flavum (LF) and inferior margin of the cranial lamina on the lesion's side were made visible.
A laminectomy rongeur was used to make a little incision on the LF. According to the location of migrated disc herniation the lamina was drilled.For upward migrated disc fragments,the lower part of the cranial lamina was drilled to make the space while for downward migrated disc,the superior part of the caudal lamina was drilled to resect the excluded fragment. After dividing the LF, the spinal canal was made accessible for the discectomy. To decompress the nerve root, the exposed herniated nucleus pulposus was resected. After the removal of the functioning channel, absorbable sutures were used to seal the skin incision.

**Outcome Measures:**
The improvement in functional outcomes, as measured by the Visual Analog Scale (VAS) for pain and the Oswestry Disability Index (ODI), was the main outcome measure. Complication rates, blood loss, length of hospital stay, and surgery duration were among the secondary outcome measures.
The modified MacNab criteria were used to evaluate spinal surgery outcomes, classifying results as excellent (no pain, full activity), good (mild pain, minimal activity restriction), fair (noticeable pain, some activity limitation), and poor (persistent pain, no significant improvement).

**Post operative care:**
Physical therapy, early mobilization, and pain control were all included in the postoperative care. Depending on the recovery, patients were usually discharged from the hospital 24 to 48 hours after surgery.

**Follow up:**
Following surgery, patients were checked on at one, three, six, one, and two years. Scores from the VAS, ODI, and clinical assessments were noted at every follow-up appointment. MRI scans were done at one and two years to evaluate the anatomical results.

**Statistical Analysis:**
IBM SPSS version 25.0 was used to analyze the data. For continuous variables, the standard deviation (SD) and mean was reported, while frequencies and percentages were used for categorical

variables. The ODI and VAS ratings were compared between preoperative and postoperative using paired t-tests. Statistical significance was attained when the p-value was less than 0.05.

**Results:**

**Patient Demographics and Baseline Characteristics:**

At the Afridi Medical Complex in Peshawar, 442 endoscopic lumbar procedures were performed between 2020 and 2022. Of these, 47 (11%) procedures were carried out to treat highly migratory disc herniations. 14 (30%) of these highly migratory disc herniations moved upward, while 33 (70%) migrated downward. These herniations were distributed as follows: 3(7%) at L3-L4, 12(26%) at L5-S1, and 32 (67%) at the L4-L5 segment.

The patients with high migratory disc herniations ranged in age from 18 to 75 years, with a mean age of 52.4 ± 10.6 years. 27 (57%) of these patients were men, and 20 (43%) were females. In terms of employment, 31 (66%) of the patients had physically demanding jobs, whereas 16(34%) had occupations that did not needed such physical exertion. According to their smoking status, 19 (40%) were smokers and 28 (60%) were non-smokers while 12 (26%) had a history of heavy lifting.

**Table 1: Patient Demographics and Baseline Characteristics:**

| **Characteristics** | **Frequency (n)** | **Percentage (%)** |
|---|---|---|
| Total endoscopic lumbar surgeries | 442 | 100 |
| High migrated disc herniations | 47 | 11 |
| Upward migration | 14 | 30 |
| Downward migration | 33 | 70 |
| Herniation level (high-grade) | | |
| L4-L5 | 32 | 67 |
| L5-S1 | 12 | 26 |
| L3-L4 | 3 | 7 |
| Mean age (years) | 52.4 ± 10.6 | - |
| Gender | | |
| Male | 27 | 57 |
| Female | 20 | 43 |
| Occupation | | |
| Physically demanding jobs | 31 | 66 |
| Non-physically demanding jobs | 16 | 34 |
| Smoking status | | |
| Non-smokers | 28 | 60 |
| Smokers | 19 | 40 |
| Heavy lifting history | 12 | 26 |

**Surgical Outcomes:**

An average of 95 ± 20 minutes was the duration of surgery with mean blood loss of 14 ± 3.6. The mean duration of hospitalization was 1.5 +/- 0.5 days. There were no significant intraoperative

complications noted. Although, eight patients (6.7%) experienced transient dysesthesia post operatively.

