Retrospective Study

Percutaneous Endoscopic Lumbar Discectomy for All Types of Lumbar Disc Herniations (LDH) Including Severely Difficult and Extremely Difficult LDH Cases

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Background: Lumbar disc herniation (LDH) is being treated with limited indication by percutaneous full endoscopic lumbar discectomy. However, microscopic lumbar discectomy (MLD) is still considered as a gold standard.

Objective: With the advances in spinal endoscopic instruments and surgical techniques, all LDHs have now become operable with percutaneous full endoscopic lumbar discectomy procedure. We report the results of percutaneous full endoscopic lumbar discectomy (PELD) for all patients diagnosed with LDH, including severely difficult and extremely difficult LDH cases who visited our clinic with leg pain and lower back pain.

Study Design: Retrospective study of consecutive prospective patients.

Setting: Spine center, Nanoori Suwon Hospital, Suwon, Korea.

Methods: Electronic medical records of 98 consecutive patients (104 levels) who underwent surgery from October 2015 to May 2016, by PELD for different LDHs either by percutaneous endoscopic transforaminal lumbar discectomy (PETLD) or percutaneous endoscopic interlaminar lumbar discectomy (PEILD) approach were reviewed retrospectively. The L5-S1 level was accessed with PEILD approach and the other levels were accessed with PETLD approach. Outcomes were analyzed utilizing the visual analog scale (VAS), Oswestry disability index (ODI), Mac Nab Criteria and endoscopic surgical success grade/score.

Results: There were 75 (72.1%) men and 29 (27.9%) women patients with a mean age of 48.12 ± 15.88 years. Follow-up range from a minimum of 10 to 15 months (mean 12.77 ± 1.84 months). Most of the LDHs were located at L4-5 level. There were 76% severely difficult and extremely difficult cases. PETLD was the choice of approach in most of the cases (78 cases, 75%). VAS decreased significantly. ODI improved from preoperative 54.67 ± 7.52 to 24.50 ± 6.45 at last follow-up. 96.1% good to excellent result was obtained as per Mac Nab criteria. 98.1% of patients were managed with a successful to completely successful grade according to the endoscopic surgical success grading/scoring. Two cases (1.9%) developed transient motor weakness.

Limitation: Retrospective analysis of consecutive prospective patients.

Conclusion: With more than 96% success (98.1% as per endoscopic success grading/scoring) all kinds of LDHs, including severely difficult and extremely difficult LDHs, are accessible by the PELD (PETLD and PEILD) technique. PELD can now be considered an alternative to microscopic lumbar discectomy (MLD) in the treatment of all kinds of disc herniations with the added benefits of keyhole surgery even for severely difficult and extremely difficult LDH cases.

Key words: Lumbar disc herniation (LDH), percutaneous endoscopic lumbar discectomy (PELD), percutaneous endoscopic transforaminal lumbar discectomy (PETLD), percutaneous endoscopic interlaminar discectomy (PEILD), evolution of PELD, difficult LDH, highly migrated LDH, high canal compromised LDH, revision LDH, LDH with discal cyst, calcified LDH

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Pioneers in endoscopic disc surgery started their work with a simple armamentarium (1). Hausmann and Forst (2) modified an arthroscope in1983. Kambin (3) published his arthroscopic disc surgery in 1992. Yeung et al (4,5) has developed YESS and published their work in 2002. Inside-out and outside-in techniques are now well introduced (6-8). The extreme lateral approach was introduced by Ruetten et al (8) as a first approach for the direct epidural space using a rigid endoscope in 2005. In 2007, Lee et al (9) introduced the half-an-half technique and the epiduroscopic approach. In 2009, suprapedicular approach was introduced by Kim et al (10) for high grade inferior migrated discs and Chae et al (11) introduced a semi-rigid flexible curved probe. Foraminoplasty techniques (12-15) are also described in the literature. L5-S1 interlaminar approach for L4-5 inferior migrated disc was described by Choi et al (16) in 2010. Yeom et al (17) and Kim et al (18) introduced the contralateral approach. The annular sealing and ligamentum flavum splitting techniques (19,20) are described in the literature as structural preservation techniques. The transiliac approach for L5-S1 disc herniation (21) has also been described in cases of high iliac crest for L5-S1 level.

Surgical armamentarium like different forceps, biter, cutter, radiofrequency (RF) coagulation system, drill, shaver, scope, irrigation system (pump), monitor with superior quality etc., are being improvised day by day to ease surgery.

