

Chapter 5

Assessment and Selection of the Appropriate Individualized Technique for Endoscopic Lumbar Disc Surgery

Clinical Outcome of 400 Patients

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Key Points

- Endoscopic lumbar disc surgery is well established as safe and effective treatment for disc herniation but choosing and performing the most appropriate procedure for an individual patient is still a challenge for spine surgeons.
- Three different endoscopic techniques, transforaminal posterolateral or selective endoscopic discectomy (SED), transforaminal posterolateral with foraminoplasty (ITE), and posterior interlaminar endoscopy (ILE), were performed in a 400 consecutive patients with lumbar disc herniation.
- Based on preoperative imaging data, patients with extraforaminal, foraminal, lateral, and central herniations as well as low-grade migrations underwent lumbar discectomy with the SED technique; patients with high-migrated intracanal fragments underwent ITE technique; and patients with L5–S1 disc herniation and a high iliac crest had endoscopic discectomy via an ILE approach.

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- After a mean follow-up of 5.4 years, excellent/good results were obtained in 90.75 % of the patients. Outcomes were similar for the three procedures. The three study groups showed similar significant decreases in VAS and ODI scores as compared with preoperative values, but scores at 1, 3, 6, 12, and 24 months after surgery were similar.
- Individualized preoperative assessment allowed targeting lumbar disc excision using the most appropriate endoscopic technique. Only with careful planning of the surgical approach can an optimal targeted access be achieved.

Introduction

Lumbar disc surgery has evolved from open microdiscectomy to minimally invasive procedures. A broad range of different endoscopic techniques currently exist, each one covering a specific and limited range of indications, so that not only a high level of expertise is necessary, but also sufficient skills are required to choose and perform the most appropriate procedure for a given individual patient.

The transforaminal intradiscal technique, originally described by Kambin and Gellman [1], was later modified by Yeung and Tsou [2], who introduced a unique rigid rod-lens and a flow-integrated and multichannel operating endoscope with slotted and beveled cannulas that allowed a same-field viewing of the epidural space, the annular wall, and the intradiscal space. This posterolateral transforaminal approach, called “selective endoscopic discectomy” (SED), provides intradiscal access and excision of low-grade migrated intracanal herniations. Ruetten et al. [3] described lateral access for a full endoscopic transforaminal operation, but it was limited to the L4–L5 level due to anatomic restrictions like the iliac crest and the kidney. However, Lee et al. [4] found that SED could fail depending on the level of migration of the fragment, so that percutaneous endoscopic lumbar discectomy can be considered to be a surgical option in nonmigrated herniations and low-grade migrations. Choi et al. [5] described percutaneous endoscopic foraminoplasty as an effective procedure for highly migrated intracanal disc herniations. Ahn et al. [6] and Hoogland [7] introduced an alternative endoscopic technique, usually referred to as “intracanal transforaminal endoscopy” (ITE) that also permits reaching high-migrated intracanal fragments. This technique uses a transforaminal posterolateral approach that requires a mandatory drilled foraminoplasty to access the canal with an endoscope [8]. Finally, Ruetten et al. [9] described an “interlaminar endoscopy” (ILE) technique that uses a posterior approach through the yellow ligament into the epidural space for the solution of intracanal herniations, especially at the L5–S1 level. This ILE approach is performed under direct endoscopic vision with minimal dissection of the yellow ligament under general anesthesia.

The use of the most suitable technique for the individual patient facilitates the access to the target area and reduces the intrinsic anatomic difficulties for the spine

surgeon. This prospective study presents the clinical outcome of 400 consecutive nonrandomized patients with lumbar disc herniation undergoing SED, ITE, or ILE. The selection of the endoscopic approach was based on the location of the herniation, the degree of migration, and the bony access conditions (e.g., the height of the iliac crest and a minimal width of the interlaminar gap).

Materials and Methods

Patient Population

Between January 2001 and January 2010, patients with symptomatic lumbar disc herniation from L1–L2 to L5–S1 who were candidates for one of the three endoscopic techniques (SED, ITE, or ILE) were eligible to participate in a prospective study. These patients were consecutively diagnosed and treated at Centro Medico Teknon in Barcelona, Spain. All patients were preoperatively informed about the type of operation, technical difficulties, and potential complications. Written informed consent was obtained from all patients.

Inclusion criteria for all three endoscopic procedures required clinical evidence of lumbar disc herniation and findings from a physical examination consistent with the magnetic resonance imaging (MRI) findings. Every patient had had at least 3 months of failed nonsurgical treatment and clinical signs of radiculopathy that included intractable leg or buttock pain with or without leg pain. Lumbar sagittal and frontal X-rays and MRI were the standard minimal images used to correlate symptoms of back and neuropathic pain.

Imaging Parameters

All patients underwent preoperative MRI and anterior-posterior (A/P) and lateral lumbar spine X-ray studies. A careful preoperative planning was performed by superimposing the MRI image of the herniated mass fragment on the A/P and lateral X-ray images (Figs. 5.1, 5.2 and 5.3). This allowed demonstration of the precise virtual location of the herniated mass in the A/P and lateral views and correlation during surgery with the C-arm fluoroscopic images (A/P and lateral projections), which was important for the surgeon to be able to orient the endoscopic instruments in the operative field (Figs. 5.4 and 5.5).