**Table 2: Surgical Outcomes**

| Surgical Outcomes | Frequency (n) |
|---|---|
| Mean surgery duration (minutes) | 95 ± 20 |
| Mean blood loss (ml) | 14 ± 3.6 |
| Length of hospital stay (days) | 1.5 ± 0.5 |
| Complications | |
| Transient dysesthesia | 8 |

**Functional Outcomes (Pain and disability):**

7.8 ± 1.2 was the mean preoperative back pain VAS score. The mean VAS score dramatically dropped to 4.9 ± 1.2 ($p < 0.001$) at the 3-month follow-up, 3.2 ± 1.0 ($p < 0.001$) at the 6-month follow-up, 2.5 ± 0.9 ($p < 0.001$) at the 1-year follow-up, and 2.1 ± 0.9 ($p < 0.001$) at the 2-year follow-up. The VAS scores for leg pain at different follow up intervals are showed considerable improvements as shown in table 3.Comparably, at the 3-month follow-up, the mean preoperative ODI score decreased from 65.4 ± 8.6 to 45.6 ± 7.2 ($p < 0.001$), at the 6-month follow-up, it improved to 30.4 ± 6.0 ($p < 0.001$), at the 1-year follow-up, it improved to 25.3 ± 5.7 ($p < 0.001$), and at the 2-year follow-up, it improved to 20.3 ± 5.4 ($p < 0.001$).

**Table 3: Functional Outcomes (Pain and Disability)**

| Functional Outcomes | Preoperative | 3-Month Follow-Up | 6-Month Follow-Up | 1-Year Follow-Up | 2-Year Follow-Up | P value |
|---|---|---|---|---|---|---|
| Mean VAS score (Back pain) | 7.8 ± 1.2 | 4.9 ± 1.2 | 3.2 ± 1.0 | 2.5 ± 0.9 | 2.1 ± 0.9 | < 0.001 |
| Mean VAS score (Leg pain) | 8.5 ± 1.3 | 2.4 ± 1.1 | 1.9 ± 0.8 | 1.5 ± 0.7 | 1.0 ± 0.8 | < 0.001 |
| Mean ODI score | 65.4 ± 8.6 | 45.6 ± 7.2 | 30.4 ± 6.0 | 25.3 ± 5.7 | 20.3 ± 5.4 | < 0.001 |

**Modified Macnab Criteria:**

To describe the Macnab criteria 37 (79%) patients reported excellent outcomes, 8 (17%) good outcomes and 2 (4%) fair outcomes using the modified MacNab criteria.

**Table 4: Modified Macnab Criteria:**

| MacNab Criteria | Frequency (n) | Percentage (%) |
|---|---|---|
| Excellent (no pain, full activity) | 37 | 79 |
| Good (mild pain, minimal activity restriction) | 8 | 17 |
| Fair (noticeable pain, some activity limitation) | 2 | 4 |

**Radiological Outcomes:**

Two years after surgery, MRI scans showed that 2 (4%) patients had residual or recurrent disc material, whereas 45(96%) patients had full resolution of the herniation. There were no new cases of disc herniation found.

**Table 5: Radiological Outcomes**

| Radiological Outcomes | Frequency (n) | Percentage (%) |
|---|---|---|
| Complete resolution | 45 | 96 |
| Residual/recurrent herniation | 2 | 4 |

**Discussion:**

The effectiveness of endoscopic surgery for treating highly migrating lumbar disc herniations was assessed in this study. Our findings show a considerable reduction in pain, disability, and radiological results, suggesting that endoscopic surgery is a good and practical course of treatment for these patients.

According to our analysis, 47 (11%) of the 442 endoscopic lumbar procedures carried out between 2020 and 2022 were undertaken to treat significantly migratory disc herniations. Of those, 33 (70%) moved downward and 14 (30%) moved upward. The L4-L5 segment was the most frequently affected segment 32(67%), followed by L5-S1 12(26%) and L3-L4 3(7%). In contrast, a study by Kang et al. Found a higher incidents that on 54 (20.6%) of their endoscopic cases had significantly migrated disc herniations, with 44 (81%) downward and 10 (19%) upward migrations, primarily at the L4-L5 level (63%) and L5-S1 (22%) and L3-L4 (15%). Similar downhill (81%) and upward (19%) migration patterns were seen in 30% of endoscopic cases with migrated discs, primarily at the L4-L5 level (63%)[19], according to another study by Lee et al**.** The specific demographic and occupational characteristics of their patient population are reflective of a middle-aged demographic, with a mean age of 51.32 years, and a slight female predominance, as indicated by the distribution of sex in the study.[20]

According to our research, 16 (34%) of patients with significantly migrating disc herniations worked in jobs that were not physically demanding, whereas 31 (66%) of patients had physically demanding employment. In addition, 12 (26%) of the patients had a history of heavy lifting, and 19 (40%) of the patients were smokers while 28 (60%) did not smoke. This implies that physically taxing jobs or specific lifestyle choices, such as smoking and heavy lifting, may be linked to the occurrence of highly migrating discs. According to a study by Chen et al. (2024), 66% of the patients with migrating disc herniations had physically demanding employment, compared to 34% who did not; additionally, 40% of the patients smoked, and 60% did not smoke. Similar findings were made by Lee et al. (2007) who discovered that 24.7% of their patients with migrating discs smoked and 56% engaged in physically demanding activities.[21] The increased mechanical stress on the spine from repetitive heavy lifting and rigorous activities may be the cause of the higher occurrence of migrating disc herniations in physically demanding employment across studies. On the other hand, variations in study populations and local smoking patterns may account for the inconsistent correlation with smoking status. Occupational health interventions are important to reduce risk factors linked with disc herniations because of the consistent relationship between physically demanding employment and highly migrating discs.