Despite all developments, the learning curve is still difficult (22,23), and until now, percutaneous full endoscopic lumbar discectomy (PELD) has been adopted only for limited indications. Microscopic lumbar discectomy (MLD) is still considered as a gold standard. With this study, we report the results of PELD for all patients diagnosed with a case of lumbar disc herniation (LDH), including severely difficult and extremely difficult LDH cases who visited our clinic with leg pain and lower back pain.

Table 1. *Grading/scoring of surgical difficulty of PELD.*

Score	Grade	Description	Types of HNP
1	Grade I	Mildly difficult	Paracentral LDH
2	Grade II	Moderately difficult	Moderately Inferiorly Migrated LDH
			Central LDH
3	Grade III	Severely difficult	Foraminal LDH
			Far Lateral LDH
			Moderately Superiorly Migrated LDH
			High Lumbar Level above L2-3
			High Canal Compromised LDH
			Revision PETLD
4	Grade IV	Extremely difficult	Highly Inferiorly Migrated LDH
			Highly Superiorly Migrated LDH
			Revision PEILD
			Calcified LDH

Modifiers: Each Adding score (1); High Iliac Crest/Hard Bony Foraminal Width/Spinal Stenosis / Discal Cyst
Summation score: Score based on highest disc characteristic + added score; Maximum score 4
LDH: Lumbar Disc Herniation; PETLD: Percutaneous Endoscopic Transforaminal Lumbar Discectomy; PEILD: Percutaneous Endoscopic Interlaminar Lumbar Discectomy

Methods

Electronic medical records of 98 consecutive patients (104 levels) who underwent surgery from October 2015 to May 2016, by PELD for different LDHs by either percutaneous endoscopic transforaminal lumbar discectomy (PETLD) or percutaneous endoscopic interlaminar lumbar discectomy (PEILD) approach were reviewed retrospectively. In the PETLD, we used the posterolateral outside-in approach. In the PEILD, structural preservation technique (19-20) was used. PEILD was done in cases who had LDH at the L5-S1 level. In the PETLD group, as per location of the LDH, they were approached either by the exiting nerve root or intervertebral or suprapedicular approach (24). Foraminoplasty was done using a drill in cases with narrow foramen width and inferiorly migrated LDHs. We have calculated the grading/scoring of surgical difficulty for LDHs as per their characteristics in Table 1, which reflects difficulty of surgical management. Higher scores reflect more difficult cases.

All surgeries were performed by one surgeon having specialized training in spinal neurosurgery. Outcomes were analyzed utilizing the visual analog scale (VAS), Oswestry disability index (ODI), Mac Nab Criteria, and endoscopic surgical success grade/score. The surgical success grade/score is based on radiological and clinical findings. It takes into consideration the postoperative status of any disc remnants per magnetic resonance image (MRI) and clinical improvement after PELD (Table 2).

Results

There were 75 (72.1%) men and 29 (27.9%) women patients with a mean age of 48.12 ± 15.88 years. Follow-up ranged from a minimum of 10 to 15 months (mean 12.77 ± 1.84 months). Most of the LDHs were located at the L4-5 level. PETLD was the choice of approach in most of the cases (78 cases, 75%). Details of patients and characteristics of the LDHs are in Table 3.

There were 76% severely difficult and extremely difficult cases. Mostly, LDHs were of the high canal compromised (25%), highly inferiorly migrated (16.3%) and formainal (14.4%) type.

Table 2. *Grading/scoring of surgical success of PELD.*

Score	Grade	Description	Disc remnant in MRI	Symptom
1	Grade I	Unsuccessful	Completely remained	Remained
2	Grade II	Partially unsuccessful	Partially Removed	Remained
3	Grade III	Successful	Completely Removed	Remained
			Partially Removed	Improved
4	Grade IV	Completely successful	Completely Removed	Improved

Table 4. *Postoperative results and surgical outcome of PELD.*

Items		Mean (n)	± SD (%)
Follow-up period (month)		12.77	± 1.84
Complication	None	102	(98.07%)
	Transient Motor Weakness	2	(1.93%)
Mac Nab criteria	Poor	1	(1.0%)
	Fair	3	(2.9%)
	Good	54	(51.9%)
	Excellent	46	(44.2%)
Endoscopic Surgical success grade	Grade I	0	(0.0%)
	Grade II	2	(1.9%)
	Grade III	39	(37.5%)
	Grade IV	63	(60.6%)
Drill assisted	No	74	(71.2%)
	Yes	30	(28.8%)
Approach	Exiting nerve	19	(18.3%)
	Suprapedicular	29	(27.9%)
	Intervertebral	56	(53.8%)
Operation performed	PETLD	78	(75.0%)
	PEILD	26	(25.0%)