Based on preoperative imaging data, patients with extraforaminal, foraminal, lateral, and central herniations as well as low-grade migrations underwent lumbar discectomy with the SED technique, patients with high-migrated intracanal fragments with ITE technique, and patients with L5–S1 disc herniation and a high iliac crest had endoscopic discectomy via an ILE approach.

Fig. 5.1 MRI sagittal view of a L2–L3 intracanal caudal sequestered 15 mm herniation. Size and fragment measurement on the MRI scale

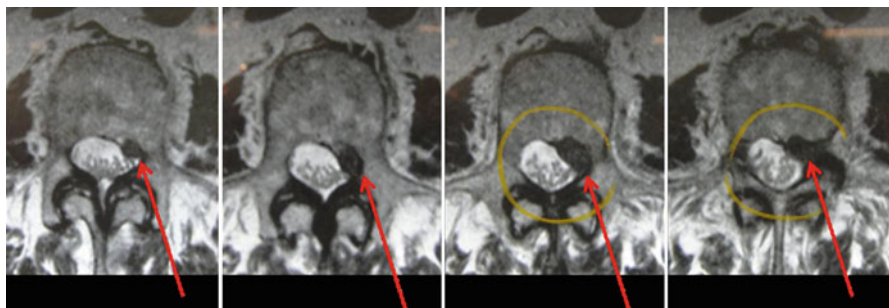
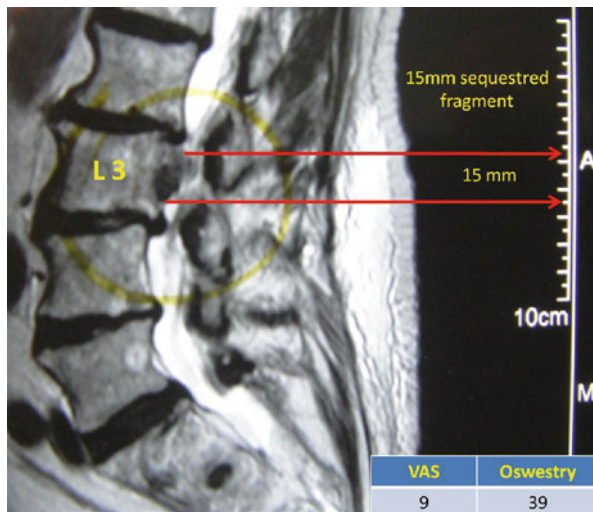


Fig. 5.2 MRI axial view of the same 15 mm intracanal fragment from Fig. 5.1 in four consecutive L3 serial cuts, (red arrow) extruded herniation, (yellow circle) herniation level

Surgical Procedures

Endoscopic transforaminal lumbar discectomies (SED, ITE) were performed under local anesthesia and light sedation, whereas the endoscopic ILE approach was performed under general anesthesia. A contrast discography with indigo carmine (Taylor Pharmaceuticals, Decatur, IL, USA) diluted with iopamidol 300 1:10 was performed in all patients to blue-stain abnormal nucleus pulposus.

The SED procedure was performed as described by Yeung and Tsou [2] using a 20° rigid endoscope (Joimax GmbH, Karlsruhe, Germany) with a working channel of 3.7 mm of diameter and radiofrequency coagulation system probes (Ellman International Inc., Hewlett, NY, USA). To perform this approach, it is necessary to first insert a needle into the disc, and a dilator is passed using the needle central guide wire. This central guide wire is then extracted and a 30° beveled cannula is passed over the dilator and the dilator extracted. The fluoroscopy X-ray arch is used

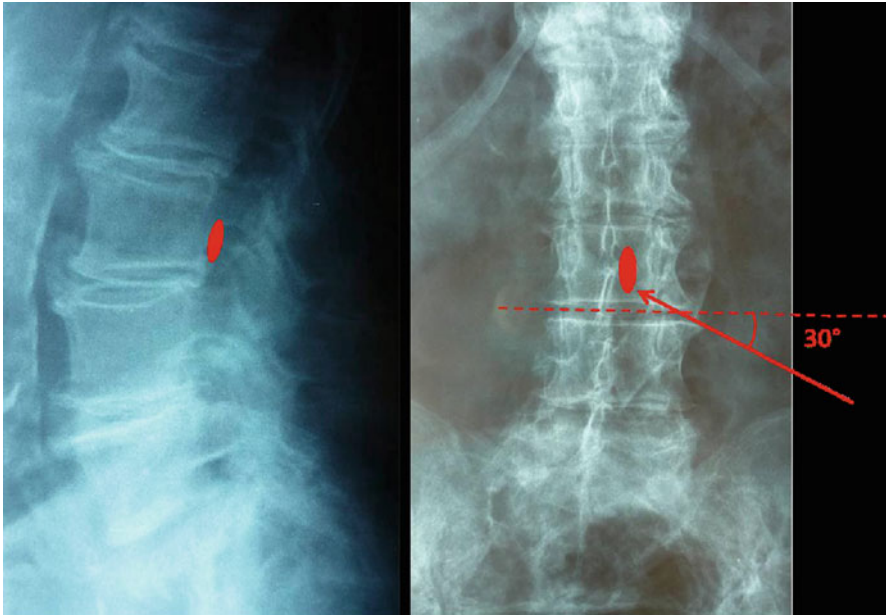


Fig. 5.3 Virtual transposition of the herniated intracanal fragment on the preoperative lateral and A/P lumbar X-ray image with preoperative planning of the access trajectory of the endoscopic instruments