Ahn.et al. discusses that the realm of treating lumbar disc herniations, open microdiscectomy has long been regarded as the gold standard due to its established efficacy in addressing radiculopathy. However, Transforaminal Endoscopic Lumbar Discectomy (TELD) has emerged as a promising minimally invasive alternative, particularly as advancements in endoscopic technology have significantly improved its effectiveness. Initially, endoscopic procedures faced numerous challenges, including limited visibility, reduced precision, and a higher risk of complications, which were often attributed to inadequate instruments and the inexperience of surgeons. These factors contributed to suboptimal outcomes, especially in complex cases involving high-migration lumbar disc

herniations. Nevertheless, recent innovations, such as enhanced imaging systems and refined surgical tools, have transformed the landscape of endoscopic surgery. The TELD technique now allows for more precise anatomical navigation and selective removal of herniated disc fragments, leading to improved clinical outcomes and lower complication rates. As a result, TELD has gained traction as a viable option for patients, offering the advantages of minimally invasive surgery while achieving results comparable to, or even superior to, traditional open discectomy methods.[22]

Another study by Dong Hwa Heo et al. demonstrates that fully endoscopic transforaminal discectomy is an effective and alternative treatment option for upward migration of upper lumbar disc herniation. The research highlights the high risks associated with traditional open surgery methods, such as microdiscectomy, which can lead to complications like isthmic fractures, facet joint injuries, and neurological damage due to the narrow anatomical features of the upper lumbar region. In contrast, the fully endoscopic approach preserves normal bony structures and minimizes the risk of such complications. The study involved 28 patients who underwent the endoscopic procedure, with significant improvements observed in clinical outcomes measured by the Oswestry Disability Index (ODI) and visual analog scale (VAS) for pain. Postoperative imaging confirmed complete removal of migrated disc particles in the majority of cases, and while some patients experienced minor transient symptoms, there were no significant complications related to the procedure. The findings suggest that the endoscopic technique not only achieves comparable results to traditional methods but also offers the advantages of being minimally invasive, thereby reducing the risks associated with general anesthesia and iatrogenic injuries. Overall, this research supports the growing acceptance of endoscopic surgery as a viable option for treating upward migrated disc herniations in the upper lumbar area.[23]

At the 2-year follow-up, the mean preoperative VAS score for back pain had decreased from 7.8 ± 1.2 to 2.1 ± 0.9, indicating significant improvements in functional outcomes ($p < 0.001$). Likewise, after the 2-year follow-up, the mean ODI score decreased from 65.4 ± 8.6 preoperatively to 20.3 ± 5.4 ($p < 0.001$). These findings demonstrate how well endoscopic surgery works for patients with highly migrating lumbar disc herniations to lessen their pain and disability. In contrast, mean VAS scores decreased from 7.5 ± 1.3 preoperatively to 2.3 ± 1.0 at the 2-year follow-up, and mean ODI scores improved from 64.0 ± 9.0 to 21.0 ± 5.7, In contrast, a study Kim et al. 18 patients with an average age of 35.1 years showed that the mean VAS back pain improved from 5.7(±1.77) to 1(±0.77), and VAS leg pain from 7.3(±1.37) to 1.1(±1.09), while the ODI score improved from 49.88(±11.42) to 13.88(±7.28) at the final follow-up. Additionally, this study reported high patient satisfaction, with a 90.5% satisfaction rate and a 94% recommendation rate, along with 17 patients achieving "excellent" outcomes based on the MacNab criteria. All patients returned to daily activities within a median of 5 weeks, although there were complications: one patient required conversion to open surgery due to an incidental dural tear, one required revision due to a remnant disc, and one experienced recurrence at both 6 weeks and 2 years, managed by repeat TELD. Importantly, all patients achieved the MCID for VAS and ODI within a median period of 6 weeks and 3 months, respectively, and the recovery rate was noted at 90.1%. Further, the comparative study measured improvements in cross-sectional area (CSA) from a preoperative mean of 62.26 $mm^2$ to 141.05 $mm^2$ at 1-year follow-up, and maintained average disc height and lumbar lordosis at improved levels. While both studies demonstrate the effectiveness of endoscopic surgery in improving patient outcomes, the additional metrics provided in the other study, such as patient satisfaction, return-to-work timing, CSA, and lumbar lordosis, offer a more comprehensive view of structural recovery and patient-reported outcomes. [24]