Surgical outcomes are shown in Table 4, Fig. 1, and Fig. 2. VAS decreased significantly. ODI also improved remarkably from preoperative 54.67 ± 7.52 to 24.50 +

Table 3. *LDH characteristics and surgery related preoperative analysis.*

Items		Mean (n)	± SD (%)
Age (years)		48.12	± 15.88
Gender	Male	75	(72.1%)
	Female	29	(27.9%)
Level of LDH	L1-2	3	(2.8%)
	L2-3	3	(2.8%)
	L3-4	11	(11.3%)
	L4-5	57	(53.8%)
	L5-S1	31	(29.2%)
Special issue associated with LDH	None	41	(39.4%)
	Modic changes	2	(1.9%)
	Narrow Hard Bony Foraminal Width	14	(13.5%)
	Calcified LDH	7	(6.7%)
	High Lumbar Level	5	(4.8%)
	Revision PETLD	9	(8.7%)
	Foraminal LDH	2	(1.9%)
	Revision PEILD	4	(3.8%)
	Spinal Stenosis	15	(14.4%)
	High Canal Compromised LDH	2	(1.9%)
	Discal Cyst	3	(2.9%)
Diagnosis	Central LDH	2	(1.9%)
	Far lateral LDH	5	(4.8%)
	Foraminal LDH	15	(14.4%)
	High Canal Compromised LDH	26	(25.0%)
	Highly Inferiorly Migrated LDH	17	(16.3%)
	Moderately Inferiorly Migrated LDH	11	(10.6%)
	Moderately Superiorly Migrated LDH	3	(2.9%)
	Paracentral LDH	24	(23.1%)
	Recurrent LDH	1	(1.0%)
Endoscopic Surgical difficulty grade	Grade I	8	(7.7%)
	Grade II	17	(16.3%)
	Grade III	34	(32.7%)
	Grade IV	45	(43.3%)