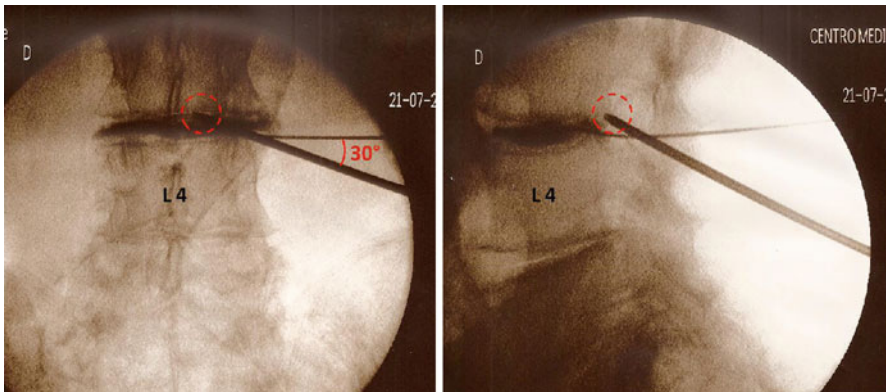


Fig. 5.4 Intraoperative fluoroscopic images in A/P and lateral with the 3 mm small dilator in the access trajectory to the intracanal herniation. See the L3–L4 discography with the intradiscal needle in position and the access from the level below the herniation, (*dotted circle*) endoscopic target

to control in A/P and lateral view the proper position of the dilator and cannula into the disc through this foraminal approach. The endoscope is passed through the cannula and under saline irrigation the disc structures are visible on the camera monitor. The careful dissection of the posterior longitudinal ligament and disc tissues with single-action baskets allows the surgeon to see the blue-stained nucleus

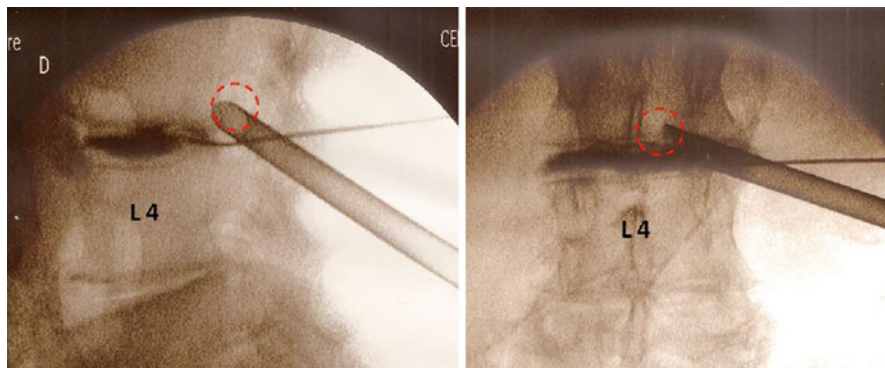


Fig. 5.5 Intraoperative fluoroscopic images in A/P and lateral with the 7.5 mm beveled cannula in the access trajectory to the intracanal herniation. See the L3–L4 discography with the intradiscal needle in position and the access from the level below the herniation (*dotted circle*) endoscopic target

pulposus and the herniation and, with careful identification, the neural structures. A foraminoplasty can optionally be performed to ablate the upper part of the superior facet and the articular capsule. Sometimes, foraminoplasty is essential to approach herniations, especially at the L5–S1 level, and also caudal migrated herniations [2, 5, 6, 8]. The reamed foraminoplasty is performed under direct endoscopic vision [8] through the endoscope's working channel employing an endoscopic chisel, high-speed burrs, or manual reamers, all with 3.5 mm outer diameter (Joimax GmbH). In order to further widen the foramen, a 5 mm trephine [2, 6] can additionally be employed through the same beveled cannula. After the herniation removal, disc curettage is usually performed.

In the ITE technique, it is mandatory to perform previously a foraminoplasty in order to remove sequestered disc fragments [5, 7]. The manually drilled foraminoplasty was performed only under X-ray fluoroscopic control using progressive manual drills (Hoogland Spine Systems GmbH, Munich, Germany). Drill diameter starts with 6 mm and progresses to 7, 8, and 9 mm. The drills are always directed to the target through the caudal part of the foramen. Once the drilling has reached the canal, a dilator of 6.5 mm is passed through the drilled hole and a beveled cannula is passed over the dilator. After the dilator is retrieved, the endoscope can be placed through the beveled cannula, the canal and the epidural space can be visually inspected, and the herniated fragment removed. The ILE approach was performed as described by Ruetten et al. [3] under direct endoscopic vision through the yellow ligament [5, 9].