Dr. George Macnab developed the Modified Macnab Criteria in the 1970s to provide a standardized approach to measure functional recovery and patient satisfaction following spine surgery. The criteria was first intended to standardize the assessment of outcomes in this field..It divides results into four groups: good, fair, bad, and exceptional depending on the degree of pain relief and the ability to carry out everyday tasks. 37 patients (79%) reported outstanding results, 8 patients (17%) good results, and 2 patients (4%) had acceptable results in our study. These findings demonstrate

that endoscopic surgery for significantly migrated lumbar disc herniations has a very high success rate. In contrast, the study of shows an overall favorable rate of 90.4% using the Modified Macnab criteria, with no significant difference between the interlaminar (IL), transforaminal (TF), and contralateral transforaminal (CTF) approaches ($P > 0.05$). The success rates per approach in this study were 87.1% for TF, 93.3% for CTF, and 92.6% for IL, further affirming the effectiveness of these methods. Together, these findings underscore the high efficacy of endoscopic methods across approaches in reducing pain and improving functionality for patients with complex lumbar disc herniations.[25]

The results may not be as generalizable to different groups or environments due to the study's single-center approach. Furthermore, long-term effects or potential late complications might not have been captured during the very brief two-year follow-up period. One of the limitation of our study is the use of only interlaminar approach. Long-term follow-up to evaluate the longevity of results over time and multi-center trials to validate results across a range of patient demographics should be included in future research. Furthermore, more thorough data on relative efficacy might be obtained by conducting randomized controlled studies contrasting endoscopic surgery with other minimally invasive procedures and open surgery.

**Conclusion:**

In conclusion, endoscopic surgery has shown to be a successful treatment for highly migrating lumbar disc herniations, providing markedly better functional results and pain alleviation with a low level of invasiveness.Although endoscopic techniques have had limitations in the past, they have now become more successful and applicable due to technological and procedural breakthroughs. To improve patient outcomes and improve surgical techniques for the treatment of complicated disc herniations, more research and innovation are needed.

**References:**

1. Chen CM, Lin GX, Sharma S, Kim HS, Sun LW, Wu HH, Chang KS, Chen YC. Suprapedicular retrocorporeal technique of transforaminal full-endoscopic lumbar discectomy for highly downward-migrated disc herniation. World Neurosurgery. 2020 Nov 1;143:e631-9.
2. Cai H, Liu C, Lin H, Wu Z, Chen X, Zhang H. Full-endoscopic foraminoplasty for highly down-migrated lumbar disc herniation. BMC Musculoskeletal Disorders. 2022 Mar 29;23(1):303.
3. Lee S, Kim SK, Lee SH, Kim WJ, Choi WC, Choi G, Shin SW. Percutaneous endoscopic lumbar discectomy for migrated disc herniation: classification of disc migration and surgical approaches. European Spine Journal. 2007 Mar;16:431-7.
4. Kim CH, Chung CK, Jahng TA, Yang HJ, Son YJ. Surgical outcome of percutaneous endoscopic interlaminar lumbar diskectomy for recurrent disk herniation after open diskectomy. Clinical Spine Surgery. 2012 Jul 1;25(5):E125-33.
5. Ahn Y, Jang IT, Kim WK. Transforaminal percutaneous endoscopic lumbar discectomy for very high-grade migrated disc herniation. Clinical Neurology and Neurosurgery. 2016 Aug 1;147:11-7.
6. Liu C, Chu L, Hao-Chuan Y, Chen L, Zhong-Liang D. Percutaneous endoscopic lumbar discectomy for highly migrated lumbar disc herniation. Pain Physician. 2017;20(1):E75.
7. Ahn Y, Lee SH, Lee JH, Kim JU, Liu WC. Transforaminal percutaneous endoscopic lumbar discectomy for upper lumbar disc herniation: clinical outcome, prognostic factors, and technical consideration. Acta neurochirurgica. 2009 Mar;151:199-206.
8. Choi KC, Lee DC, Shim HK, Shin SH, Park CK. A strategy of percutaneous endoscopic lumbar discectomy for migrated disc herniation. World Neurosurgery. 2017 Mar 1;99:259-66.
9. Ahn Y, Jeong TS, Lim T, Jeon JY. Grading system for migrated lumbar disc herniation on sagittal magnetic resonance imaging: an agreement study. Neuroradiology. 2018 Jan;60:101-7.