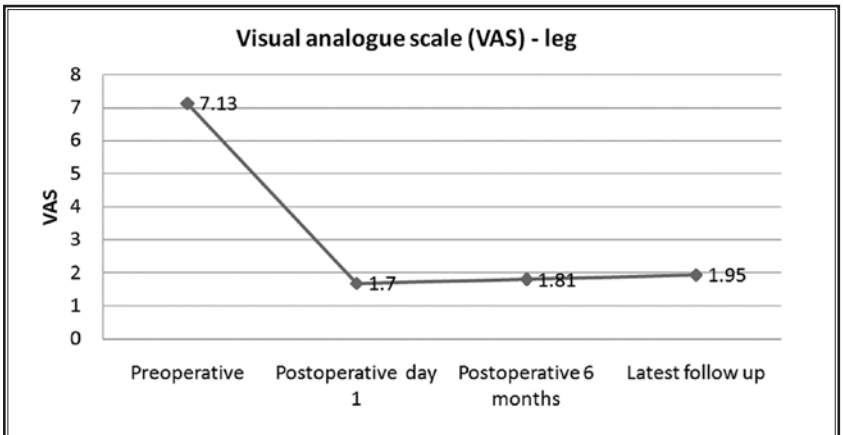

Fig. 1. *VAS leg change from preoperative to final follow-up.*

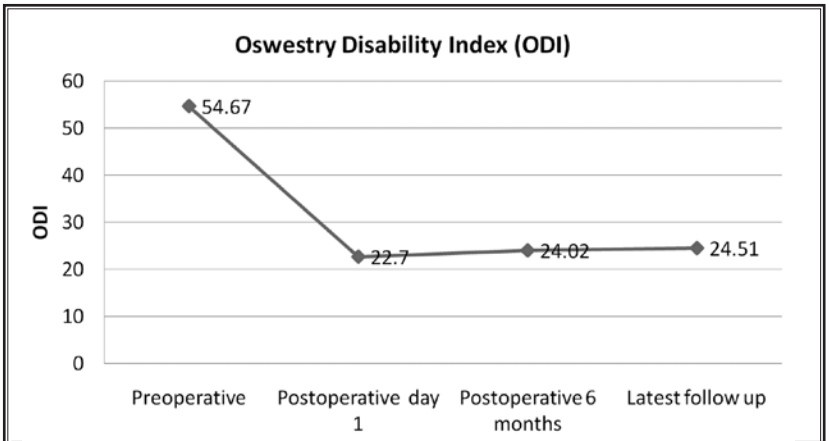

Fig. 2. *ODI change from preoperative to final follow-up.*

6.45 at last follow-up. 96.1% good to excellent result was obtained as per Mac Nab criteria. 98.1 % of patients were managed with a successful to completely successful grade according to the endoscopic surgical success grading/scoring. We had only 2 cases of partially unsuccessful grade, and 2 (1.9%) cases treated with the transforaminal approach that developed transient motor weakness, which resolved completely over 4 weeks. Representative preoperative and postoperative MRI of LDH cases are illustrated in Figs. 3-6.

Discussion

Indications for PELD are ever expanding with progressive understanding of LDHs and the advent of new surgical instruments and techniques, as well as a better understanding of endoscopic anatomy. Until now, PELD has been adopted only for limited indications. We have to take into consideration some facts about endoscopic discectomy to achieve successful outcomes even for difficult LDH cases like we had (76% severely difficult and extremely difficult cases) in

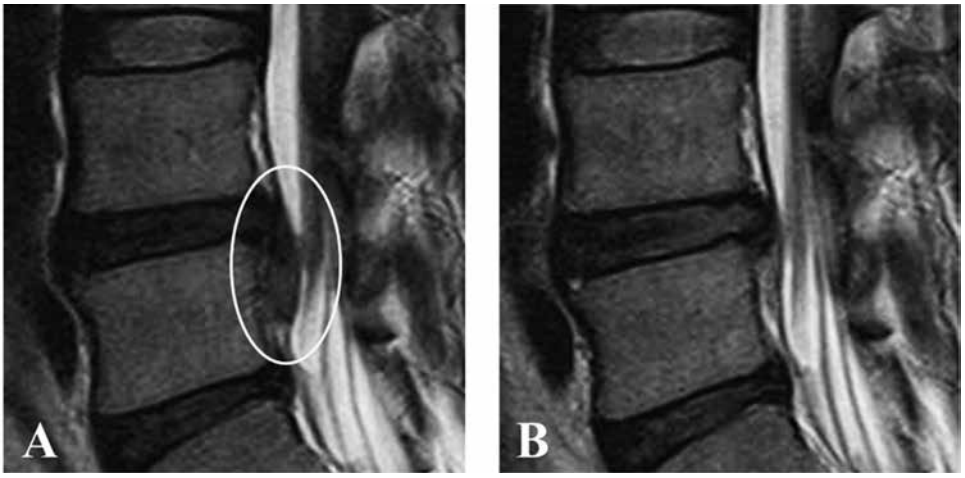

Fig. 3. *Highly inferiorly migrated LDH. A) Preoperative MRI LDH encircled. B) Postoperative MRI with complete removal of LDH.*

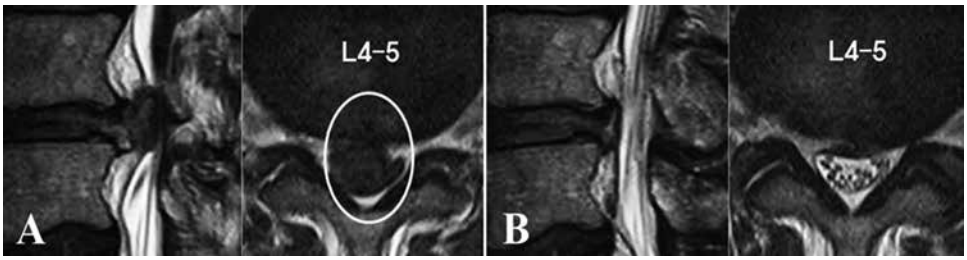

Fig. 4. *High canal compromised LDH. A) Preoperative MRI LDH encircled. B) Postoperative MRI with complete removal of LDH.*