In all procedures after retrieving the endoscope, the skin was sutured. A corticoid such as depomedrol 125 mg was locally injected before the skin suture. During the endoscopic procedure and 16 h later, a third-generation cephalosporin (1 g every 8 h) was administered intravenously. All procedures were video-recorded for subsequent analysis. Discography images were printed for the patient's documentation.

Early deambulation was usually resumed 4 h after surgery. Most patients were discharged in less than 24 h after surgery.

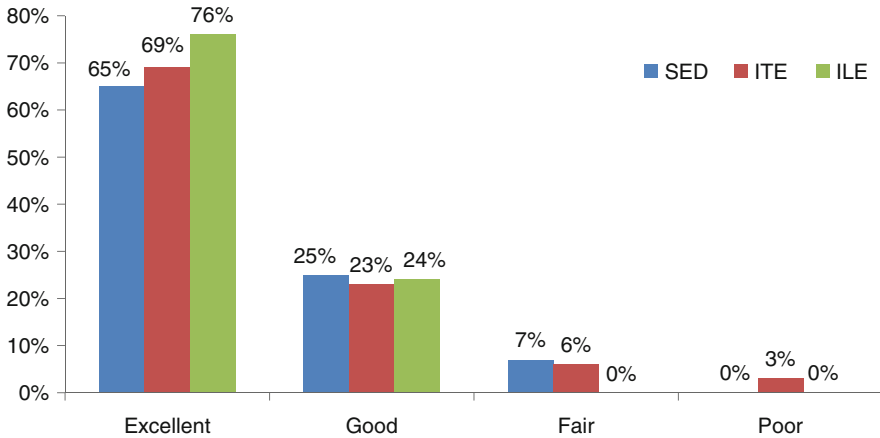


Fig. 5.6 Comparative outcome like Macnab (11) in % for three different endoscopic techniques

Outcome Evaluation

Clinical and neurological examination was performed at 1 h after operation and repeated at 12 h and 30 days after the procedure. Patients with neurological symptoms (paresis, dysesthesia, hypoesthesia, etc.) underwent electromyographic evaluation. Total pain and pain in the back and the lower extremity was scored on a visual analog scale (VAS) (0=no pain, 10=most severe pain) and the disability was evaluated with the Oswestry Disability Index (ODI) [10] for every patient. Assessments were performed pre- and postoperatively for the VAS and the ODI score at 1, 3, and 6 months after surgery, and every 6 months thereafter to achieve a minimal follow-up of 24 months for every case. VAS and ODI scores were determined blindly by independent physiotherapists who routinely participated in the physical rehabilitation of surgical patients. Patient outcomes were graded as excellent, good, fair, and poor using modified Macnab criteria [11] (see Fig. 5.6).

Statistical Analyses

Differences in VAS and ODI scores between the three intervention groups were assessed with the Wilcoxon rank-sum test. Moreover, differences in VAS and ODI scores between the groups with excellent/good results (threshold at a VAS score ≤ 4 and an ODI score ≤ 15) and fair/poor results (threshold at a VAS score ≥ 5 and an ODI score ≥ 16) were also analyzed. The Statistical Package for Social Sciences (SPSS) (version 15.0) for Windows was used for the analysis of data. Statistical significance was set at $P < 0.05$.

Results

A total of 400 patients met the inclusion criteria and underwent endoscopic lumbar discectomy. There were 245 men and 155 women, with a mean (standard deviation, SD) age of 46 (13.9) years (range 17–87 years). The mean age of male (45.3 years) and female (47.2 years) patients was similar. The SED technique was performed in 344 patients, the ITE in 35, and the ILE in 21. A total of 480 discs were operated on, with an average of 1.2 discs per patient. The type of herniation and the operated disc distribution in the three study groups are shown in Table 5.1. Patients were followed for a mean (SDS) of 5.4 (2.5) years (range 0.5–10 years). The overall follow-up rate was 97.5 %.

Clinical outcome was considered excellent in 264 (66 %) patients, good in 99 (24.75 %), fair in 27 (6.75 %), and poor in 10 (2.5 %) (Table 5.2). Overall, excellent and good results were obtained in 90.75 % of the patients. As shown in Table 5.2, results were similar for the three endoscopic techniques, with outcomes rated as excellent/good in 90.1 % of cases for the SED group, 91.4 % for the ITE group, and 100 % for the ILE group. The rates of fair/poor results were 9.9 % in the SED group and 8.6 % in the ITE group.