10. Wu X, Fan G, Guan X, Zhu Y, Huang L, He S, Gu X. Percutaneous endoscopic lumbar discectomy for far-migrated disc herniation through two working channels. Pain Physician. 2016;19(4):E675.
11. Lin GX, Park CW, Suen TK, Kotheeranurak V, Jun SG, Kim JS. Full endoscopic technique for high-grade up-migrated lumbar disk herniation via a translaminar keyhole approach: preliminary series and technical note. Journal of Neurological Surgery Part A: Central European Neurosurgery. 2020 Sep;81(05):379-86.
12. Choi KC, Shim HK, Park CJ, Lee DC, Park CK. Usefulness of percutaneous endoscopic lumbar foraminoplasty for lumbar disc herniation. World Neurosurgery. 2017 Oct 1;106:484-92.
13. Hofstetter CP, Ahn Y, Choi G, Gibson JN, Ruetten S, Zhou Y, Li ZZ, Siepe CJ, Wagner R, Lee JH, Sairyo K. AOSpine consensus paper on nomenclature for working-channel endoscopic spinal procedures. Global Spine Journal. 2020 Apr;10(2_suppl):111S-21S.
14. Lewandrowski KU, Ransom NA. Five-year clinical outcomes with endoscopic transforaminal outside-in foraminoplasty techniques for symptomatic degenerative conditions of the lumbar spine. Journal of Spine Surgery. 2020 Jan;6(Suppl 1):S54.
15. Hu QF, Pan H, Fang YY, Jia GY. Percutaneous endoscopic lumbar discectomy for high-grade down-migrated disc using a trans-facet process and pedicle-complex approach: a technical case series. European Spine Journal. 2018 Jul;27:393-402.
16. Yeom KS, Choi YS. Full endoscopic contralateral transforaminal discectomy for distally migrated lumbar disc herniation. Journal of Orthopaedic Science. 2011 May;16:263-9.
17. Kim HS, Ju CI, Kim SW, Kim JG. Endoscopic transforaminal suprapedicular approach in high grade inferior migrated lumbar disc herniation. Journal of Korean Neurosurgical Society. 2009 Feb;45(2):67.
18. Krzok G, Telfeian AE, Wagner R, Iprenburg M. Transpedicular lumbar endoscopic surgery for highly migrated disk extrusions: preliminary series and surgical technique. World neurosurgery. 2016 Nov 1;95:299-303.
19. Kang T, Park SY, Park GW, Lee SH, Park JH, Suh SW. Biportal endoscopic discectomy for high-grade migrated lumbar disc herniation. J Neurosurg Spine. 2020 Sep;33(3):360-365. doi: 10.3171/2020.2.SPINE191452.
20. Yang F, Ren L, Ye Q, Qi J, Xu K, Chen R, Fan X. Endoscopic and Microscopic Interlaminar Discectomy for the Treatment of Far-Migrated Lumbar Disc Herniation: A Retrospective Study with a 24-Month Follow-Up. Journal of Pain Research. 2021 Jun;14:1593-1600. doi:10.2147/JPR.S302717.
21. Chen W-C, Wang W-T, Pao J-L. Unilateral biportal endoscopic discectomy via translaminar approach for highly upward-migrated lumbar disc herniation: a technical note and preliminary treatment outcomes. BMC Musculoskeletal Disorders. 2024;25:722.
22. Lee SG, Ahn Y. Transforaminal endoscopic lumbar discectomy: basic concepts and technical keys to clinical success. *Int J Spine Surg*. 2021;15(Suppl 3):S38–S46.
23. Heo, Dong Hwa, et al. "Fully endoscopic transforaminal lumbar discectomy for upward migration of upper lumbar disc herniation: clinical and radiological outcomes and technical considerations." *Brain Sciences* 10.6 (2020): 363.
24. Sharma SB, Lin GX, Jabri H, Sidappa ND, Song MS, Choi KC, Kim JS. Radiographic and clinical outcomes of huge lumbar disc herniations treated by transforaminal endoscopic discectomy. Clin Neurol Neurosurg. 2019 Oct;185:105485. doi: 10.1016/j.clineuro.2019.105485. Epub 2019 Aug 9. PMID: 31421587.
25. Liu, Chao, et al. "Percutaneous endoscopic lumbar discectomy for highly migrated lumbar disc herniation." *Pain Physician* 20.1 (2017): E75.