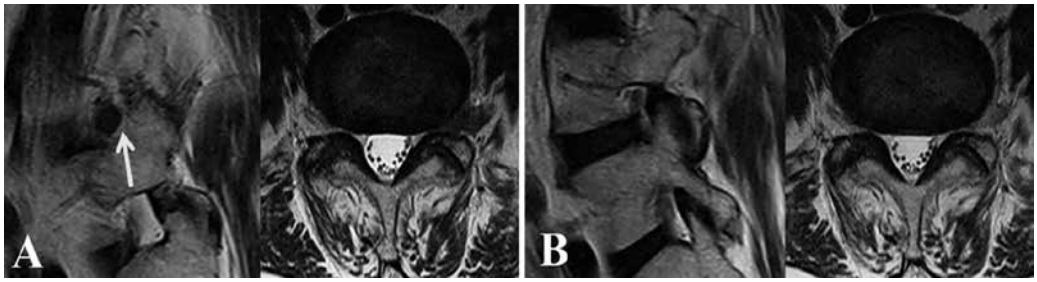

Fig. 5. *Extraforaminal far lateral LDH preoperative MRI. A) Preoperative MRI LDH arrowed. B) Postoperative MRI with complete removal of LDH.*

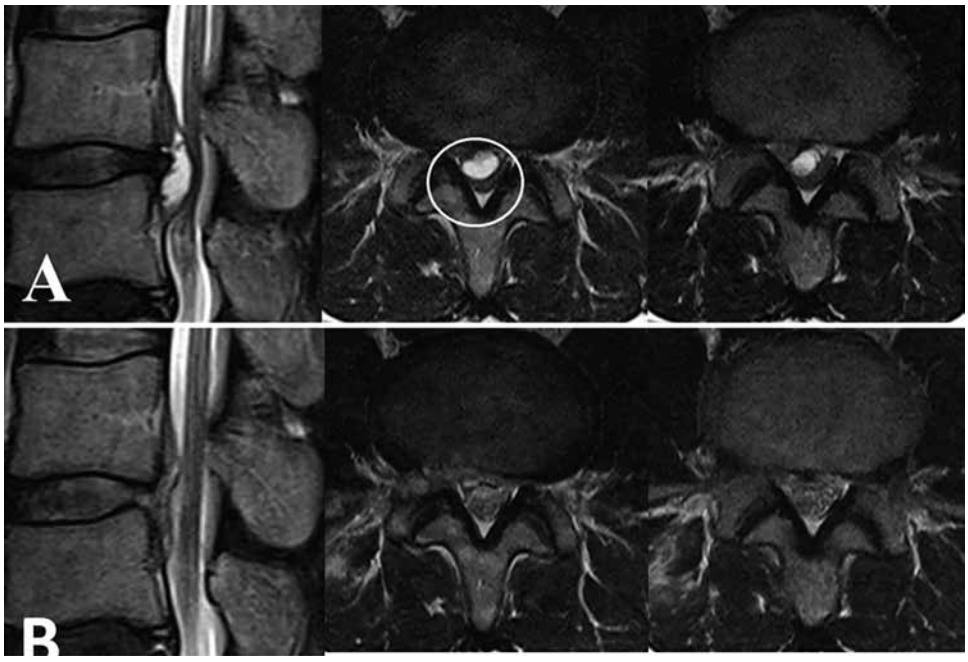

Fig. 6. *Highly inferiorly migrated LDH with discal cyst. A) Preoperative MRI LDH encircled. B) Postoperative MRI with complete removal of LDH.*

this study. Each LDH should be individualized as per surgical difficulty (Table 1) prior to surgical procedure to achieve a successful outcome. We should be aware of native and endoscopic anatomy, LDH characteristics (location of disc, hardness of disc (calcified or soft), hard bony foraminal width, canal occupation by disc, iliac crest height, status of recurrence and presence/absence of discal cyst etc.). Competent knowledge of surgical

approaches, technique and special surgical armamentarium are also paramount (9,12-15,24).