At follow-up, the mean VAS and ODI scores decreased significantly as compared with preoperative values ($P < 0.05$) (Table 5.3). Statistically significant

Table 5.1 Type of hernia and distribution of the operated discs in the three study groups

	Transforaminal endoscopy (SED)	Intracanal transforaminal endoscopy (ITE)	Interlaminar endoscopy (ILE)	Total
Herniation				
Central	48	5	2	55
Lateral	131	27	19	177
Foraminal	160	3		163
Extraforaminal	5			5
Total	344	35	21	400
Disc level				
L1–L2	4			4
L2–L3	12	1		13
L3–L4	46	2		48
L4–L5	206	10	4	220
L5–S1	156	22	17	195
Total	424	35	21	480

Table 5.2 Results by endoscopic technique in 400 patients

Outcome	Transforaminal endoscopy (SED)	Intracanal transforaminal endoscopy (ITE)	Interlaminar endoscopy (ILE)	Total
Excellent	224 (65.1 %)	24 (68.5 %)	16 (76.2 %)	264 (66 %)
Good	86 (25 %)	8 (22.9 %)	5 (23.8 %)	99 (24.75 %)
Fair	25 (7.3 %)	2 (5.7 %)	0	27 (6.75 %)
Poor	9 (2.6 %)	1 (2.9 %)	0	10 (2.5 %)
Total	344	35	21	400

differences between preoperative and postoperative VAS and ODI scores for each endoscopic technique were also observed; however, differences between the three study groups in VAS and ODI scores after 1, 3, 6, 12, and 24 months of surgery were not found (Table 5.4). On the other hand, postoperative VAS and ODI scores were significantly lower in patients in the excellent/good group than in those in the fair/poor group ($P < 0.05$) (Table 5.5).

Sterile discitis of unknown cause was reported in four patients in the SED. Postoperative neuropathic pain was reported in ten patients in the SED group. Nine of these cases were classified as transient dysesthesias and were treated with corticosteroids (2 mg every 8 h), gabapentine (75 mg every 8 h), and benzodiazepines (5 mg every 8 h) for 2–3 weeks. In one of these patients, a drop foot syndrome with residual partial paresis of the L5 nerve root was found. No dural tears or wound infections were reported.

Table 5.3 Results of clinical assessments for pain and functional disability in 400 patients

	VAS score, mean (SD)		ODI score, mean (SD)
	Back pain	Leg pain	
Preoperative	6.6 (2.1)	7 (2.1)	31.3 (7.1)
Follow-up			
1 month	2.8 (2.8) ^a	3.8 (2.8) ^a	16.5 (13) ^a
3 months	2.1 (0.2) ^a	2.3 (0.2) ^a	11.6 (7.1) ^a
6 months	1.6 (2.1) ^a	1.5 (2.1) ^a	7.8 (13) ^a
12 months	1.5 (0.1) ^a	1.4 (1.4) ^a	7 (7.1) ^a
>24 months	1.8 (0.1) ^a	1.2 (1.4) ^a	6.6 (2.1) ^a

^a $P < 0.05$ as compared with preoperative values

Table 5.4 Results of clinical assessments for pain and functional disability according to the endoscopic technique

	Preoperative	Follow-up				
		1 month	3 months	6 months	12 months	>24 months
VAS back, mean (SD)						
SED	6.4 (2.2)	2.8 (2.5) ^a	2.1 (2.2) ^a	1.6 (1.9) ^a	1.6 (2.0) ^a	2.2 (2.4) ^a
ITE	6.8 (1.9)	2.4 (2.3) ^a	1.5 (1.9) ^a	0.9 (1.2) ^a	0.6 (1.3) ^a	0.6 (1.1) ^a
ILE	6.2 (1.6)	2.0 (2.1) ^a	1.4 (1.9) ^a	1.5 (1.2) ^a	1.3 (1.3) ^a	1.3 (1.1) ^a
VAS leg, mean (SD)						
SED	6.2 (2.5)	3.5 (2.5) ^a	2.1 (2.0) ^a	1.4 (1.9) ^a	1.4 (2.4) ^a	1.3 (2.2) ^a
ITE	8.0 (1.1)	3.9 (2.4) ^a	2.2 (2.6) ^a	1.2 (1.7) ^a	1.0 (1.5) ^a	0.7 (1.3) ^a
ILE	8.4 (1.4)	1.9 (2.0) ^a	1.2 (1.8) ^a	1.2 (1.7) ^a	1.2 (1.5) ^a	1.2 (1.3) ^a
ODI score, mean (SD)						
SED	28.1 (8.4)	15.7 (10.1) ^a	11.4 (9.1) ^a	7.4 (7.0) ^a	7.1 (7.4) ^a	7.3 (8.1) ^a
ITE	34.6 (8.4)	15.7 (9.8) ^a	8.6 (8.1) ^a	5.8 (6.0) ^a	4.4 (4.8) ^a	4.1 (4.8) ^a
ILE	35.6 (8.8)	10.8 (6.8) ^a	6.6 (2.1) ^a	3.8 (2.0) ^a	3.4 (1.8) ^a	3.1 (1.8) ^a

SED transforaminal endoscopy, ITE intracanal transforaminal endoscopy, ILE interlaminar endoscopy

^a $P < 0.05$ as compared with preoperative values

Table 5.5 Results of clinical assessments for pain and functional disability according to outcome

Outcome	Follow-up				
	1 month	3 months	6 months	12 months	>24 months
Excellent/good					
VAS back, mean (SD)	2.1 (2.8)	1.6 (0.3)	1.2 (2.1)	0.9 (0.1)	1.0 (0.1)
VAS leg, mean (SD)	3.0 (2.8)	1.9 (0.3)	1.1 (2.1)	0.7 (1.4)	0.5 (1.4)
ODI score, mean (SD)	13.1 (13)	9.0 (7.1)	6 (13)	4.5 (7.1)	3.6 (2.1)
Fair/poor					
VAS back, mean (SD)	5.2 (3.1) ^a	3.3 (2.6) ^a	4.0 (2.4) ^a	4.7 (2.1) ^a	4.9 (2.2) ^a
VAS leg, mean (SD)	5.4 (2.9) ^a	2.8 (2.3) ^a	3.7 (2.3) ^a	4.8 (2.4) ^a	5.0 (2.3) ^a
ODI score, mean (SD)	23.4 (13.3) ^a	15.6 (13) ^a	18.3 (10.6) ^a	20.8 (8.4) ^a	19.7 (7.4) ^a

^a $P < 0.05$ as compared with the corresponding values in the excellent/good outcome group for each follow-up interval

In 18 patients, reoperation was required because of persistent postoperative pain, usually due to the presence of small disc fragments that have been missed during the initial SED operation. In 8 patients, residual intracanal fragments were removed by ITE with drilled foraminoplasty under local anesthesia. Four patients with reherniation at the same disc level and side underwent a second SED procedure. In four patients in whom the transforaminal approach with foraminoplasty had been too difficult because of a high iliac crest, reoperation with the ILE approach under general anesthesia was carried out. In the remaining two patients in whom the interlaminar gap was too small for an ILE approach, an open microdiscectomy under general anesthesia was performed. In all patients, satisfactory results were obtained.

Discussion

This study presents the outcome of 400 consecutive patients with lumbar disc herniation treated with endoscopic discectomy. Three different endoscopic techniques were presented and for each specific case only one approach was selected and applied, depending on the patient's specific anatomic and pathological characteristics. The selection criteria of the most convenient endoscopic procedure were primarily based on the anatomic location of the herniation and the level of migration (high or low level migration). The outcome was graded as excellent or good in 90.75 % of the patients. These results are similar to data reported in other clinical series [2, 7, 9] in which only one endoscopic approach was used and usually including a small range of migrated herniations and level distributions. In our opinion, the key point in obtaining optimal and consistent results is the technical ability to access all lumbar disc levels (especially L5–S1) by selecting the ideal needle trajectory, performing a drilled facetectomy [7, 8, 12] when required, and choosing the most appropriate instrument angle depending on the location of the herniation with a selective and direct targeted approach (Fig. 5.7). The angle in degrees of the needle's direction and the distance in centimeters to the midline depend on the anatomy

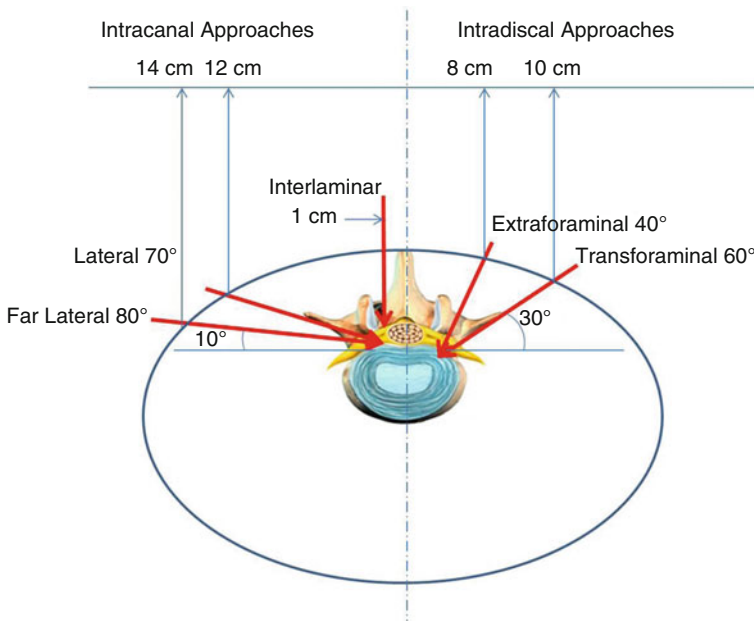


Fig. 5.7 Axial representation of the intradiscal and intracanal access trajectories with approximated angles and midline distances. Central or lateral herniation in L5–S1 with a high iliac crest: interlaminar (1 cm) lateral from the midline and 0° needle direction; extraforaminal herniation: distance to the midline 5–8 cm, use a more steep 40° needle direction; foraminal herniation: distance to the midline 8–12 cm, use a more medial entry and 60° needle direction; lateral herniation: distance to the midline 12 cm, use a more lateral entry and slight horizontal 70° needle direction; and central herniation: distance to the midline ≥ 14 cm, use an extreme far lateral entry and a horizontal 70°–80° needle direction

of the patient and can vary in each particular case. However, some technical specifications are also shown in Fig. 5.7.