When the hard bony foraminal space is wide enough, it is easy to expose the epidural space by using the half-and-half approach (9). However, when the hard bony space is narrow, it is difficult to directly expose the epidural space. In this situation, foraminoplasty with a drill or shaver helps to reach the target LDH more conveniently (12-15). When the iliac crest is at approximately the same level with the target disc level, surgical manipulation will be easy. But if the iliac crest is high, it is difficult to move upward from the intraspinal space and to open the epidural space. We had to approach to that level either by PEILD or transiliac approach. In the LDH with high canal compromised situation, we had to approach using the intervertebral approach. The possibility of root and dural injury increases with these cases and careful epidural exposure will be the most important point for achieving successful removal of the LDH. Foraminoplasty gives easier and safer access to the epidural space. In superior migrated, foraminal and far lateral LDH, we had to approach by the exiting root approach. The segmental artery commonly passes under the exiting nerve root and must be protected. Injury to the segmental artery is associated with postoperative retro-peritoneal hematoma (25,26). The treatment of segmental artery injury is supportive treatment with blood transfusion in an intensive care unit. The dorsal root ganglion also must be protected otherwise postoperative dysesthesia will ensue from this ganglion. It is also important to identify the remnant disc by exposing the axilla area that is located upward from the disc. One must be well aware of the relationship between the exiting nerve root and the working channel. A round type working channel provides a safer and better clinical result than a beveled working channel. The round type working channel helps to protect the exiting nerve root and also helps to avoid soft tissue crowding from fat, vessel, and ligament. To prevent exiting nerve root injury, the exiting root should be exposed by motions of gentle pushing with a round working channel. When the exiting root is identified, only then should the working channel be introduced into the axilla area. In inferior migrated LDH, we recommend using the intervertebral approach and the suprapedicular approach. In the L4-5 level, there are anatomical barriers like the pedicle, the iliac crest and narrow foraminal width. Due to these anatomical barriers, the L4-5 inferior migrated disc is difficult to reach with a rigid percutaneous endoscope. For cases of a highly inferior migrated disc, epidural exposure around the suprapedicular area (10,11) will be helpful to expose the epidural space. This suprapedicular area is usually covered with abundant fatty tissue. After removal of the fatty tissue and clearing of this area, we can expose the ruptured, inferior migrated LDH and the traversing nerve root. In the difficult situation of insertion of forceps or a working instrument into the epidural space due to the barrier of bony structures, foraminoplastic widening (12-15) using a high speed drill or reamer will be helpful. The calcified LDH has a high risk of dural or neural injury while removing and may need special instruments like a high speed drill to remove .The LDH with discal cyst has a tendency to bleed more when it is present. Surgeons should possess an RF system or intraoperative bleeding control system like an irrigation pump with brief adjustment of pressure between 60-80 mm of H_2O: slightly higher pressure than for irrigation purposes only (40-60 mm of H_2O).In the revision case of LDH, only removal of ruptured discs can improve the symptoms. However, since remnant discs remaining in the existing adhesion site may cause residual symptoms, the remaining discs in the adhesion tissue should be removed as much as possible. Adhesion from previous surgery makes the procedure difficult and the possibility of neural injury will increase when addressing revision case.

MLD is being accepted as a gold standard of discectomy as of today. But, with consideration of facts about endoscopic discectomy as described earlier and good preoperative planning, we were able to achieve more than 96% (98.1% as per endoscopic success grading/scoring) of a successful to completely successful result despite 76% severely difficult and extremely difficult cases of LDH (high canal compromised, superior migrated, foraminal and far lateral LDH, highly Inferior migrated LDH, LDH associated with discal cyst, calcified LDH, revision case of LDH etc.). We had only 2 cases of partially unsuccessful grade. The reason may be the presence of disc herniations at multiple levels (L3-4 and L4-5) in one of the cases and modic changes of vertebrae in the other case. The first case had undergone a microscopic endoscopic discectomy at L3-4 level as a second surgery by another surgeon. This level was just above the level of the endoscopic discectomy performed by us. The second patient, who had modic changes, underwent a transforaminal lumbar interbody fusion (TLIF) as a second surgery at the same level L4-5 by another surgeon. Modic changes and multilevel disc pathology might have contributed to the partially unsuccessful outcome. Two cases (1.9%) developed

transient motor weakness that resolved over 4 weeks spontaneously. The transient motor weakness occurred using the transforaminal approach and may be related to thermal injury during RF application or traction injury from the working channel. The transient motor weakness was not severe.

Despite this study being retrospective, the result is very encouraging for treatment of severely difficult and extremely difficult LDH cases. Therefore, all kinds of LDHs are accessible by the PELD (PETLD and PEILD) technique. We believe that in the future all discectomy surgery will be endoscopic and MLD will be replaced by PELD. PELD has advantages over MLD as it provides the benefits of keyhole surgery and can be done under local anesthesia when the patient is lightly sedated.

Conclusion

With more than 96% success (98.1% as per endoscopic success grading/scoring) all kinds of LDH including severely difficult and extremely difficult LDHs are accessible by the PELD (PETLD and PEILD) technique. PELD now can be considered an alternative to MLD in the treatment of all kinds of disc herniations with the added benefits of keyhole surgery even for severely difficult and extremely difficult LDH cases.

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