The SED technique was convenient for removing intradiscal material and to extract all types of herniations that can be reached from the operated disc level (Fig. 5.8). In cases of low-grade intracanal migration, this procedure allowed extraction of fragments that were migrated less than the distance of one disc space height when measured from the adjacent endplate [4]. The extreme far lateral approach [3] was not considered in this study as a separate technique and was included into the group of SED. In our case, a lateral shallow access with an angle between 70° and 80° was applied (Fig. 5.7). We consider that this approach should be limited to treat herniations at the L4–L5 level, given that the iliac crest may prevent a far lateral access to the levels below, while the kidney could become a dangerous obstacle when accessing the levels above it.

The ITE approach was especially indicated for high-grade intracanal migration (see Fig. 5.9) and was suitable for fragments that were migrated more than the distance of one disc space height measured from the adjacent endplate [12]. The ILE approach was only employed in cases where the height of the iliac

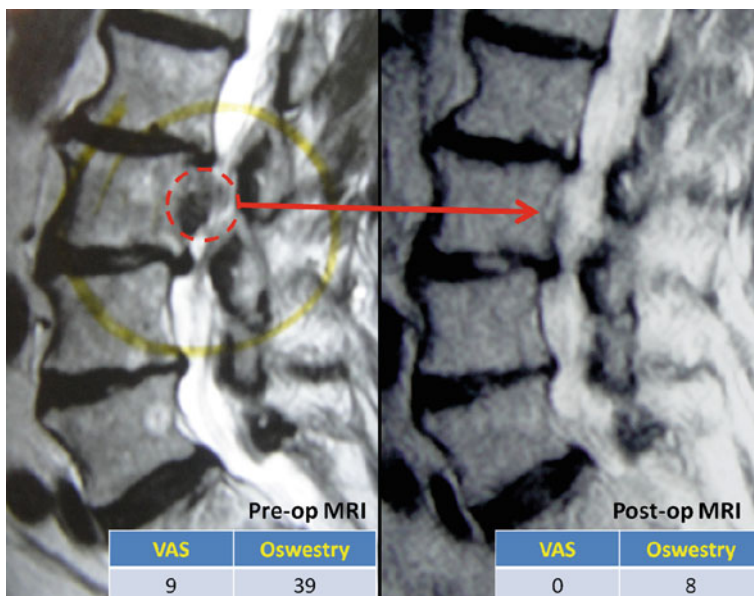


Fig. 5.8 Comparative pre-op and post-op MRI sagittal view showing the complete removal of the L3 intracanal migrated fragment

crest did not allow a direct transforaminal access even if a drilled foraminoplasty was performed. In these cases, the access angle in the A/P frontal plane becomes too steep and difficult, reaching the intracanal space especially in cases with cranially migrated fragments. The ILE approach was only employed if the interlaminar gap was wider than 2 cm, allowing the access through the yellow ligament into the vertebral canal.

In the group of operated ILE cases, men accounted for 71.4 % of the cases, probably due to the gender-specific anatomic characteristic of a higher iliac crest. In comparison, men accounted only for 62 and 60 % of cases in the SED and ITE groups, respectively. In these circumstances, the selection criteria of the degree of migration of the herniated fragment prevailed over gender-related anatomic conditions. Choi et al. [5] introduced an interlaminar approach that can be performed under local anesthesia by employing direct needle intracanal puncture and tissue dilatation only under fluoroscopic control. However, we preferred the approach described by Ruetten et al. [9] because, according to this technique, the yellow ligament dissection and epidural access are performed under direct endoscopic vision and additionally fluoroscopic control. This is an important advantage of the technique as it facilitates better intraoperative identification of anatomic structures despite the use of general anesthesia. A schematic overview of the advantages and limitations of the three endoscopic techniques is provided in Table 5.6.

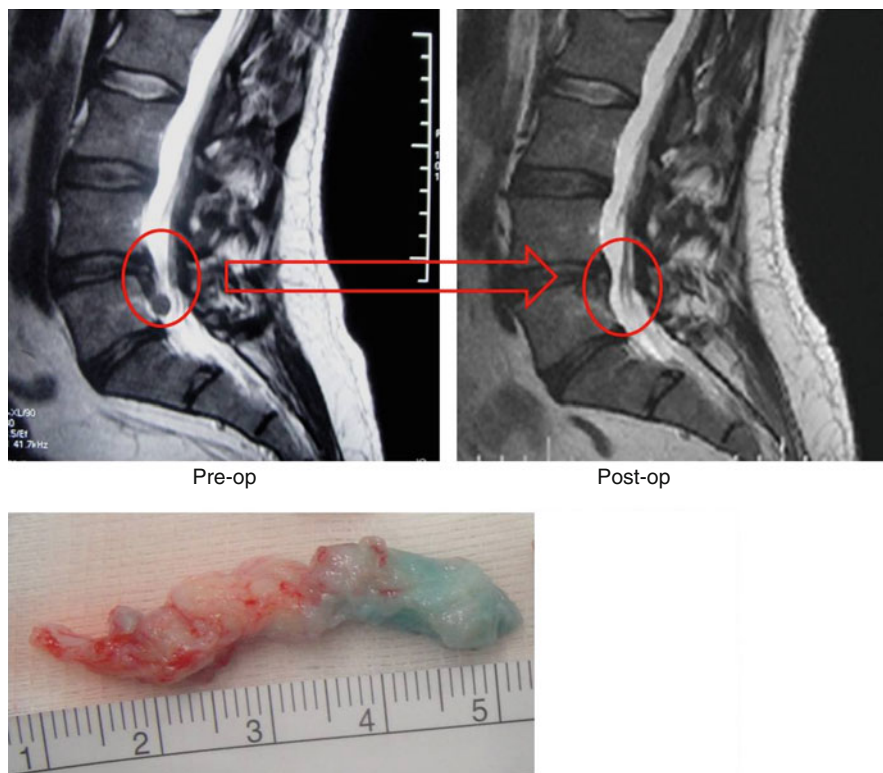


Fig. 5.9 Comparative pre-op and post-op MRI sagittal view showing the complete removal of the L4-L5 intracanal migrated herniation and the 5 cm blue stained extracted fragment, (red circle) fragment location

Table 5.6 Indications and limitations of different endoscopic approaches for reaching lumbar disc herniated fragments at various anatomic sites

Approach	Intradiscal	Intracanal	Limitations
Transforaminal posterolateral (SED)	Foraminal herniations [2]	Low-grade migration [2, 4]	High-grade migration
Transforaminal posterolateral with foraminoplasty (ITE)	Lateral herniations [2]	High-grade migration [6, 7]	Too high iliac crest, high-grade canal compromise
Transforaminal far lateral	Intradiscal limited access	Lateral and central herniations [3, 9]	Only for L4-L5
Posterior interlaminar (ILE)	Intradiscal limited access	Lateral and central herniations [3, 5, 9]	Mostly for L5-S1 if enough interlaminar gap

SED selective endoscopic discectomy, *ITE* intracanal transforaminal endoscopy, *ILE* interlaminar endoscopy

Conclusion

Endoscopic lumbar disc surgery can be performed using different intradiscal or intracanal approaches. In this study, three different endoscopic procedures were combined to target most of the typical spectrum of herniations. The selection of different endoscopic techniques helps to overcome natural anatomic obstacles. The approach and the needle position must be carefully chosen depending on multiple factors, including location of the herniation, herniation size, disc level, and other anatomic conditions such as height of the iliac crest and width of the interlaminar gap. Only after a careful planning of the approach can optimal targeted access be achieved.

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References

1. Kambin P, Gellman H. Percutaneous lateral discectomy of the lumbar spine: a preliminary report. *Clin Orthop Relat Res.* 1983;174:127–32.
2. Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: surgical technique, outcome, and complications in 307 consecutive cases. *Spine.* 2002;27:722–31.
3. Ruetten S, Komp M, Godolias G. An extreme lateral access for the surgery of lumbar disc herniations inside the spinal canal using the full-endoscopic uniportal transforaminal approach-technique and prospective results of 463 patients. *Spine.* 2005;30:2570–8.
4. Lee SH, Kang BU, Ahn Y, et al. Operative failure of percutaneous endoscopic lumbar discectomy: a radiologic analysis of 55 cases. *Spine.* 2006;31:E285–90.
5. Choi G, Lee SH, Raiturker PP, et al. Percutaneous endoscopic interlaminar discectomy for intracanalicular disc herniations at L5-S1 using a rigid working channel endoscope. *Neurosurgery.* 2006;58(1 Suppl):ONS59–68.
6. Ahn Y, Lee SH, Park WM, et al. Posterolateral percutaneous endoscopic lumbar foraminotomy for L5-S1 foraminal or lateral exit zone stenosis. Technical note. *J Neurosurg.* 2003;99(3 Suppl):320–3.
7. Hoogland T. Transforaminal endoscopic discectomy with foraminoplasty for lumbar disc herniation. *Surg Tech Orthop Traumatol.* 2003;C40:55–120.
8. Morgenstern R. Transforaminal endoscopic stenosis surgery: a comparative study of laser and reamed foraminoplasty. *Eur Musculoskelet Rev.* 2009;4:1–6.
9. Ruetten S, Komp M, Merk H, et al. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: a prospective, randomized, controlled study. *Spine.* 2008;33:931–9.
10. Fairbank JC, Pynsent PB. The Oswestry disability index. *Spine.* 2000;25:2940–52.
11. Macnab I. Negative disc exploration. An analysis of the causes of nerve-root involvement in sixty-eight patients. *J Bone Joint Surg Am.* 1971;53:891–903.
12. Choi G, Lee SH, Lokhande P, et al. Percutaneous endoscopic approach for highly migrated intracanal disc herniations by foraminoplastic technique using rigid working channel endoscope. *Spine.* 2008;33:E508–15.